DIVER MEDIC TECHNICIAN COURSE

INDEX

LESSON 1_01 INTRODUCTION, SAFETY & FAMILIARISATION ROLE & RESPONSIBILITIES OF A DIVER MEDIC

Introduction

- The diver-medic technician must first be a well-trained general medic; it is certain that all accidents at dive sites are not dive-related. Many times diver medics are called upon to treat burns, fractures and other ordinary injuries and often their patients are employees of other companies working at the same location.
- DMT are divers or supervisors who are trained to look after the special medical problems of divers. DMT must be able to carry out clinical examinations and be able to report their findings accurately. They must also be capable of carrying out potentially dangerous practical manoeuvres on instruction from a doctor for example, introducing a needle into the chest to relieve pneumothorax under tension (see Lesson 7.06). All divers should be trained in relevant first aid. Ideally the supervisor and at least one member of each saturation team should have paramedical training. At the time of writing it is expected that this will become a legal requirement in Britain. Special practical courses are organized for such personnel.
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IMCA syllabus

- In the DMT course you will be taught on the different following subjects according to the IMCA syllabus:
- The causes, prevention, signs and symptoms, and the management under normal and hyperbaric conditions of:
- Bleeding
- Fractures, sprains and muscle trauma
- Shock
- Burns
- Electric shock
- Asphyxia, pulmonary oedema, respiratory arrest
- Cardiac arrest
- Convulsions
- Hypothermia, hyperthermia
- The structure and function of the following system should be described in appropriate detail
- The musculo-skeletal system

- The nervous system
- The heart, blood vessels, circulation and blood
- The lungs
- The ears, sinuses and vestibular organs
- The importance of personal hygiene in the management of injuries
- The systematic method of examining injured or ill patients including divers.
- Methods for monitoring vital signs such as pulse, respiratory rate, temperature (including use and reading of low-reading thermometer), blood pressure
- Methods of caring for a casualty on site and during transportation
- The administration of oxygen.
- The causes, effects, symptoms, prevention and management of the following conditions:
- Decompression illness including pulmonary barotrauma and gas embolism
- Squeeze
- Ear problems - infections, barotrauma, routine hygiene in saturation environments
- Injuries to skin and eyes
- Near drowning, secondary drowning, vomiting under water
- Carbon dioxide retention and poisoning
- Carbon monoxide poisoning
- Other breathing gas contaminants, e.g. hydrocarbons
- Oxygen toxicity
- Anoxia and hypoxia
- Nitrogen narcosis
- Underwater blast injury
- High pressure nervous syndrome (HPNS)
- Diving accidents
- Thermal stress - the effect of cold on divers' performance, hypothermia, hyperthermia
- Dental problems - recognition and first aid
- Dangerous marine animals - treatment of common injuries
- The first-aid equipment available at the site of a diving operation and its care and use
- The management of medical emergencies within a diving bell, e.g. ECM
- Methods of care for a casualty when transferring from the diving bell to the main chamber
- Medical record keeping (including confidentiality) and liaison with medical services/communication with medical personnel, including the use of a suitable aide-memoir for recording and transmitting medical data (e.g. publication DMAC 01)
- Use of medical equipment to be held at the site of an offshore diving operation, including the management of common minor illnesses if possible with the scales carried and as described in the publication DMAC 015 (Revision 1)

- Use and hazards of the drugs and intravenous fluids carried in the scales defined in publication DMAC 015 (Revision 1)
- Practice in the skills of:
- Setting up intravenous infusions
- Parenteral administration of drugs
- Suturing
- Theoretical teaching of bladder catheterisation
- Theoretical teaching and practice where available of:
- Insertion of pleural drain for pneumothorax
- Airway maintenance (laryngeal mask)
- Catheterisation.

Roles and Responsibilities of the DMT

- The roles and responsibilities of the DMT can be divided into two categories: primary responsibilities and additional responsibilities.

Primary Responsibilities

- The DMT must be physically, mentally, and emotionally prepared for the job of providing emergency care. This includes a daily commitment to positive health practices, having the appropriate equipment and supplies, and maintaining adequate knowledge and skills of the profession. The DMT must respond to the scene in a safe and timely manner. During scene assessment the DMT must consider personal safety; safety of the crew, patients, and bystanders; and the mechanism of injury or probable cause of illness.
- The DMT must perform patient assessment quickly to recognize the injury or illness so that priorities of care and transportation can be established. Managing the emergency often involves following protocols and interacting with medical direction as needed. After stabilizing the patient in the field, the DMT should provide appropriate transportation by sea or air to a proper receiving facility based on the patient's condition. Selection of the receiving facility for optimal patient care requires a knowledge of available facilities, hospital designation, and categorization. Knowledge of transfer agreements and payers insurance systDMT also can be a factor in arranging for patient transportation.
- The DMT is the patient's advocate as care is transferred to the staff at the receiving facility. Transfer of the patient includes briefing the hospital staff about the patient's condition at the scene and during transportation and providing thorough and accurate documentation in the patient care report (PCR). The DMT should complete required documentation in a timely manner so that the DMT crew can return to service. The crew should prepare the transportation support for return to service by replacing equipment and supplies. The crew also should openly review the call to see if there are ways to improve the patient care services that were provided at the scene and during transportation.

Additional Responsibilities

- The best solution to the special problems of diver's health seems to be the establishment of a system of medicine which allows for several levels of expertise to function in a coordinated manner, namely, the ***health care team.***
- It is important that the diver understands how this system operates because he plays a crucial part in it. He may be the only person able to take immediate action when an emergency occurs. When a casualty has been given first aid the divers must be able to describe the problem accurately to a doctor onshore, so that high quality advice can be given. He must then be able to act on instructions from the doctor and carry out the practical manoeuvres suggested by him.
- The best care of an injured worker in a remote place is provided as a continuous process from the immediate care on the spot to the treatment in hospital. This can only be achieved with a good network of communications from one level of the health care team to another.

Medical Direction for DMT

- Many services provided by DMTs are derived from medical practices whereby DMTs function as "physician extenders." This is made possible through medical direction (medical control or medical oversight). The medical direction physician serves as the medical leader, resource, and patient advocate for the DMT system. This relationship between the physician and DMT permits delivery of advanced prehospital care. The ideal medical direction physician is properly educated as an DMT medical director and is motivated to provide the following
- • DMT system design and operations
- • Education and training of DMT personnel
- • Participation in personnel selection
- • Participation in equipment selection
- • Development of clinical protocols in cooperation with expert DMT personnel
- • Participation in CQI and problem resolution
- • Direct input into patient care
- • Interface between DMT systDMT and other health care agencies
- • Advocacy within the medical community
- • Guidance as the "medical conscience" of the DMT system (advocating for quality patient care)
- Types of Medical Direction

LESSON 1_02 PRINCIPLES AND PRIORITIES OF FIRST AID

First aid is the immediate assistance or treatment given to someone injured or suddenly taken ill before the arrival of an ambuance, doctor or other appropriately qualified person. The person offering this help to a casualty must act calmly and with confidence, and above all must be willing to offer assistance whenever the need arises.

Being a First Aider

Most people can, by following the guidance given in this book, give useful and effective first aid. However, first aid is a skill based on knowledge, training, and experience. The term "First Aider" is usually applied to someone who has completed a theoretical and practical instruction course, and passed a professionally supervised examination.

The standard First Aid Certificate, awarded by St. John Ambulance, St. Andrew's Ambulance Association, and the British Red Cross, is proof of all-round competence. A certificate is valid for only three years; to keep up to date, you must be re-examined after further training. Once qualified, you may volunteer for additional training to broaden the scope of your skills.

Aims of First Aid

• To preserve life.

• To limit worsening of the condition.

• To promote recovery.

THE FIRST AIDER IS:

Highly trained.

• Examined and regularly re-examined.

• Up-to-date in knowledge and skill.

Being a First Aider

The first aid learned from a manual or course is not quite like reality Most of us feel apprehensive when dealing with "the real thing". By facing up to these feelings, we are better able to cope with the unexpected.

Doing your part

First aid is not an exact science, and is thus open to human error. Even with appropriate treatment, and however hard you try, a casualty may not respond as hoped. Some conditions inevitably lead to death even with the best medical care. If you do your j best, your conscience can be clear.

Assessing risks

The golden rule is, "First do no harm", while applying the principle of "calculated risk". You should use the treatment that is most likely to be of benefit to a casualty, but do not use a doubtful treatment just for the sake of doing something.

The "Good Samaritan"

This principle supports those acting in an emergency (but not those who go beyond accepted boundaries). If you keep calm, and you follow the guidelines in this book, you need not fear any legal consequences.

Protecting casualty

To avoid cross-infection when giving first aid, if possible you should: avoid direct contact with body fluids where possible; wash your hands; wear protective gloves. IF gloves are unavailable, life-saving treatment must still be given.

Your responsibilities as a first aider

- To assess a situation quickly and safely, and summon appropriate help.
- To protect casualties and others at the scene from possible danger.
- To identify, as far as possible, the injury or nature of the illness affecting a casualty.
- To give each casualty early and appropriate treatment, treating the most serious conditions first.
- To arrange for the casualty's removal to hospital, into the care of a doctor, or to his or her home.
- Treat casualty in position found
- To remain with a casualty until appropriate care is available.
- To report your observations to those taking over care of the casualty, and to give further assistance if required.
- To prevent cross-infection between yourself and the casualty as much as possible.

Giving care with confidence

Every casualty needs to feel secure and in safe hands. You can create an air of confidence and assurance by: * being in control, both of yourself and the problem; acting calmly and logically; being gentle, but firm, with your hands, and speaking to the casualty kindly, but purposefully.

Building up trust

- Talk to the casualty throughout your examination and treatment.
- Explain what you are going to do.
- Try to answer questions honestly to allay fears as best you can. If you do not know the answer, say so.
- Continue to reassure the casualty even when your treatment is complete - find out about the next-of-kin, or anyone else who should be contacted about the incident. Ask if you can help to make arrangements so that any responsibilities the casualty may have, such as collecting a child from school, can be taken care of.
- Do not leave someone whom you believe to be dying. Continue to talk to the casualty, and hold his or her hand; never let the person feel alone.

Talking to relatives

The task of informing relatives of a death is usually the job of the police or the doctor on duty However, it may well be that you have to tell relatives or friends that someone has been taken ill, or has been involved in an accident.

Always check that you are speaking to the right person first. Then explain, as simply and honestly as you can, what had happened, and, if appropriate, where, the casualty has been taken. Do not be vague or exaggerate; you may cause undue alarm. It is better to admit ignorance than to give misleading information.

Looking after yourself

It is important not to jeopardise your personal safety. Do not attempt heroic rescues in hazardous circumstances.

Coping with unpleasantness

The practice of first aid can be messy, smelly, and distasteful, and you may feel: that you will not be able to cope with this. Such fears are common but usually groundless. First-aid training will bolster your self-reliance and confidence and will help you to control your emotions in a difficult situation.

Taking stock after an emergency

Assisting at an emergency is a stressful event, and you may suffer a "delayed reaction" some time afterwards. You may feel satisfaction or even elation, but it is common to be upset, particularly if the casualty was a stranger and you might not know the outcome of your efforts.

Above all, never reproach yourself, or bottle up your feelings. It often helps to talk over your experience with a friend, your doctor or your first-aid trainer.

Protecting yourself against infection

You may worry about picking up infections from casualties. Often, simple measures such as washing your hands and wearing gloves will protect both you and the casualty from cross-infection.

However, there is a risk that bloodborne viruses, such as hepatitis B or C and HIV (which can lead to AIDS Acquired Immune Deficiency Syndrome), may be spread by blood-to-blood contact.

These viruses can be transmitted only if an infected person's blood makes contact with a break in the skin, such as a cut or abrasion containing blood or blood products, of another person. No evidence exists of hepatitis or HIV being passed on during mouth-to-mouth resuscitation.

To prevent cross-infection, you should:

always carry protective gloves;

cover your own sores or skin wounds with a waterproof plaster;

wear a plastic apron when dealing with large quantities of a casualty's body fluids and wear plastic glasses to protect your eyes against splashes;

take care not to prick yourself with any needle found on or near the casualty, or to cut yourself on glass;

if your eyes, nose or mouth or any wound on your skin is splashed by the casualty's blood, wash thoroughly with soap and water as soon as possible, and consult a doctor;

use a mask or face shield for mouth-to-mouth ventilation if the casualty's mouth or nose is bleeding;

dispose of blood and waste safely after treating the casualty.

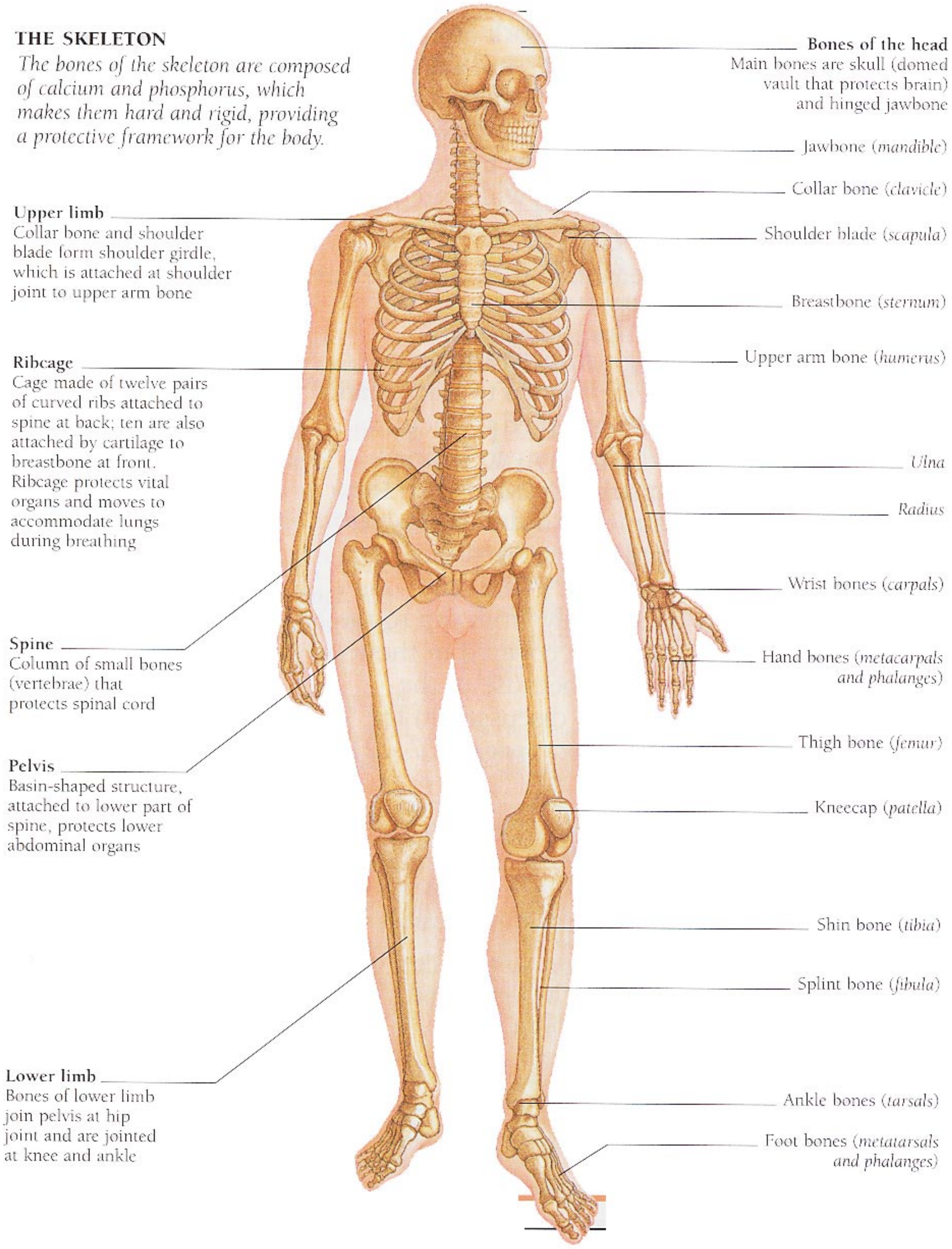
Seeking immunisation

First Aiders should seek medical advice on hepatitis B immunisation from their own doctors. If, after giving first aid, you are concerned that you have been in contact with infection of any sort, seek further medical advice.

LESSON 1_03 THE MUSCULO-SKELETAL SYSTEM

The Skeletal system

The skeletal system consists of bones and associated connective tissues, including cartilage, tendons and ligaments. The skeletal system provides a rigid framework for support and protection and provides a system of levers on which muscles act to produce body movements. The skeletal system contains 206



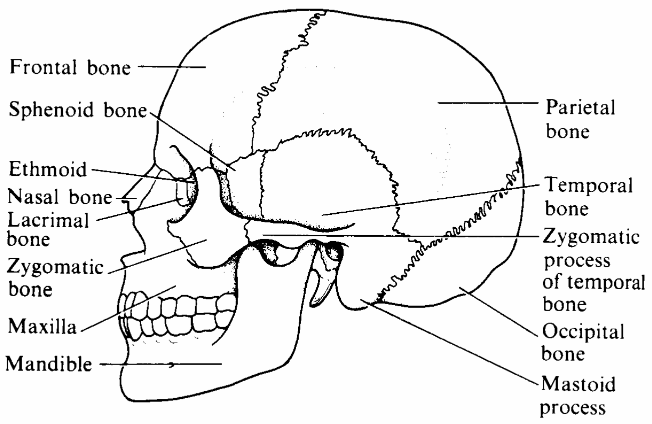
individual bones. Bones are divided into two categories: the axial skeleton and the appendicular skeleton.

Axial skeleton

The axial skeleton consists of the skull, hyoid bone, vertebral column, and thoracic cage. The skull is composed of 28 separate bones divided into the following groups: the auditory ossicles, cranial vault, and facial bones. The 6 auditory ossicles (3 on each sides of the head) are located inside the cavity of the temporal bone. The auditory ossicles function in hearing.

The cranial vault consists of 6 bones that surround and protect the brain. They are the parietal, temporal, frontal, occipital, sphenoid, and ethmoid bones.

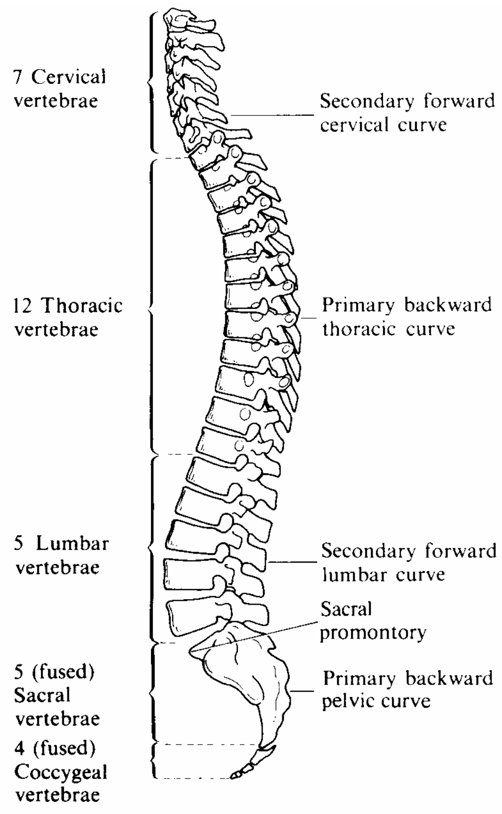
The 14 facials bones from the structure of the face in the anterior skull but do not contribute to the cranial vault. The bones include the maxilla, mandible, zygomatic, palatine, nasal, lacrimal, vomer, and inferior concha bones. The frontal and ethmoid bones contribute to both the cranial vault and the face.



The bones of the head.

The hyoid bone is attached to the skull by muscles and ligaments and floats in the superior aspect of the neck, just below the mandible. The hyoid bone serves as the attachment point for several important neck and tongue muscles.

The vertebral column consists of 26 bones, which can be divided into five regions: 7 cervical vertebrae, 12 thoracic vertebrae, 5 lumbar vertebrae, 1 sacral bone, and 1 coccygeal bone. A total of 34 vertebrae originally from during development, but the 5 sacral vertebrae fuse to form 1 bone, as do the 4 or 5 coccygeal bones.

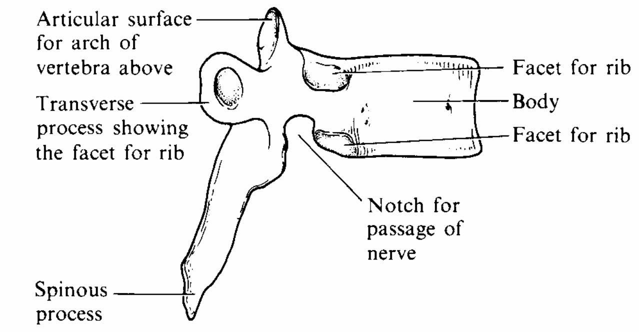


The curves of the spine.

The weight-bearing portion of the vertebrae is a bony disk called the body. Intervertebral disks, located between the bodies of adjacent vertebrae, serve as shock absorbers for the vertebral column, provide additional support for the body, and prevent the vertebral bodies from rubbing against each other. The spinal chord is protected by the vertebral arch and the dorsal portion of the body. A transverse process extend laterally from each side of the arch, and a single spinous process is present at the point of junction. Much vertebral movement is accomplished by the contraction of skeletal muscles attached to the transverse and the spinous processes.

The thoracic cage protects vital organs within the thorax and prevents the collapse of the thorax during respiration. T consists of the thoracic vertebrae, ribs with their associated costal cartilages, and sternum.

The 12 pairs of ribs can be divided into true or false ribs. The superior 7 (the true ribs) articulate with the thoracic vertebrae and attach directly through their costal cartilages to the sternum. The inferior 5 (the false ribs) articulate with the thoracic vertebrae but



A typical thoracic vertebra (side view).

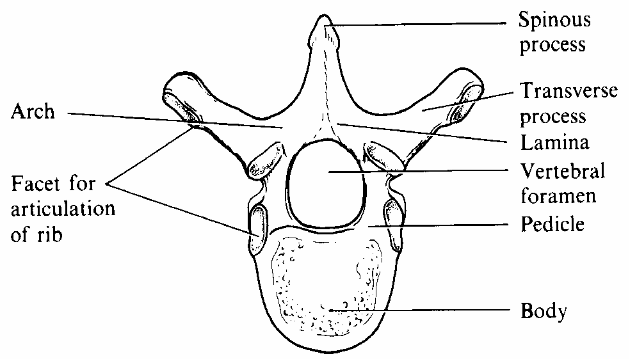
do not attach directly to the sternum. The eight, ninth, and tenth ribs are joined to a common cartilage, which is attached to the sternum. The eleventh and twelfth ribs are "floating" ribs that have no attachment to the sternum.

The sternum is divided into three parts: the manubrium, body, and xyphoid process. At the superior margin of the manubrium is the jugular notch, witch can easily be palpated at the anterior base of the neck. The point at which the manubrium joins the body of the sternum is the sternal angle. The second rib is found lateral to the sternal angle and is used clinically as starting point for counting the other ribs.

Appendicular skeleton

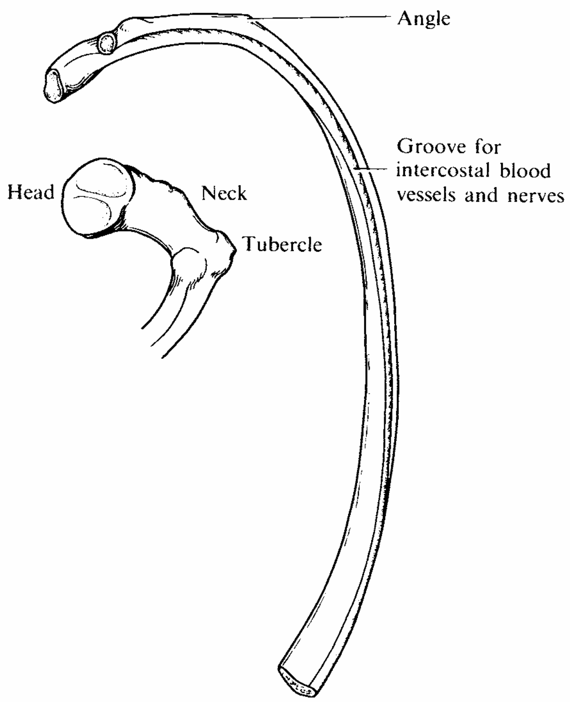
The appendicular skeleton consists of the upper and lower extremities and their girdles, by which they are attached to the body.

The scapula and clavicle constitute the pectoral girdle, which attaches the upper limbs to the axial skeleton. The direct point of attachment between the bones of the appendicular and axial skeleton occurs at the sterno-clavicular joint between the clavicle and the sternum.



A typical thoracic vertebra (from above).

The humerus is the second longest bone in the body. The head of the humerus articulates with the scapula the greater and the lesser tubercles are on the lateral and anterior surfaces of the proximal end of the humerus, where they function as sites of muscles attachment. The humerus articulates with the radius and the ulna at its distal end. The capilatulum (lateral aspect of the humerus) articulates with the head of the radius, and the trochlea (medial aspect of the humerus) articulates with the ulna. Proximal to the trochlea and capitulum are the medial and lateral epicondyles, respectively, which function as muscles attachments for the muscles of the forearm.



A typical rib.

The large bony process of the ulna (the olecranon process) can be felt at the point of the elbow. This process fits in a large depression on the posterior surface of the humerus known as the olecranon fossa. The structural relationship between these two processes makes movement of the joint possible. The distal end of the ulna has a small head that articulates with the radius and the wrist bones. The posterior medial side of the head has a small stilloid process to which the ligament of the wrist are attached. The proximal end of the radius articulates with the humerus, and the medial surface of the head constitutes a smooth cylinder where the radius rotates against the radial notch of the ulna. Major anterior arm muscles (biceps brachii) are attached to the radial tuberosity.

The wrist is composed of 8 carpal bones, which are arranged in two rows of 4 each. A total of 5 metacarpals are attached to the carpal bones and constitute the bony framework of the hand. A total of 28 phalanges make up the 10 digits of the hands. There are two phalanges for each thumbs and 3 for each finger.

The pelvic girdle attaches the leg to the trunk. The girdle consists of 2 coxa (hip bones), 1 located on each side of the pelvis. Each coxa surrounds a large obturator foramen, through which muscles, nerves and blood vessels pass to the leg. A fossa called the acetabulum is located on the lateral surface of each coxa and is the point of articulation of the lower limb with the girdle. During development, each coxa is formed by the fusion of 3 separate bones: the ilium, ischium and pubis. The superior portion of the ilium is the iliac crest. The crest ends anteriorly as the anterior-superior iliac spine and posteriorly as the superior-posterior spine.

The femur is the longest bone in the body. It has a well-defined neck and a prominent rounded head that articulates with the acetabulum. The proximal shaft has 2 tuberosities: a great trochenter lateral to the neck and a smaller or lesser trochenter inferior and posterior to the neck. Both trochenters are attachment sites for muscles that attach the hip to the thigh. The distal end of the femur has medial and lateral condyles that articulate with the tibia. Located laterally and proximally to the condyles are the medial and lateral epicondyles, which are sites of muscle and ligament attachment.

Distally, the femur also articulates with the patella, which is located in a major tendon of the thigh muscle. The patella allows the tendon to turn the corner over the knee.

The 2 bones of the leg are the tibia and the fibula.

The tibia is the largest of the 2 and supports most of the weight of the leg. A tibial tuberosity can be seen and palpated just inferior to the patella. The proximal end of the tibia has flat medial and lateral condyles that articulate with the condyles of the femur. The distal end of the tibia forms the medial malleolus, which helps to form the medial side of the ankle joint.

The foot consists of 7 bones. The talus articulates with the tibia and the fibula to form the ankle joint. The calcaneus is located inferior and jus lateral to the talus, supporting the bone. It protrudes posteriorly where the calf muscles attach to it and easily identified as the heel. The foot consists of tarsals, metatarsals, and phalanges, which are arranged in a manner similar to the metacarpals and phalanges of the hand, the great toe being analogous to the thumb. The ball of the foot is the junction between the metatarsals and the phalanges. Strong ligaments and leg muscles tendons normally hold the foot bones firmly in their arched position.

Joints

With the exception of the hyoid bone, every bone in the body connects to at least 1 other bone. The connections or joints commonly are named according to the bones or portions of the bones that are united at the joint. The three major classifications of joints are fibrous, cartilaginous, and synovial.

Fibrous joints

Fibrous joints consists of 2 bones united by fibrous tissue that have little or no movement. The joints are further divided on the basis of structure into sutures, syndesmosomes, or gomphoses. Structures (seams between flat bones) are located in the skull bones and may be completely immobile in adults. In newborns, the sutures have gaps between them, called fontanelles; these gaps are fairly wide to allow give to the skull during birth and allow growth of the head during development.

A syndesmosis is a fibrous joint in which the bones are separated by a greater distance than in a suture and are joined by ligaments. These ligaments may provide some movement of the joint. An example of these joints is the radioulnar syndesmosis that binds the radius and the ulna together.

A gomphosis joint consists of a peg that fits into a socket. The peg is held in place by fine bundles of collagenous connective tissue. The joints between the teeth and the sockets along the processes of the mandible and maxillae are examples of gomphoses joints.

Cartilaginous joints

Cartilaginous joints unit two bones by means of hyaline cartilage (synchondrose) or fibrocartilage (symphyses). A synchondrosis allows only slight movement at the joint. Common examples of this type of joint are epiphysial plate of a growing bone and the cartilage rod between most of the ribs and the sternum. Symphyses joint are slightly moveable because of flexible nature of the fibrocartilage. Symphyses include the junction between the manubrium and the body of the sternum in adults, the symphisis pubis of the coxae, and the Intervertebral disks.

Synovial joints

Synovial joints contain synovial fluid, a thin, lubrificating film that allows considerable movement between articulating bones. Most joints that unite the bones of the appendicular skeleton are synovial. The articular surfaces of bones within synovial joints are covered with a thin layer of hyaline cartilage, which provides a smooth surface where the bones meet. The joint is enclosed by a joint capsule, which consists of an outer fibrous capsule and an inner synovial membrane. The synovial membrane lines the joint and produces synovial fluid. Synovial joints are classified into six divisions according to the shape of the adjoining articular surfaces :

Plane or gliding joints consist of two opposed flat surfaces that are about equal in size. Examples of these joints are the articular processes between vertebrae.

Saddle joints consist of two saddle-shaped articulating surfaces oriented at right angles to one another. Movement in these joints can occur in two planes. An example of saddle joint is the carometacarpal joint of the thumb.

Hinge joints consist of a convex cylinder in one bone applied to a corresponding concavity in an other bone. These joints permit movement in one plane only. Examples of hinge joints are those of the elbow and the knee.

Pivot joints consist of a relatively cylindrical bony process that rotates within a ring composed partly of bone and partly of ligament. An example of pivot joint is the head of the radius articulating with the proximal end of the ulna.

Ball-and-socket joints consist of a ball (head) at the end of one bone and a socket into an adjacent bone into which a portion of the ball fits. These joints allow wide ranges of movement in almost any direction. Examples are the shoulder and the hip joints.

Ellipsoid joints are modified ball-and-socket joint where the articular surfaces are ellipsoid rather than spherical in shape. The shape of the joint limits the movement, making it similar to a hinge motion, but the motion occurs in two planes. The atlantooccipital joint is an ellipsoid joint.

Muscular system

The three primary functions of the muscular system are movement, postural maintenance, and heat production. As previously discussed, the major types of muscles are skeletal, cardiac, and smooth muscle. Skeletal muscle is far more common than other types of muscles in the body and is the focus of this section. Cardiac and smooth muscle are presented in an other part of this course.

Physiology of skeletal muscle

Muscle tissue consists of specialized contractile cells or muscle fibers. Skeletal muscle contracts in response to electrochemical stimuli. Nerve cells regulate the function of skeletal muscle fibres by controlling the series of events that result in muscle contraction.

Each skeletal muscle fiber is filled with thick and thin myofilaments, which are fine, threadlike structures. The thick myofilaments are formed from the protein myosin, and the thin myofilaments are composed of the protein actin. The sarcomere is the contractile unit of skeletal muscle, containing thick and thin myofilaments. During the contraction process, energy obtained from ATP molecules enables the two types of myofilaments to slide toward each other and shorten the sarcomere and eventually the entire muscle.

Neuromuscular junction

A nervous impulse enters the muscle fiber through a specialized nerve known as the motoneuron. The point of contact between the nerve ending and the muscle fiber is the neuromuscular junction or synapse. Each muscle fiber receives a branch of an axon, and each axon innervates more than a single muscle fiber. When a nerve impulse passes through this junction, specialized chemicals are released, causing the muscle to contract.

Skeletal muscle movement

Most muscles extend from one bone to another and cross at least one joint. Muscles contraction causes most body movement by pulling one of the bones toward the other across the moveable joint. The points of attachment of each muscle are the origin and insertion. The origin is the end of the muscle attached to the more stationary of the two bones. The insertion is the end of the muscle attached to the bone undergoing the greatest movement. Some muscles of the face are not attached to bone at both ends but attach to the skin, which moves when muscles contract.

The contraction of some muscles with the simultaneous relaxation of others produces movement. Muscle that work in cooperation with one other to cause movement are called synergist, and a muscle working in opposition to another muscle (moving the structure to an opposite direction) is called an antagonist. The muscle that is primarily responsible for a particular movement is called the prime mover. For example, the biceps brachii, brachialis, and triceps brachii muscles are all involved in flexion and extension of the forearm at the elbow joint. The biceps brachii is the prime mover during flexion, and the brachialis is the synergic muscle. When the biceps brachii and the brachialis muscles flex the forearm, the triceps brachii relaxes (antagonistic muscle). During extension of the forearm, the triceps brachii becomes the prime mover, and the biceps and the brachialis become the antagonisic muscles. The coordinated activity of synergists and antagonists is what makes muscular movement smooth and gracefull.

Types of muscle contraction.

Muscle contraction are classified as either isometric or isotonic, depending on the type of contraction that predominates. In isometric contractions, the length of the muscle does not change, but amount of tension increases during the contraction process. Isometric contractions are responsible for the constant length of the postural muscles of the body. During isotonic contractions, the amount of tension produced by the muscle is constant during contraction, but the length of the muscle changes. An example of isotonic contraction is the movement of the arms or fingers. Most muscle contractions are a combination of isotonic and isometric contractions.

Postural maintenance

Postural maintenance is a result of muscle tone, the constant tension produced by muscles of the body for long periods. This tone is responsible for keeping the back and the leg straight, the head in an upright position, and the abdomen from bulging. These positions balance the distribution of weight and therefore put less strain on muscles, tendons, ligaments and bones.

Heat production

The energy required to produce muscle contraction is obtained from ATP. Most of the energy released in the breakdown of ATP during a muscular contraction is used to shorten the muscle fibers, but some energy is lost as heat during the chemical reaction. The normal body temperature results in large part from this metabolism in skeletal muscle. If the body temperature declines below a certain level, the nervous system responds by inducing shivering. Shivering involves rapid contractions of skeletal muscles that produce shaking rather than coordinate movements. The muscle movement increases heat production up to 18 times that of resting levels. The heat produced during shivering can exceed that produced during moderate exercise, helping to raise the body temperature to its normal range

LESSON 1_04 THE NERVOUS AND ENDOCRINE SYSTEMS

The nervous system and the endocrine system are the major regulatory and coordinating systems of the body. The nervous rapidly transmits information by means of nerve impulses conducted from one body area to another. The endocrine systems transmits information more slowly by means of chemical secreted by ductless glands into the bloodstream. These chemicals and hormones are then circulated to other parts of the body. The constancy of the internal environment of the body (homeostasis) is maintained to a large degree by these regulatory and coordinating activities.

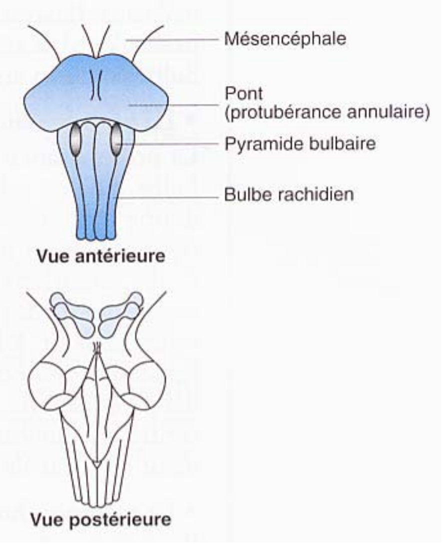
The human body has a single nervous system, even though some of its subdivisions are referred to as separate systems. Each subdivision has structural and functional features that separate it from the other subdivisions.

The central nervous system (CNS) consists of the brain and the spinal cord, which are encased in and protected by bone. The brain and the spinal cord are continuous with each other. The peripheral nervous system (PNS) consists of nerves and ganglia (collections of nerve cells bodies located outside the CNS). A total of 43 pairs of nerves originate from the CNS to form the PNS; 12 pairs, the cranial nerves, originate from the brain, and remaining 31 pairs, the spinal nerves, originate from the spinal cord. The afferent division transmits action potentials from the sensory organs to the CNS. The efferent division transmits action potentials from the CNS to effector organs such as muscles and glands. The efferent division is further divided into the somatic nervous system and the autonomic nervous system. The somatic nervous system transmits impulses from the CNS to skeletal muscle. The autonomic nervous system transmits action potentials from the CNS to the smooth muscle, cardiac muscle, and certain gland.

Central nervous system

The CNS consists of the brain and the spinal cord. The major regions of the adult brain are the brain stem (consisting of the medulla, pons, and midbrain), the diencephalons, the cerebrum, and the cerebellum.

Brain stem



The medulla, pons, and midbrain constitute the brain stem. The brain stem connects the spinal cord to the remainder of the brain and is responsible for many essential functions. All but 2 of the 12 cranial nerves enter or exit the brain through the brain stem.

The medulla, also known as the medulla oblongata, is the most inferior portion of the brain stem. It acts as a conduction pathway for both ascending and descending nerve tracts. Several body functions, such as regulation of the heart rate, blood vessel diameter, breathing, swallowing, vomiting, coughing, and sneezing, are controlled by the medulla.

The pons contains ascending and descending nerve tracts and relays information from the cerebrum to the cerebellum. In addition, the pons houses the sleep center and respiratory center that, along with the medulla, help control breathing.

The midbrain, or mesencephalon, is the smallest region of the brain stem. It is involved in hearing through audio pathways in the CNS and in visual reflexes such as visual tracking of moving objects and turning of the eyes. Other parts of the midbrain help regulate the automatic functions that require no conscious thought (e.g., coordination of motor activities, muscle tone).

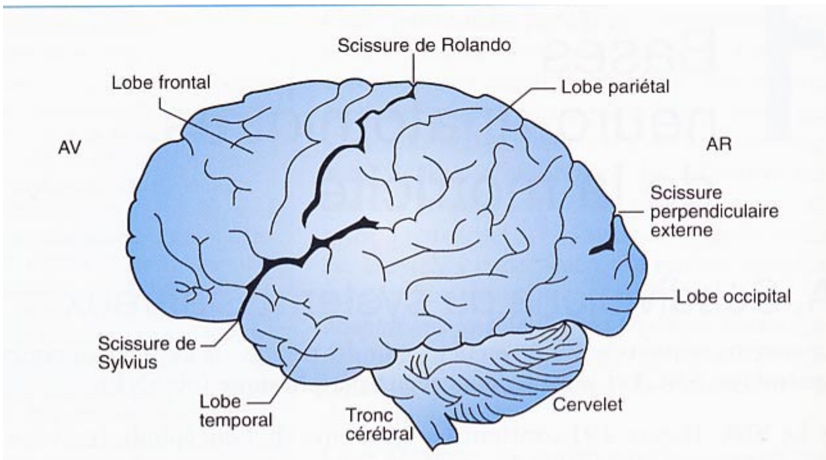
The reticular formation is a group of nuclei scattered throughout the brain stem that receives axons from a large number of sources, especially from the nerves that innervate the face. The reticular formation and its connections are known as the reticular activating system. This system is involved in the sleep-wake cycle and is important in arousing and maintaining consciousness. Coma after head injury results from damage to the reticular activating system.

Diencephalon

The diencephalon is the part of the brain between the brain stem and the cerebrum. Major components of this organ include the thalamus and hypothalamus. The thalamus is the largest portion of the diencephalon. The thalamus receives sensory input from various sense organs of the body and relay these impulses to the cerebral cortex. The thalamus also has other functions, such as influencing mood and general body movements associated with strong emotions such as fear or rage.

The hypothalamus is a major controller in the brain. It serves as a “gatekeeper” to determine what information is passed along to the cerebrum and is an active participant in emotions, hormonal cycles, and sexuality.

Cerebrum



The cerebrum is the largest portion of the brain. It is divided into left and right hemispheres, and each cerebral hemisphere is divided into lobes named for the bones that lie over them.

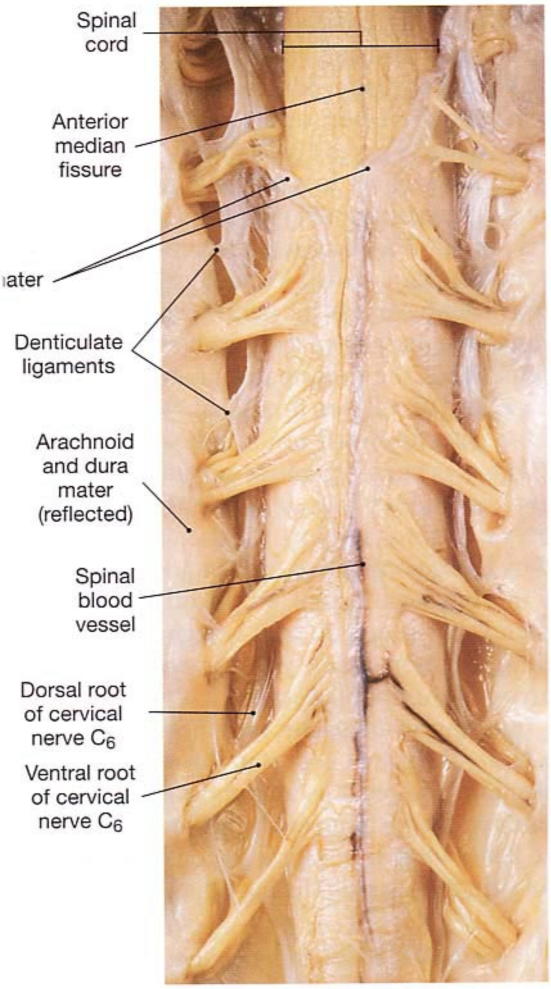
The frontal lobe is important in voluntary motor function, motivation, aggression, and mood. The parietal lobe is the major center for the reception and evaluation of most sensory information (excluding smell, hearing, and vision). The occipital lobe functions in the reception and the integration of visual input and is not distinctly separate from other lobes. The temporal lobe receives and evaluate olfactory and auditory input and plays an important role in memory. A thin layer of gray matter made up of neuron dendrites and cells body composes the surface of the cerebrum (cerebral cortex).

The limbic system consists of portions of the cerebrum and diencephalon. It influences emotions, mood, and sensations of pain and pleasure.

Cerebellum

The cerebellum is the second largest part of the human brain. It is involved in gross motor coordination, and the production of smooth, flowing movements. A major function of the cerebellum is to compare impulses from the motor cortex with those from the moving structure (e.g., position of the body or body parts that innervate the joints and tendons of the structure being moved). The cerebellum compares the intended movement with the actual movement. If a difference is detected, the cerebellum sends impulses to the motor cortex and the spinal cord to correct the discrepancy. Loss of cerebellum functioning results in an inability to make precise movements.

Spinal cord



The spinal cord lies within the spinal column and extends from the occipital bone to the level of the second lumbar vertebrae. The spinal cord has a central gray portion and a peripheral white portion. The white matter consists of nerve tracts, and the gray matter consists of nerve cells body and dendrites. The dorsal root conveys afferent nerve processes to the cord, and the ventral root conveys efferent nerve processes away from the cord. Spinal ganglia, or dorsal root ganglia, contain the cell bodies of sensory neurons.

The spinal cord is the primary reflex center of the body. Many of these reflexes are autonomic or visceral (e.g., increased heart rate in response to decreased blood pressure). Other reflexes include the stretch reflex ("knee-jerk reflex) and withdrawal reflexes (removing a limb or other body part from a painful stimulus). In addition to functioning as a primary reflex center, the spinal cord tracts carry impulses to the brain in afferent, ascending tracts, and they carry motor impulses from the brain in efferent, descending tracts.

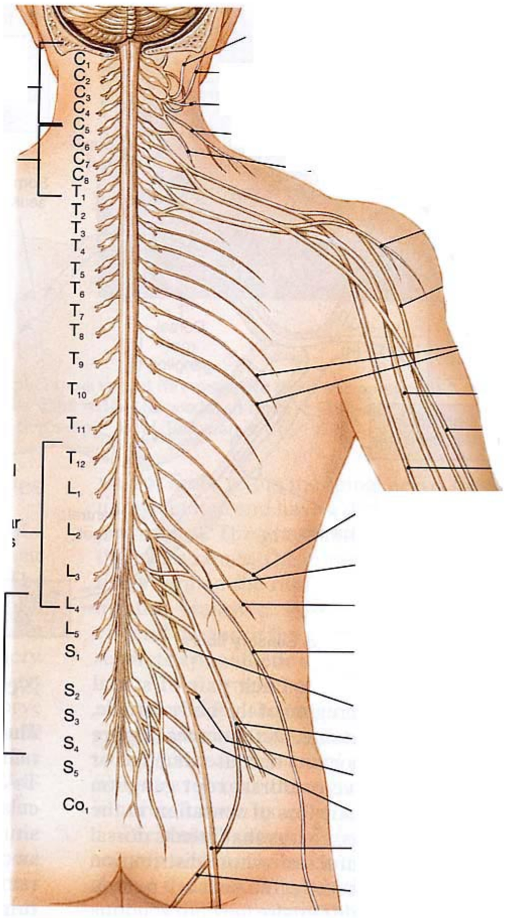
The organs of the nervous system are surrounded by a tough, fluid-containing membrane known as the meninges. The meninges are surrounded by bone and have three connective tissue layers. The most superficial and thickest layer is the dura matter, consisting of two layers around the brain and one around the spinal cord. The two layers of the dura matter are fused around most of the brain but are separate in several places. The dura matter of the brain is tightly attached and continuous with the periosteum of the cranial vault, whereas the dura matter of the spinal cord is separated from the periosteum of the vertebral canal by the epidural space. The arachnoid layer is the second meningeal layer. The space between this layer and the dura matter is known as the subdural space, which contains a small amount of serous fluid. The third meningeal layer is the pia matter. It lies external to a basement membrane formed by special cells called the glia limitans, which completely envelops the CNS. The space between the pia matter and the arachnoid layer is the subarachnoid space. This space is field with blood vessel and cerebrospinal fluid (CSF).

The CSF is similar to plasma and interstitial fluid (fluid that occupies the space outside the blood vessels). It serves to bath the brain and spinal cord and act as a protective cushion around the CNS. Cerebrospinal fluid is formed continually from fluid filtering out of the blood in a network of brain capillaries and cells known collectively as the choroid plexus. This special fluid fills the ventricles of the brain, the subarachnoid space, and the central canal of the spinal cord.

Peripheral nervous system

The PNS collects information from numerous sources,, both inside the body and on the body surface. This information is relayed by way of afferent fibers to the CNS, where it is evaluated. Efferent fibers in the PNS relay information from the CNS to various parts of the body, primarily to muscles and glands.

Spinal nerves



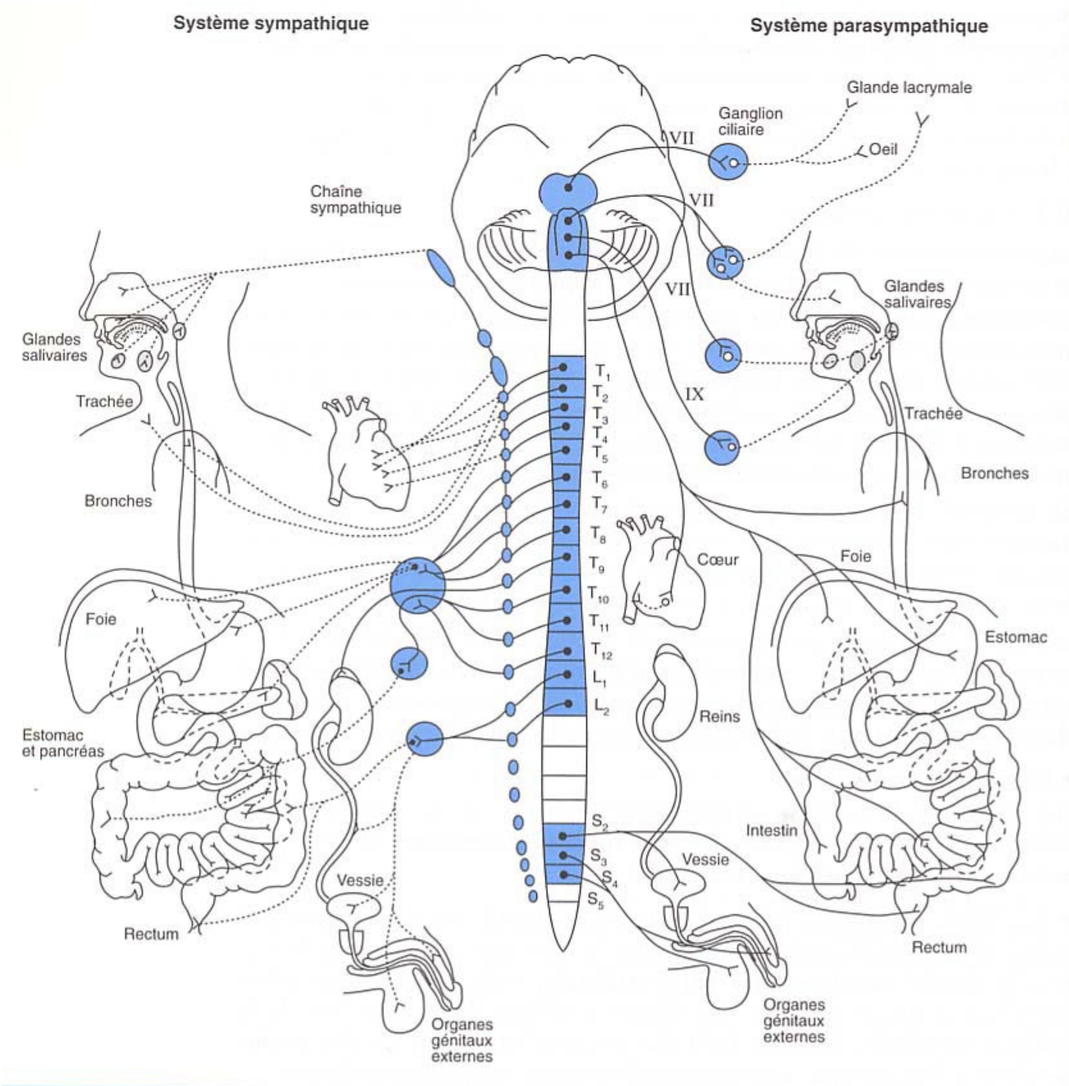
The spinal nerves arise from numerous rootlets along the dorsal and ventral surfaces of the spinal cord. All of the 31 pairs of spinal nerves, except the first pair of spinal nerves and the nerves in the sacrum exit the ventral column through adjacent vertebrae. The first pair of spinal nerves exit between the skull and the first cervical vertebrae. The spinal nerves in the sacrum exit through the bone. A total of 8 spinal nerve pairs exit the vertebral column in the cervical region, 12 in the thoracic region, 5 in the lumbar region, 5 in the sacral region, and 1 in the coccygeal region.

Each spinal nerve except C1 has a specific cutaneous sensory distribution. Detailed mapping of the skin surface reveals a close relationship between the source on the cord of each spinal nerve and the level of the body that it innervates. (An understanding of this relationship is important when examining a patient with a spinal cord injury). The skin surface areas supplied by a single spinal nerve are known as dermatomes.

Cranial nerves

The 12 cranial nerves are divided into three categories: sensory, somatomotor and proprioception, and parasympathetic. Sensory functions include the special senses such as vision, and the more general senses such as touch and pain. Somatomotor functions control the skeletal muscle through motor neurons, and proprioception provides the brain with information about the position of the body and its various parts, including joints and muscles. Parasympathetic function involves the regulation of glands, smooth muscle, and cardiac muscle (functions of the autonomic nervous system). Some cranial nerves have only one of the three functions, whereas other have more than one.

Autonomic nervous system



As previously stated, the PNS is composed of afferent and efferent neurons. Afferent neurons carry action potentials from the periphery to the CNS, and efferent neurons carry action potential from the CNS to the periphery. Afferent neurons provide information to the CNS that may stimulate both somatomotor and autonomic reflexes. Therefore they cannot be easily divided into functional groups. In contrast, efferent neurons differ structurally and functionally. They can be clearly separated into either the somatomotor nervous system or the autonomic system.

Somatomotor neurons innervate skeletal muscles and play important role in locomotion, posture, and equilibration. The movement controlled by the somatomotor nervous system usually are considered to be conscious movements. Their effect on skeletal muscle is always excitatory. Neurons of the autonomic nervous system innervate smooth muscles, cardiac muscle, and glands and usually are unconsciously controlled. The effect of autonomic neurons on their target tissue is either inhibitory or excitatory.

The autonomic nervous system is composed of sympathetic and parasympathetic divisions. Both of these divisions, in turn, consist of autonomic ganglia and nerves. The action potential in sympathetic neurons generally prepare an individual for physical activity, whereas parasympathetic stimulations activates vegetative functions such as digestion, defecation, and urination.

The functions of the autonomic nervous system serve to maintain or quickly restore homeostasis. Many internal organs receive fibers from sympathetic and parasympathetic divisions. Therefore sympathetic and parasympathetic impulses continually bombard them, influencing their function in opposite or antagonistic ways. For example, the heart receives sympathetic impulses that increase the heart rate and parasympathetic impulses that decrease the heart rate. The ratio between these two forces determines the actual heart rate.

Endocrine system

The endocrine system is composed of glands that secrete hormones into the circulatory system. The endocrine and nervous system have significant amount of functional and anatomical overlap. Some neurons secrete regulatory chemicals (neurohormones) that function as hormones, such as antidiuretic hormone (ADH), into the circulatory system. Other neurons innervate endocrine glands and influence their secretory activity. Conversely, some hormones secreted by the endocrine glands affect the nervous system.

LESSON 1_05 THE CIRCULATORY SYSTEM

Blood vessels extend throughout the body, carrying blood to and from all tissues. Blood transports nutrients and oxygen to tissues, carries carbon dioxide and waste products away from tissues, and carries hormones produced in the endocrine glands to their target tissues. In addition, blood plays an important role in temperature regulation and fluid balance and protects the body from bacteria and foreign substances. These and other functions of blood help to maintain homeostasis.

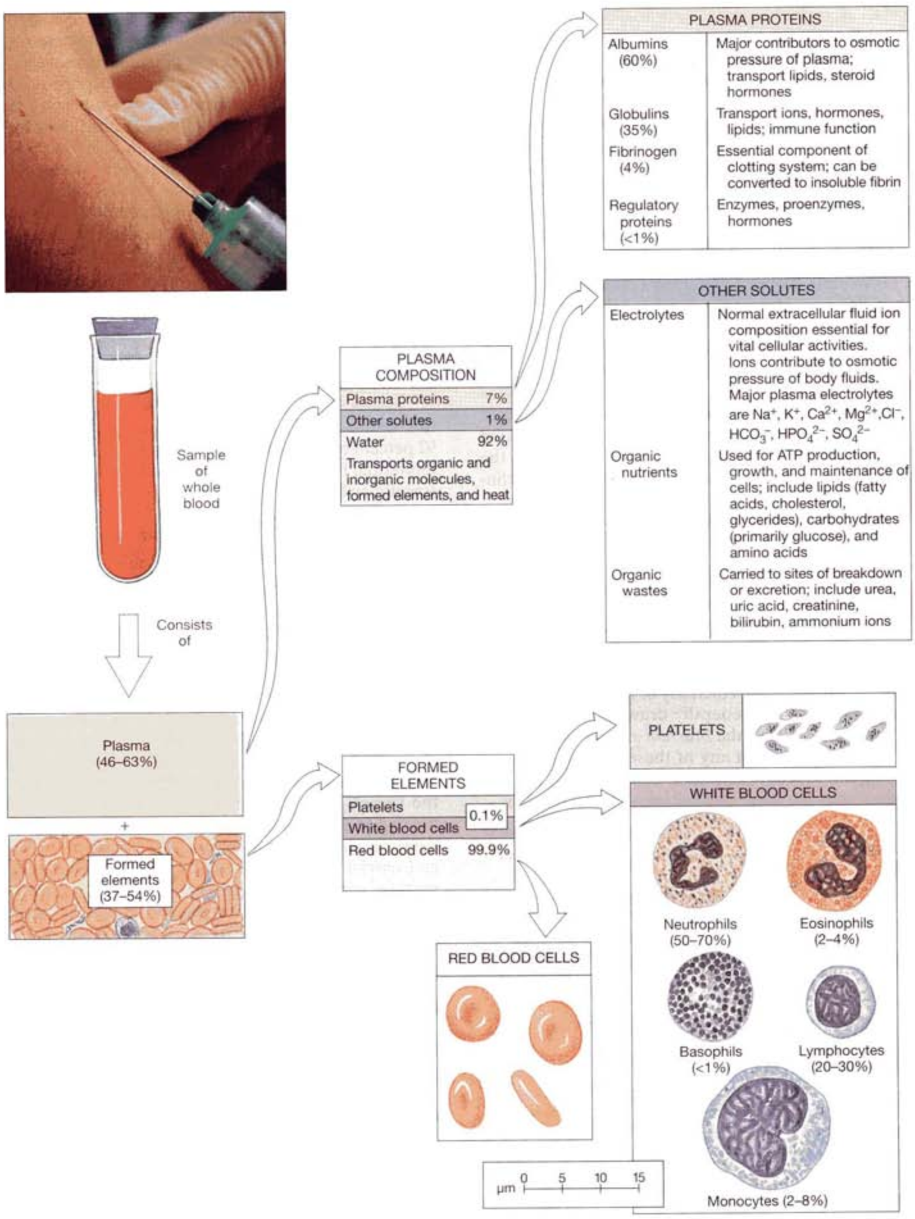
Blood Components

Blood is a special form of connective tissue consisting of cells and cell fragments (formed elements) surrounded by a liquid intercellular matrix (plasma). About 95% of the volume of formed elements consists of RBCs (erythrocytes). The remaining 5% consists of white blood cells (leukocytes) and cell fragments called platelets.

Plasma

Plasma is a pale yellow fluid composed of about 92% water and 8% dissolved or suspended molecules. Plasma contains proteins such as albumin, globulins, and fibrinogen. When the proteins that produce clots are removed from the plasma, the remaining fluid is called serum.

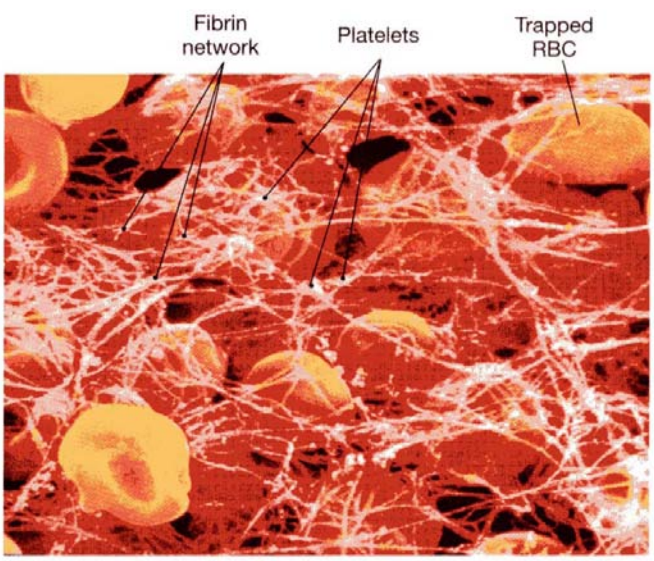
Formed elements. Three formed elements of blood are erythrocytes, leukocytes, and platelets, or thrombocytes (cell fragments) (Table 6-10). Formed elements are produced in the embryo and foetus and in tissues such as the liver, thymus,



spleen, lymph nodes, and red bone marrow.

Erythrocytes are the most numerous of the formed elements. There are about 5.2 million erythrocytes in one drop of male blood and about 4.5 million in one drop of female blood. The major erythrocyte contents include lipids, ATP, and the enzyme carbonic anhydrase. The main component of erythrocytes is hemoglobin, the protein that gives blood its red color. The primary functions of erythrocytes are to transport oxygen from the lungs to the various tissues of the body and to transport carbon dioxide from the tissues to the lungs. Under normal conditions, about 2.5 million erythrocytes are destroyed and replaced by the body each second. The average erythrocyte circulates for 120 days.

Leukocytes are clear white blood cells that do not contain hemoglobin. The several types of leukocytes are all are involved in protecting the body against invading microorganisms and removing dead cells and debris. Some leukocytes are classified according to their appearance, based on the presence or absence of cytoplasmic granules. Classifications include neutrophils, eosinophils, and basophils. Other types of leukocytes are nongranular and are named according to nuclear morphology and major site of proliferation. These include lymphocytes and monocytes. **Neutrophils** are the most common type of leukocyte in the blood. These cells normally remain in the circulation for 10 to 12 hours, after which they move into tissue to seek out and destroy bacteria and other foreign matter (phagocytosis). They also secrete lysosomes that can destroy certain bacteria. Neutrophils usually survive for 1 to 2 days after leaving the circulation. **Eosinophils** leave the circulation to enter the tissues during an inflammatory reaction. Their numbers usually are elevated in the blood of people who have allergies and certain parasitic infections. Although these cells have phagocytic properties, they are not thought to be as important in this function as neutrophils. **Basophils** are the least common of all leukocytes. Like eosinophils, basophils leave the circulation and migrate through tissues to play a role in allergic and inflammatory reactions. They also release heparin, which inhibits blood clotting. **Lymphocytes** are the smallest of all leukocytes and are capable of migrating through the cytoplasm of other cells. The many different types of lymphocytes play a major role in immunity, including antibody production. Lymphocytes originate in bone marrow and are most abundant in lymphoid tissues: the lymph nodes, spleen, tonsils, lymph nodules, and thymus. **Monocytes** are the largest of the leukocytes. They remain in the circulation for about 3 days before transforming into macrophages, large "eating" cells that migrate through various tissues. An increase in the number of monocytes is common in patients with chronic infections

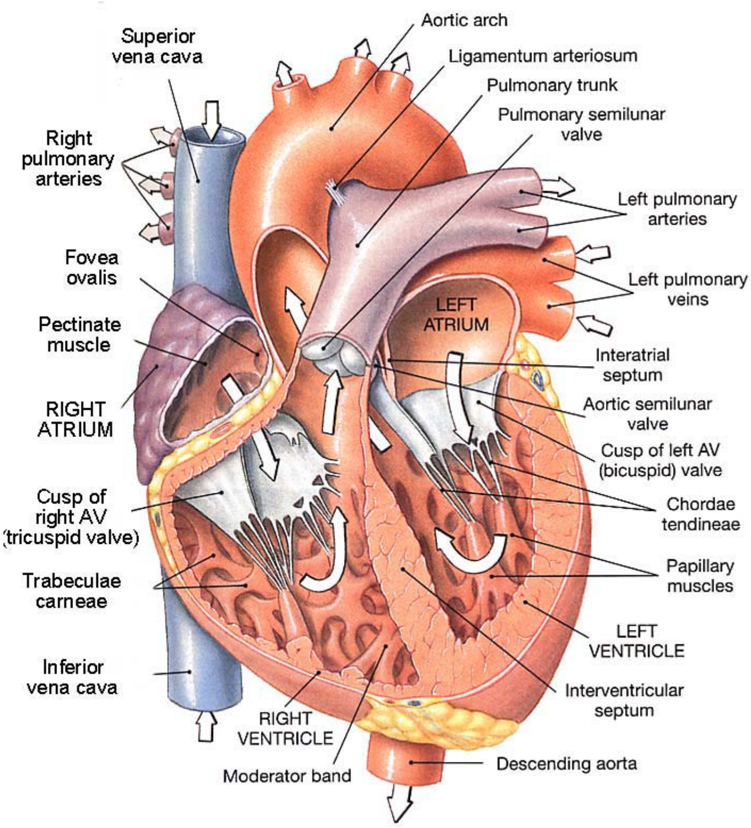


Platelets are produced within bone marrow and are 40 times as common in blood as leukocytes. Platelets play an important role in preventing blood loss by forming "plugs" that seal holes in small vessels and by forming clots that seal off larger wounds in the vessels.

Cardiovascular System

The heart and cardiovascular system are responsible for circulating blood throughout the body.

Anatomy of the heart



The heart is a muscular pump consisting of four chambers: two atria and two ventricles. The adult heart is shaped like a blunt cone and is about the size of a closed fist. It is located in the mediastinum of the thoracic cavity in the pericardial cavity. The blunt, rounded point of the heart is apex, and the larger, flat portion at the opposite end is the base.

The heart lies obliquely in the mediastinum, with the base directed posteriorly and slightly superiorly The apex is directed anteriorly and slightly inferiorly. Two thirds of the heart's mass lies to the of the midline of the sternum.

Pericardium. The pericardium, or the pericardial sac, has a fibrous outer layer (fibrous pericardia and a thin inner layer (serous pericardium) that, rounds the heart. The portion of the serous pericardium that lines the fibrous pericardium is parietal pericardium; the portion that covers heart surface is the visceral pericardium or the epicardium. The cavity between the parietal pericardium and the visceral pericardium normally contains a small amount of pericardial fluid i reduces friction as the heart moves within the pericardial sac.

Coronary vessels. Seven large veins normally carry blood to the heart: four pulmonary veins carry blood from the lungs to the left atrium, the superior and inferior venae cavae carry blood from the body to the right atrium, and the coronary sinus carries blood from the walls of the heart to the right atrium. Two arteries, the aorta and pulmonary trunk, exit the heart. The aorta carries blood from the left ventricle to the body, and the pulmonary trunk carries blood from the right ventricle to the lungs. The right and left coronary arteries exit the aorta near the point where the aorta leaves the heart and supply the heart muscle with oxygen and nutrients.

Heart chambers and valves. The right and left chambers of the heart are separated by a septum. The *interatrial* septum separates the right and left atria, and the *interventricular* septum separates the two ventricles. The atria open into the ventricles through the *atrioventricular* canals. An atrioventricular valve on each atrioventricular canal is composed of cusps or flaps. These valves allow blood to flow from the atria into the ventricles but prevent blood from flowing back into the atria. The atrioventricular valve between the right atrium and right ventricle has three cusps and is called the tricuspid valve. The atrioventricular valve between the left atrium and left ventricle has two cusps and is called the bicuspid, or mitral, valve.

The aorta and pulmonary trunk possess aortic and pulmonary semi lunar valves, which meet in the center of the artery to block blood flow. Blood flowing out of the ventricles pushes against each valve, forcing it open, but when blood flows back from the aorta or pulmonary trunk toward the ventricles, the valves close.

Conduction system of the heart

The heart's specialized muscle tissue has the unique capability for spontaneous, rhythmic self-excitation by way of four specialized structures embedded in the wall of the heart. These structures are the sinoatrial node (SA node), the atrioventricular node (AV node), the bundle of His, and the Purkinje fibers.

An impulse conduction normally begins in the SA node. From there it spreads in all directions through both of the atria, causing an atrial contraction. As the electrical impulses reach the AV node, they are relayed to the ventricles through the bundle of His and the Purkinje fibers. This impulse conduction causes both of the ventricles to contract shortly after the atrial contraction.

Route of blood flow through the heart

This text presents blood flow through the heart with a discussion of right heart and left heart circulation. It is important to remember that both atria contract at the same time, followed shortly thereafter by essentially simultaneous contraction of both ventricles, to clearly understand electrical impulses of the heart, pressure changes, and heart sounds.

Blood enters the right atrium from the systemic circulation via the inferior and superior venae cavae and from the heart via the coronary sinus. Most of this blood passes into the right ventricle as the ventricle relaxes after the previous contraction. When the right atrium contracts, the blood remaining in the atrium is pushed into the ventricle. The contraction of the right ventricle pushes blood against the tricuspid valve, forcing it closed, and against the pulmonary semilunar valve, forcing it open. This flow allows blood to enter the pulmonary trunk. The pulmonary trunk divides into left and right pulmonary arteries that carry blood to the lungs, where carbon dioxide is released and oxygen is picked up.

Blood returning from the lungs enters the left atrium through four pulmonary veins. The blood passing from the left atrium to the relaxed left ventricle opens the bicuspid valve. The contraction of the left atrium completes the filling of the left ventricle. Contraction of the left ventricle pushes blood against the bicuspid valve, closing it. The pressure of the blood against the aortic semilunar valve causes it to open, allowing blood to enter the aorta. Blood flowing through the aorta is distributed to all parts of the body except for the pulmonary vessels in the lungs.

Peripheral Circulation

Blood is pumped from the ventricles of the heart into large elastic arteries, which branch repeatedly to form many progressively smaller arteries. As these vessels become smaller, the amount of elastic tissue in the arterial wall decreases, and the amount of smooth muscle increases. Blood flows from the arterioles into capillaries and from capillaries into the venous system. Compared with artery walls, vein walls are thinner and contain less elastic tissue and fewer smooth muscle cells. As veins approach the heart, the walls increase in diameter and thickness.

Capillary network

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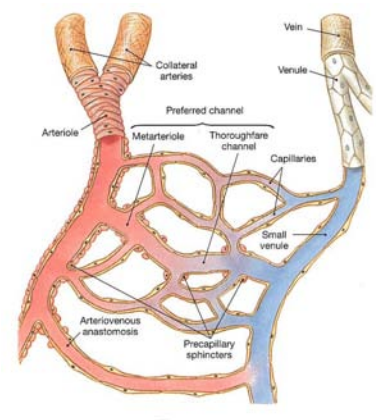
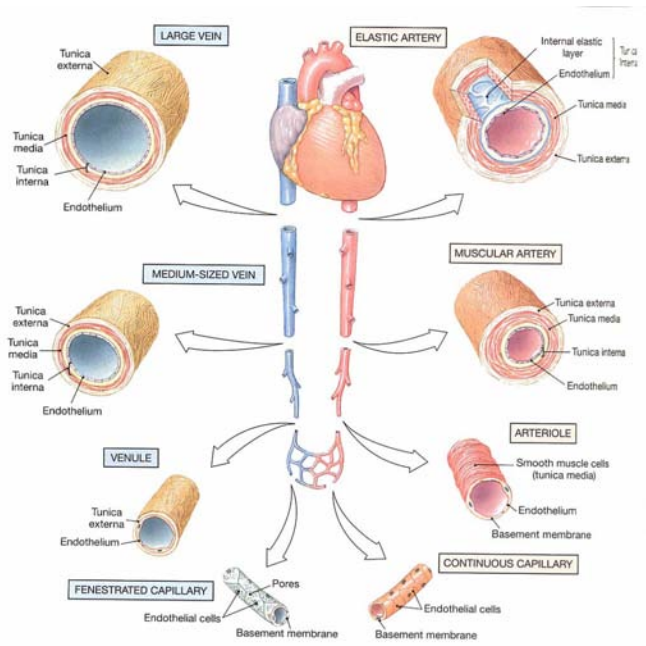


Arterioles supply blood to each capillary network. Blood flows through this network and into the venules. The ends of the capillaries closest to arterioles are arterial capillaries; the ends closest to venules are venous capillaries.

Blood flow through arterioles may continue through metarterioles and into a thoroughfare channel to a venule in relatively constant way, or it may enter the capillary circulation. Flow in the capillaries is regulated by smooth muscle cells known as precapillary sphincters. Nutrient and product waste exchange is the major function of capillaries.

Arteries and veins



With the exception of capillaries and venules, blood vessel walls are composed of three distinct layers (tunics) of elastic tissue and smooth muscle: the tunica intima (inner layer), the tunica media (middle layer), and the tunica adventitia (outer layer). The thickness and composition of each layer vary with the type and diameter of the blood vessel.

Large elastic arteries are often called conducting arteries because they are the arteries largest in diameter. These vessels have more elastic tissue and less smooth muscle than other arteries. Medium-sized and small arteries have relatively thick muscular walls and well-developed elastic membranes. These vessels are called distributing arteries because the smooth muscle allows these vessels to partially regulate blood supply to various body regions by constriction or dilation. Arterioles are the smallest arteries in which the three tunics can be identified. Like small arteries, arterioles are capable of vasodilatation and vasoconstriction.

Venules have only a few isolated smooth muscle cells and are very similar in structure to the capillaries. Venules collect blood from the capillaries and transport it to small veins, which in turn transport the blood to the medium-sized veins. Nutrient exchange occurs across the walls of the venules, but as the small veins increase in thickness, the degree of nutrient exchange decreases.

As venules increase in diameter, the vessels become veins, whose walls are a continuous layer of smooth muscle cells. Medium-sized and large veins collect blood from small veins and deliver it to the large venous trunks. Large veins transport blood from the medium-sized veins to the heart.

Veins with large diameters have valves that allow blood to flow to but not from the heart. There are many valves in medium-sized veins, and more valves in the veins of the lower extremities than of the upper extremities. They help prevent the backflow of blood, especially in dependent tissues.

Arteriovenous anastomoses (AV shunts) allow blood to flow from arteries to veins without passing through capillaries. Natural AV shunts occur in large numbers in the sole of the foot, palm, and nail bed, where they regulate body temperature. Pathological shunts can result from injury or tumors and cause a direct flow of blood from arteries to veins. Severe shunts may lead to "high output" heart failure from increased venous return to the heart and its resultant demand on cardiac output.

Pulmonary Circulation

Blood from the right ventricle is pumped into the pulmonary trunk, which bifurcates into the right and left pulmonary arteries (which transport blood to the respective lungs). After the exchange of oxygen and carbon dioxide, two pulmonary veins exit each lung and enter the left atrium.

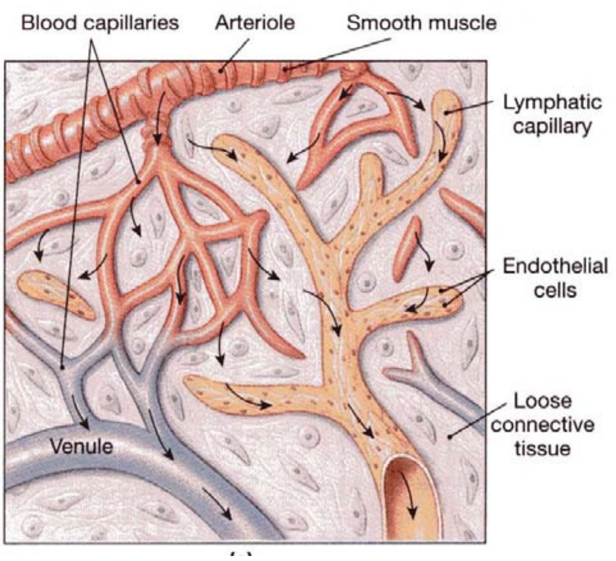
Systemic Circulation

Oxygenated blood enters the heart from the pulmonary veins, passing through the left atrium into the left ventricle and from the left ventricle into the aorta. From the aorta, blood is distributed to all parts of the body The arteries of systemic circulation include the aorta, coronary arteries, arteries of the head and neck, arteries of the upper and lower limbs, the thoracic aorta and its branches, the abdominal aorta and its branches, and arteries of the pelvis.

The veins of systemic circulation include coronary veins, veins of the head and neck, veins of the upper and lower limbs, veins of the thorax, veins of the abdomen and pelvis, and the hepatic portal system, which transports blood from the digestive tract to the liver.

Lymphatic System

The lymphatic system is considered part of the circulatory system because it consists of a movingfluid that comes from the body and returns to the blood. Unlike the circulatory system, the lymphatic system only carries fluid away from the tissues.



The lymphatic system includes lymph, lymphocytes, lymph nodes, tonsils, spleen, and the thymus gland. The three basic functions of the lymphatic system are to help maintain fluid balance in tissues, absorb fats and other substances from the digestive tract, and play a role in the body's immune defense system.

The lymphatic system begins in the tissues as lymph capillaries. Lymph capillaries differ structurally from blood capillaries in that lymph capillaries have a series of one-way valves that allow fluid to enter the capillary but prevent fluid from passing back into the interstitial spaces. Lymph capillaries are present in almost all tissues of the body with the exception of the CNS bone marrow, an(tissues without blood vessels (e.g., cartilage, epidermis, cornea). Lymph capillaries join to form large lymph capillaries that resemble small veins.

Lymph nodes are distributed along various lymph vessels, and most lymph passes through at least one node before entering the blood. Passing through the node filters the lymph; removing microorganisms and foreign substances to prevent them from entering the general circulation. Three major collections of lymph nodes are located on each side of the body: inguinal nodes, axillary nodes, and cervical nodes. If a part of the body is inflamed or otherwise diseased, the nearby lymph nodes become swollen and tender as they limit the spread of microorganisms and foreign substances.

After passing through lymph nodes, lymph vessels converge toward either the right or left subclavian vein. Vessels from the upper right limb and the right side of the head enter the right lymphatic duct. Lymph vessels from the rest of the body enter the larger thoracic duct. The right lymphatic duct drains the right thorax, right upper limb, and right side of the head and neck and opens into the right subclavian vein. The thoracic duct drains the left thorax, the left upper extremity, and the left side of the head and neck. The duct ends by entering the left subclavian vein. Thus all fluid drained from the tissue spaces eventually returns to the venous circulation.

LESSON 1_06 THE RESPIRATORY SYSTEM

Oxygen is an essential requirement for normal cell metabolism, from which carbon dioxide is a major waste product. The organs of the respiratory system and the cardiovascular system transport oxygen to individual cells and transport carbon dioxide from individual cells to the lungs, where it is released into the air.

The respiratory system is a very complex component of the human body. The purpose of this section is to familiarize the reader with respiratory anatomy

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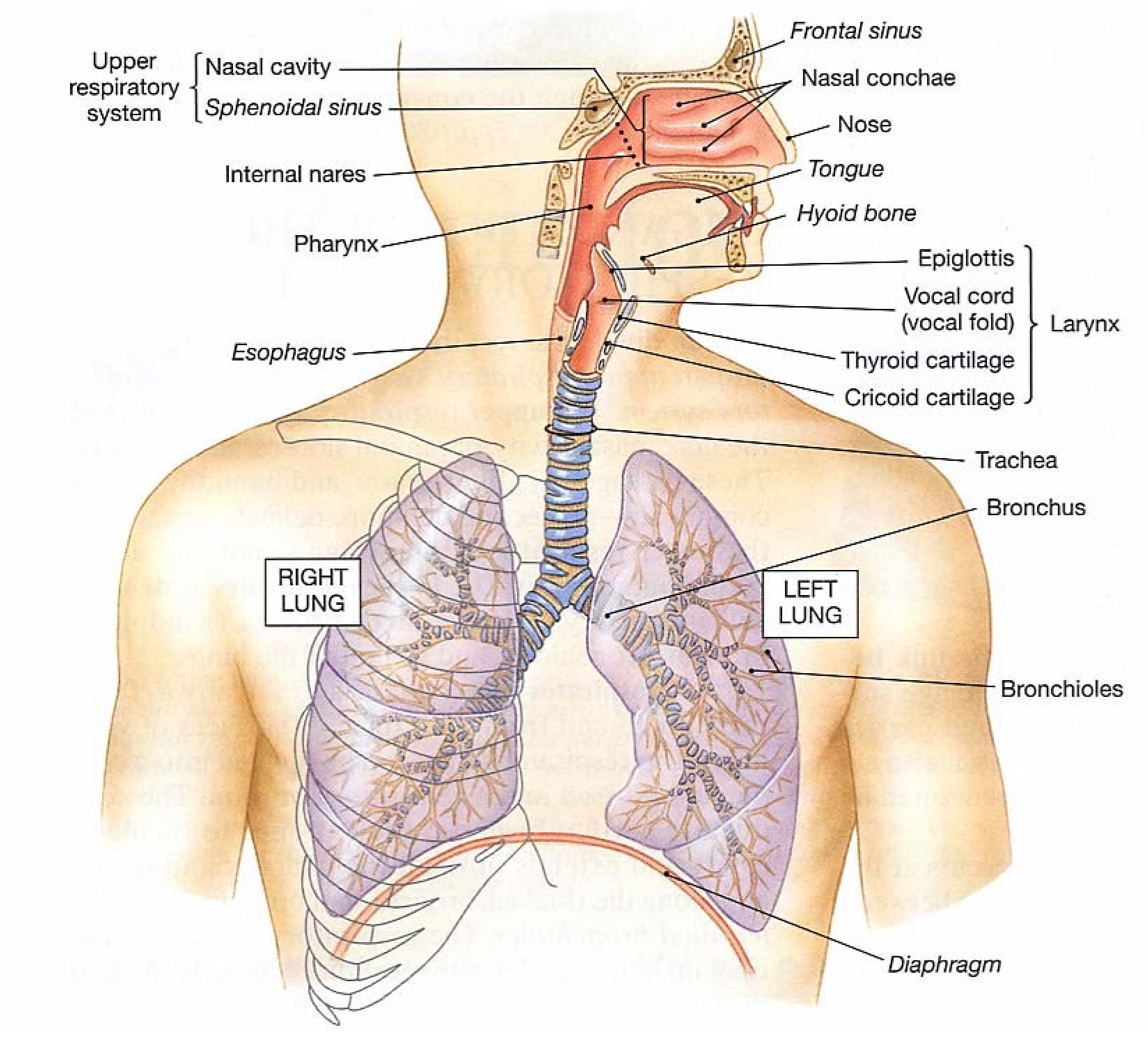


Airway Anatomy

The structures of the respiratory system are divided into upper airway and lower airway by their locations relative to the glottic opening (the vocal cords and the space between them). For the purpose of this discussion, all airway structures located above the glottis are considered to be upper airway, and all structures located below the glottis are considered to be lower airway .

Upper airway structures

The entrance to the respiratory tract begins with the nasal cavity and includes the nasopharynx, oropharynx, laryngopharynx, and larynx.

NASOPHARYNX.

Air passes into the nasal cavity through the nostrils or *nares*. The right and left nasal cavities are separated by the nasal septum, a bony partition covered with a mucous membrane. This membrane has a rich blood supply that warms and humidifies the nasal lining and the inspired air as it passes through the nose. Inside each nostril, a slight enlargement known as the vestibule is lined with coarse hairs that trap foreign substances carried into the nasal cavity by inspired air. The floor of the nasal cavity is composed of the hard palate; the lateral walls are formed by bony ridges coated with respiratory mucosa. These ridges are known as conchae, or turbinates.

Two patches of yellow-grey tissue lie just beneath the bridge of the nose and compose the olfactory membranes. Located in the roof of the nasal cavity, these membranes contain the receptors for the sense of smell. The nasal cavities also connect to the middle-ear cavities through the auditory (or eustachian) tubes.

Sinuses are cavities in the bones of the skull that connect to the nasal cavities by small channels. Four groups of sinuses, each named for the skull bone in which it lies, are: the frontal sinuses, above the eyebrows; maxillary sinuses (the largest sinuses), in the cheekbones; ethmoid sinuses, just behind the bridge of the nose; and sphenoid sinuses, in a bone that cradles the brain, slightly anterior to the pituitary gland. These hollow chambers are lined with mucous membranes that secrete mucus into the nasal cavities. They are thought to aid in adding resonance to the voice and decreasing the weight of the skull.

The back of each nasal cavity opens into the nasopharynx, the superior part of the pharynx, which extends from the internal nares to the level of the uvula. Like the nasal cavity, the nasopharynx is lined with mucous membrane.

OROPHARYNX.

At the level of the uvula, the nasopharynx ends and the oropharynx begins, extending downward to the level of the epiglottis. Anteriorly the oropharynx opens into the oral cavity, which contains the lips, cheeks, teeth, tongue (which is at tached to the mandible), hard and soft palates, and palatine tonsils. The palatine tonsils and the pharyngeal tonsils (located in the roof and posterior wall of the nasopharynx) form a partial ring of lymphoid tissue surrounding the respiratory tract. This ring is completed by the lingual tonsils, which lie on the floor of the oropharyngeal passageway at the base of the tongue.

LARYNGOPHARYNX.

The laryngopharynx extends from the tip of the epiglottis to the glottis and the oesophagus. The laryngopharynx is lined with mucous membrane that protects internal surfaces from abrasion.

LARYNX.

The laryngopharynx opens into the larynx, which lies in the anterior neck. The larynx serves three main functions: it is the air passageway between the pharynx and the lungs, it is a protective sphincter to prevent solids and liquids from passing into the respiratory tree, and it is involved in producing speech.

The larynx consists of an outer casing of nine cartilages connected to each other by muscles and ligaments. Six of the nine cartilages are paired; three are unpaired. The largest, most superior of the cartilages is the unpaired thyroid cartilage, or Adam's apple. This prominence is hardly visible in children or adult females but is marked in males after puberty.

The most inferior cartilage of the larynx is the unpaired cricoid cartilage (the only complete cartilaginous ring in the larynx). This cartilage forms the base of the larynx on which all other cartilages rest. The third unpaired cartilage is the epiglottis.

The six paired cartilages are stacked in two pillars between the cricoid cartilage and the thyroid cartilage. The largest inferior cartilages are ladle shaped and are known as the arytenoids cartilages. The middle pair are horn shaped and are known as corniculate cartilages. The smallest, most superior cartilages are wedge shaped and are known as cuneiform cartilages.

The U-shaped hyoid bone is tucked beneath the mandible. As previously mentioned, it is the only bone of the human body that does not articulate with another bone. The hyoid bone helps to suspend the airway by anchoring the muscles (particularly those of the tongue) to the jaw. The fibrous membrane that joins the hyoid and the thyroid cartilage is called the thyroid membrane. The membrane joining the thyroid and cricoid cartilages is called the cricothyroid membrane.

Two pairs of ligaments extend from the anterior surface of the arytenoid to the posterior surface of the thyroid cartilage. The superior pair forms the vestibular folds, or false vocal cords, which are not directly involved in the production of voice sounds. The inferior pair of ligaments composes the vocal cords, or true vocal cords, which participate directly in producing voice sounds. In talking, air expelled from the lungs rushes up the throat to the larynx. There the air creates sound by vibrating the vocal cords. Muscles tighten the folds of the cords to produce the high-pitched tones and relax the cords to produce the deeper tones. The lip, tongue, and jaw further modify the sounds into intelligible words.

Lower airway structures

Below the glottis are the structures of the lower airway and lungs. These structures include the trachea, the bronchial tree (primary bronchi, secondary bronchi, and bronchioles), the alveoli, and the lungs.

TRACHEA.

The trachea is the air passage from the larynx to the lungs. It is composed of dense connective tissue and smooth muscle reinforced with 15 to 20 C-shaped pieces of cartilage that form an incomplete ring. This ring protects the trachea and maintains an open passage for air. The adult trachea is about 1.5 centimetres (cm) in diameter and 9 to 15 cm in length. The trachea is located anterior to the oesophagus and extends from the larynx to the fifth thoracic vertebrae.

The trachea is lined with ciliated epithelium that contains many goblet cells. These cilia protect the lower airway by sweeping mucus, bacteria, and other small particles toward the larynx. There they may be expelled through coughing or enter the oesophagus, where they are swallowed and digested. Constant exposure to some irritants (e.g., cigarette smoke) may produce a tracheal epithelium that lacks cilia and goblet cells. When this protective mechanism is disrupted, the mucus and bacteria may contribute to disease.

BRONCHIAL TREE.

The lower airway may be thought of as an inverted tree; the many subdivisions become narrower and shorter until they terminate at the alveoli. The large branches are primary bronchi; they divide into smaller secondary bronchi and bronchioles.

The trachea divides into the right and left primary bronchi at the level of the angle of Louis (the sterno-manubrial joint). The point of bifurcation of the trachea into the right and left mainstem bronchi is called the carina. The right primary bronchus is shorter, wider, and more vertical. Like the trachea, the primary bronchi are lined with ciliated epithelium and are supported by C-shaped cartilage rings. As the bronchi sequentially branch into smaller subdivisions, the amount of cartilage decreases and the bronchi become increasingly muscular until there is no cartilage. The primary bronchi extend from the mediastinum to the lungs.

The primary bronchi divide into the secondary bronchi as they enter the right and left lungs. Two secondary lobar bronchi in the left lung conduct air to its two lobes; three in the right lung conduct air to its three lobes. From there, the secondary bronchi divide into the tertiary segmental bronchi, of which there are 10 in the right lung and 9 in the left. The tertiary bronchi extend to the individual segments of each

LOBE OF THE LUNG (LOBULE).

The bronchial tree continues to branch several times. As the cartilage continues to decrease and the diameter is reduced to about 1 millimetre (mm), the bronchi become bronchioles.

The bronchiole walls are devoid of cartilage, and their muscles are sensitive to certain circulating hormones, such as epinephrine. Contraction and relaxation of these muscles alter resistance to air flow. The bronchioles can constrict if the smooth muscle contracts forcefully. (An example of this phenomenon is an asthma exacerbation.) Bronchioles continue to divide, eventually becoming terminal bronchioles and finally respiratory bronchioles. Each respiratory bronchiole divides to form alveolar ducts. These ducts end as grapelike clusters of tiny, hollow air sacs called alveoli. It is here that the majority of respiratory gas exchange takes place.

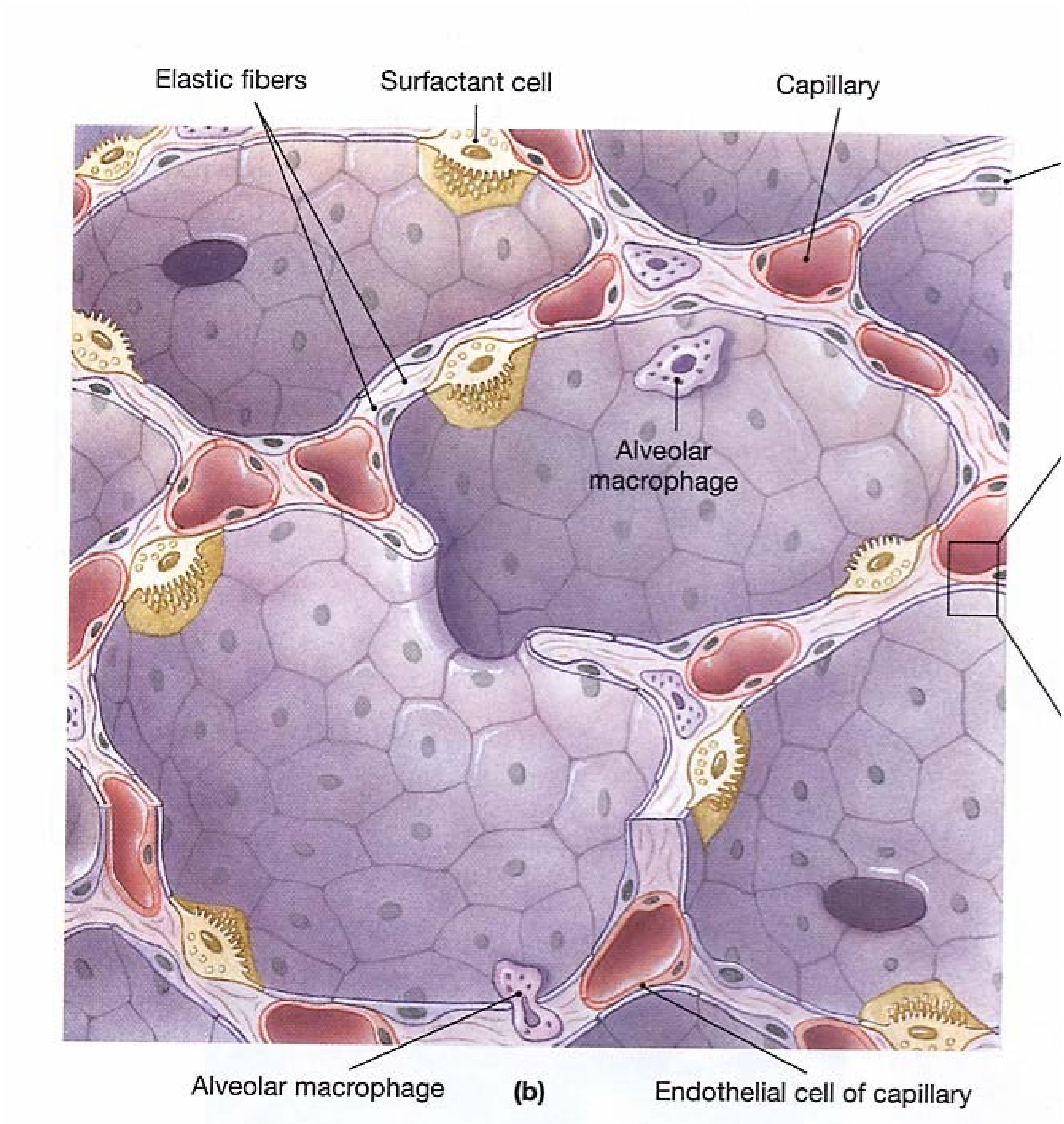
ALVEOLI.

The alveoli are the functional units of the respiratory system and are the prominent constituent of

lung tissue. Some 300 million alveoli exist in the two lungs. The wall of an alveolus consists of a single layer of epithelial cells and elastic fibers that permit it to stretch and contract during breathing. The exchange of oxygen and carbon dioxide in the lungs takes place in the alveoli.

Each alveolus is surrounded by a fine network of blood capillaries arranged so that air within the alveolus is separated by a thin respiratory membrane from the blood contained within the alveolar capillaries. The large surface area of the respiratory membrane may be decreased by respiratory diseases, such as emphysema and lung cancer, which significantly restrict the exchange of oxygen and carbon dioxide.

Alveoli are coated with pulmonary surfactant, a thin film produced by alveolar cells. This fluid prevents the alveoli from collapsing. In addition, pores in the alveolar membrane allow for a limited flow of air between alveoli. This collateral ventilation provides some protection for the alveolus that is occluded by disease.



LUNGS.

The lungs are large, paired, spongy organs whose principal function is respiration. Although there is smooth muscle in the bronchioles of the lungs, the lungs expand and contract during the respiratory cycle as a result of the expansion of the thoracic cavity during inspiration and elastic recoil during expiration. The lungs are attached to the heart by the pulmonary artery and veins. The two lungs are separated by the mediastinum and its contents (the heart, blood vessels, trachea, oesophagus, lymphatic tissues, and vessels). The point of entry for the bronchi, vessels, and nerves of each lung is known as the hilum, or root, of each lung. At birth, the colour of the lungs is rose pink. However, by adulthood, the colour of the lungs changes to slate grey with dark patches as particulate matter is inhaled and deposited in the tissues. An adult lung weighs less than 2 pounds.

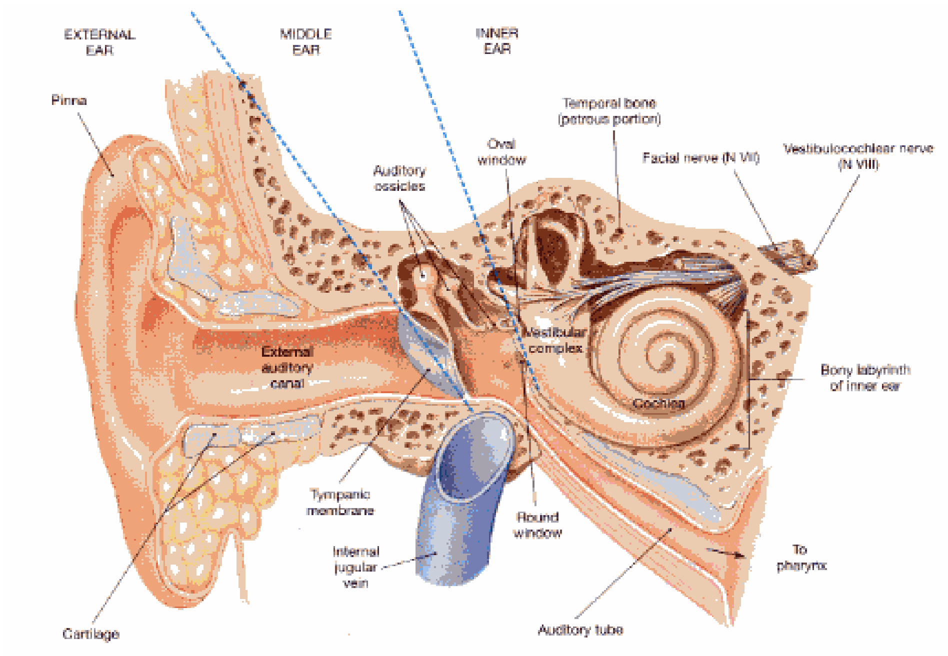
Each lung is conical in shape, with its base resting on the diaphragm and its apex extending to a point about 2.5 cm superior to each clavicle. The right lung is divided into three lobes. The left lung is slightly smaller than the right and is divided into two lobes. Each lobe is divided into lobules separated by connective tissue. Major blood vessels and bronchi do not cross this connective tissue, allowing for a diseased lobule to be surgically removed, leaving the remaining lung relatively intact. There are 9 lobules in the left lung and 10 lobules in the right lung.

Both lungs are surrounded by a separate pleural cavity and are attached to each other only at the point of entry of the bronchi, vessels, and nerves of each lung. The two layers of pleura (visceral and parietal) are so close that they are virtually in contact with each other. They are separated by a thin fluid that acts as a lubricant to allow the pleural membranes to slide past each other during respiration.

Between the two pleurae there is a potential space known as the pleural space. When there is significant chest wall injury or pulmonary pathology, the pleural space may become filled with air (pneumothorax) or blood (hemothorax). Other fluid collections that may accumulate in the pleural space include transudates, most commonly from congestive heart failure (CHF), and exudates, which can result from infectious or malignant etiologies.

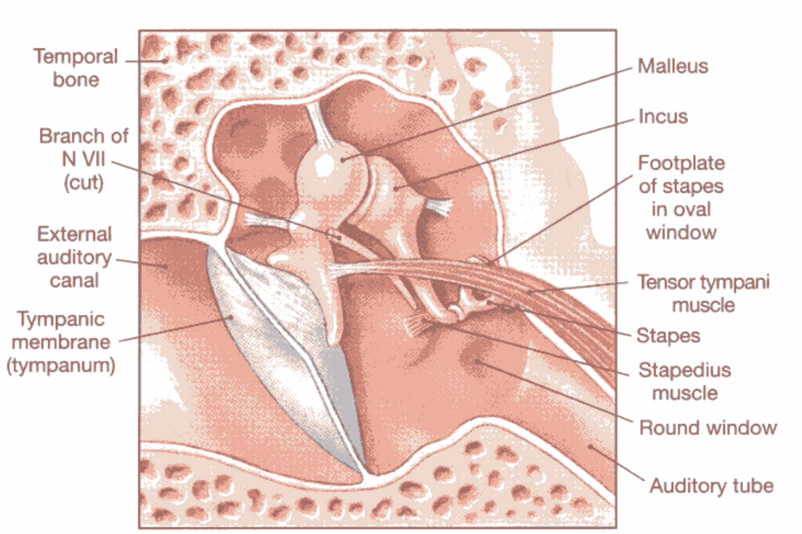
LESSON 1_07 HEARING AND BALANCE

The organs of hearing can be divided into three portions: external, middle, and inner ear. The external and middle ear are involved in hearing only, and the inner ear functions in both hearing and balance. The special senses of hearing and balance are both transmitted by the vestibulocochlear nerve (eighth cranial nerve).



The external ear includes the auricle, or pinna, and the external auditory meatus, which opens into the external auditory canal. The external auditory canal is lined by hairs and ceruminous glands, which produce cerumen. It terminates medially at the eardrum, or tympanic membrane. The middle ear is an air-filled space within the temporal bone, which contains the auditory ossicles.

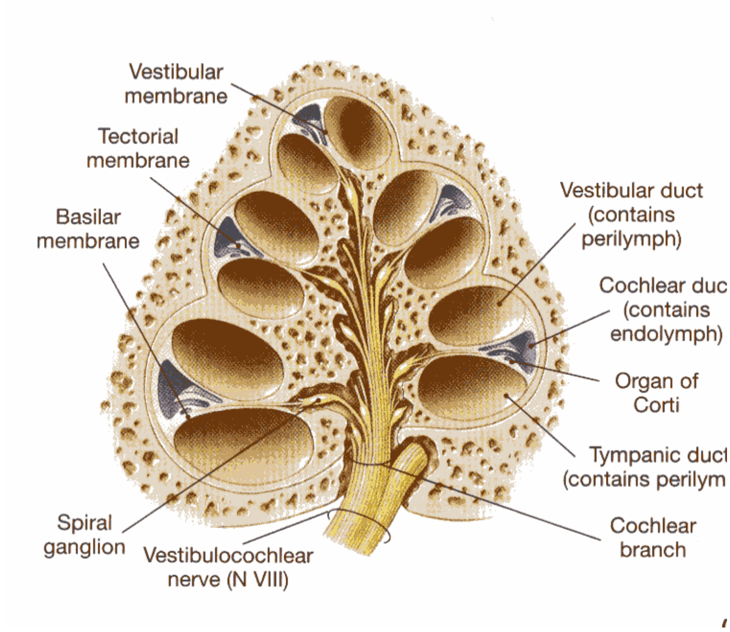
The inner ear contains the sensory organs for hearing and balance. It consists of interconnecting tunnels and chambers within the bony labyrinth. Inside the bony labyrinth is another set of membranous tunnels and chambers called the membranous labyrinth, which is filled with a clear fluid called endolymph. The space between the membranous and bony labyrinth is filled with a fluid called perilymph. These fluids are similar to cerebrospinal fluid.

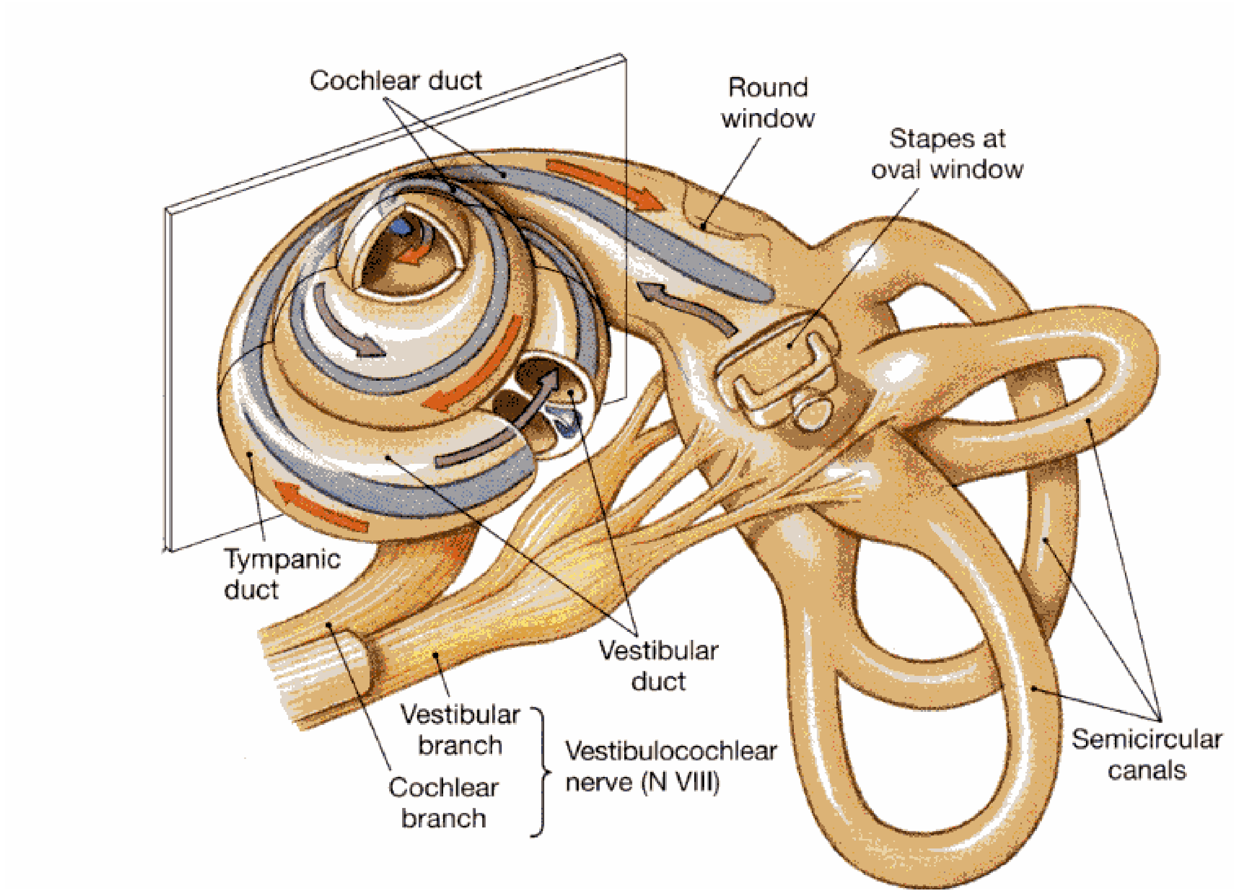


The auricle is shaped to collect sound waves and direct them toward the external auditory meatus. From the external auditory meatus, sound waves travel through the auditory canal to the tympanic membrane, causing the membrane to vibrate.

The middle ear is connected to the inner ear by two membrane-covered openings, the round and oval windows. Two other openings that are not covered by membranes provide a passage for air from the middle ear. One opens into the mastoid air cells. The second opening, the auditory (or eustachian) tube, opens into the pharynx and permits the equalization of air pressure between the outside air and middle ear cavity. (The shorter eustachian tubes in children make it easier for bacteria to travel from infected areas in the throat to the middle ear. This anatomical difference between children and adults is responsible for the increased frequency of pediatric earaches and infections). The auditory ossicles of the middle ear (called the malleus, incus, and stapes) transmit vibrations from the tympanic membrane to the oval window.

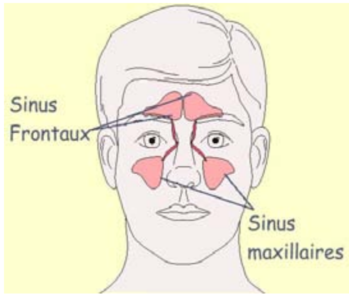
The bony labyrinth of the inner ear is divided into three regions, called the vestibule, cochlea, and semicircular canals. The vestibule and semicircular canals are involved primarily in balance, and the cochlea is involved in hearing. The hearing sense organ, which lies inside the cochlea, is called the organ of Corti. In young, healthy people, the frequencies that can be detected by the ear range (over octaves) from 20 to 20,000 cycles per second.

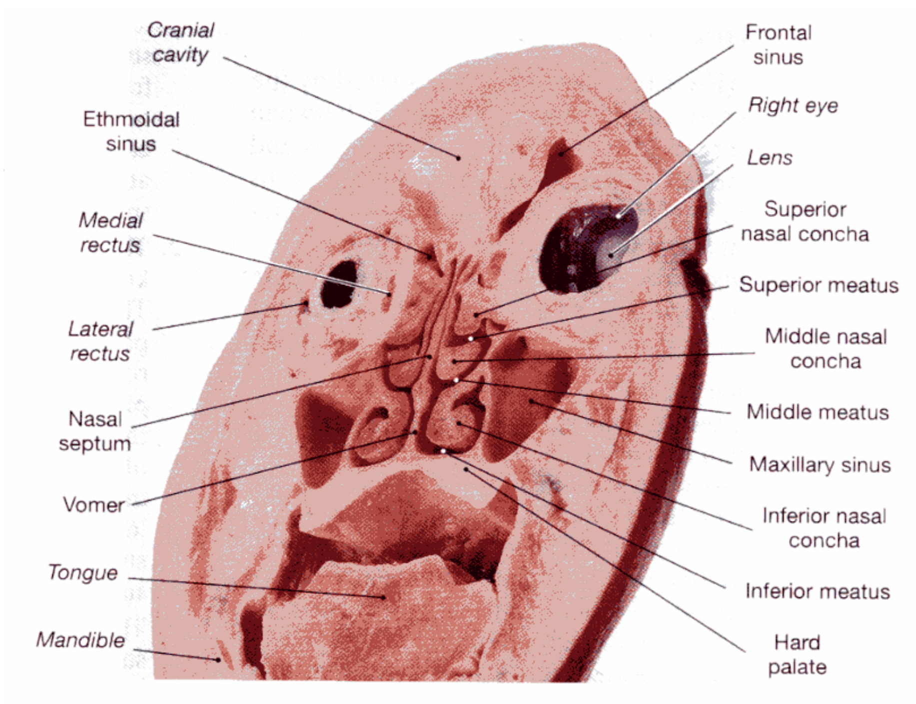




Sinuses

Sinuses are cavities in the bones of the skull that connect to the nasal cavities by small channels. Four groups of sinuses, each named for the skull bone in which it lies, are: the frontal sinuses, above the eyebrows; maxillary sinuses (the largest sinuses), in the cheekbones; ethmoid sinuses, just behind the bridge of the nose; and sphenoid sinuses, in a bone that cradles the brain, slightly anterior to the pituitary gland. These hollow chambers are lined with mucous membranes that secrete mucus into the nasal cavities. They are thought to aid in adding resonance to the voice and decreasing the weight of the skull.





LESSON 2_01 2._02 2_03 CARDIOPULMONARY RESUSCITATION (CPR)

Basic life support is used for the immediate treatment of cardiovascular collapse in cardiac arrest and drowning. The theory of first aid resuscitation is simple; when it is established that the patient is unconscious and the breathing and/or pulse are absent the A B C method is followed. Airway is cleared. Breathing and Circulation are reestablished if possible.

The methods used are described below, but it is known that these are performed poorly if not practised regularly e.g. on manikins (this is also true for laryngoscopy techniques). While CPR is in progress, help should be summoned from the ambulance as advanced life support may be needed.

Mouth-to-mouth resuscitation (M-to-M)

Although this is still widely used and the risk of contracting acquired immunodeficiency syndrome (AIDS) from this method is said to be minimal many rescuers prefer to use a Brook airway; others may use apparatus such as the bag and mask type.

Method

- Check that there is no active breathing.
- Loosen any tight clothing.
- Ensure that the patient is supine and on a hard surface.
- Clear the airway, leaving the dentures in if they are well fixed.
- Extend the neck by placing one hand behind it and the other on the forehead; then transfer the first hand to under the chin; elevate the chin with that hand but do not hyperextend the neck (e.g. by placing anything under the shoulders).
- Pinch the patient's nose and take a deep breath.
- Cover the patient's mouth with yours (or use the Brook airway) and breathe into the patient's lungs; the chest wall should rise. Inhale through your nose to avoid

inhaling vomit from the patient. Repeat twelve to fourteen times per minute.

External cardiac massage (ECM)

Method

- Ensure that the patient is supine, ideally lying on a hard surface (but time must not be wasted arranging this).
- Loosen any tight clothing.

- Kneel at one side of the patient's chest.

Adults

- Place the heel of your right hand on the lower half of the patient's sternum.
- Place your left hand on top of the right.
- Keep both your arms straight and push vertically downwards for about 1.5 inches (4 cm).

Children

- Press with your fingertips instead of your hands.
- Repeat 60 to 80 times per minute.

Combined M-to-M and ECM

If a helper is available, four ECMs should be used for each

M-to-M (Le 4 ECM : 1 M-to-M).

If managing alone the ratio is 15 ECMs to every M-to-M i.e.

15 ECM : 1 M-to-M.

Basic Life Support for adult (Table)

A-Airway	1. Assessment: Determine unresponsiveness.	Tap or gently shake shoulder. Ask, "Are you okay?"
	2. Position victim.	Turn on back as unit, supporting head and neck if necessary.
	3. Open airway.	Open airway with head-tilt/chin-lift.
B-Breathing	4. Assessment: Determine breathlessness.	Maintain open airway. Place ear over mouth, observing chest. Look, listen, feel for breathing (3-5 sec).
	5. Give two rescue breaths.	Seal mouth-to-mouth with barrier device or bag-valve device. Give two rescue breaths 1'/2-2 sec each. Observe chest rise. Allow lung deflation between breaths. '
C-Circulation	6. Assessment: Determine pulselessness.	Feel for carotid pulse (5-10 sec); maintain head-tilt.
	7. If pulseless, begin chest compressions. a. Landmark check.	Run middle finger along bottom edge of rib cage to notch at center (tip of sternum).
	b. Hand placement.	Place index finger next to finger on notch: Place two hands next to index finger. Depress 1'/2-2 inches.
	c. Compression rate.	Give 80-100 compressions per min.
CPR cycles	8. Compressions to one breath.	Give two breaths every 15 compressions.
	9. Number of cycles.	4 (52-73 sec)
	10. Reassessment.	Feel for carotid pulse. If there is no pulse, resume CPR.
Entrance of second rescuer	Second rescuer should perform one-rescuer CPR when first rescuer becomes fatigued. Compression rate for two-rescuer CPR is 80-100 per min; compression ratio is five chest compressions to one breath.	
Option for pulse return	If no breathing, give rescue breaths.	Give one breath every 5 sec (12 per min).

LESSON 2_04 BURNS

Incidence and Patterns of Burn Injury

Burns are a devastating form of trauma associated with high mortality rates, lengthy rehabilitation, côsmetic disfigurement, and permanent physical disabilities. Each year, more than 2 million Americans seek medical attention for burns. Of these, 70,000 are hospitalized and up to 10,000 die as a result of thermal injury or burn-related infection.

Morbidity and mortality rates from burn injury follow significant patterns with regard to gender, age, and socioeconomic status. For example, two thirds of all fire fatalities are men; the death rate from thermal injury is highest among children and older adults; and three fourths of all fire deaths occur in the home, with the highest incidence in lower-income households.2 A key composent of the professional role of the paramedic is community education to stress prevention as the most effective management of these injuries.

Major Sources of Burns

A burn injury is caused by an interaction between energy (thermal, chemical, electrical, or radiation) and biological matter. The majority of burns are thermal and commonly result from flames, scalds, or contact with hot substances. (Frostbite, also considered a thermal injury, is addressed in Chapter 36.)

Chemical burns are caused by substances capable of producing chemical changes in the skis, with or without heat production. Although heat may be generated during the burning process, the chemical changes in the skip, sot the heat, produce the greatest injury. Chemical burns differ from thermal burns in that the topical agent generally adheres to the skin for prolonged periods, producing continuous tissue destruction. The severity of the chemical injury is related to the type of agent, its concentration and volume, and the duration of contact. Chemical agents that frequently cause burn injury include acids and alkalis, which are found in many household cleaning products and organic compounds. Chemical burns are associated with high morbidity, especially when they involve the eyes.

Electrical injuries (including lightning injuries) result from direct contact with an electric current or arcing of electricity between two contact points near the skin. In direct contact injury, the current itself is not considered to have any thermal properties, but the potential energy of the current is transformed into thermal energy when it meets the electrical resistance of biological tissue interposed between the entrance and exit sites. Arc injuries are localized at the termination of current flow and are caused by the intense heat or flash that occurs when the current "jumps," making contact with the skin. Flame burn also may occur as a result of arcing if the heat generated ignites clothing or other fuel source near the patient.

Studies have shown that surface temperatures of 44° C (111° F) do not produce burns unless exposure time exceeds 6 hours.' At temperatures between 44° C and 51° C (111° F and 124° F), the rate of epidermal necrosis approximately doubles with each degree of temperature rise. At 70° C (185° F) or greater, the exposure time required to cause transepidermal necrosis is less than 1 second. The degree of tissue destruction depends on the temperature and duration of exposure. Factors that influence the body's ability to resist burn injury include the water content of the skin tissue; thickness and pigmentation of the skin; presence or absence of insulating substances such as skin oils or hair; and peripheral circulation of the skin, which affects dissipation of heat.

Local Response to Burn Injury

Burn injury immediately destroys cells or so completely disrupts their metabolic functions that cellular death ensues. Cellular damage is distributed over a spectrum of injury. Some cells are destroyed instantly, others are irreversibly injured, and some injured cells may survive if rapid and appropriate intervention is provided in the prehospital setting and in-hospital care.

Major burns have three distinct zones of injury (Jackson's Thermal Wound Theory), which usually appear in a "bull's eye" pattern (Fig. 21-1). The central area of the burn wound, which has sustained the most intense contact with the thermal source, is the zone of coagulation. In this area, coagulation necrosis of the cells has occurred, and the tissue is nonviable. The zone of stasis surrounds the critically injured area and consists of potentially viable tissue despite the serious thermal injury. In this zone, cells are ischemic because of clotting and vasoconstriction. The cells die within 24 to 48 hours after injury if no supportive measures are undertaken. At the periphery of the zone of stasis is the zone of hyperemia. This zone has increased blood flow as a result of the normal inflammatory response. The tissues in this area recover in 7 to 10 days if infection or profound shock does not develop.

Tissue damage from burns depends on the degree of heat and duration of exposure to the thermal source. As a rule, the burn wound swells rapidly because of the release of chemical mediators, which cause an increase in capillary permeability and a fluid shift from the intravascular space into the injured tissues. The increased permeability is accentuated by injury to the sodium pump in the cell walls. As sodium moves into the injured cells, it causes an increase in osmotic pressure that increases the inflow of vascular fluid into the wound. Finally, the normal process of evaporative loss of water to the environment is dramatically accelerated (5 to 15 times that of normal skin) through the burned tissue. In a small wound, these physiological alterations produce a classic local inflammatory response (pain, redness, swelling) without major systemic effects. If the wound covers a large body surface area, however, these local tissue responses can produce major systemic effects and life-threatening hypovolemia.

Systemic Response to Burn Injury

As local events occur at the injury site, other organ systems become involved in a general response to the stress caused by the burn. One of the earliest manifestations of the systemic effects of a large thermal injury is hypovolemic shock with a decrease in venous return, decreased cardiac output, and increased vascular resistance (except in the hyperemic zone). This hypovolernic state, when combined with hemolysis (the breakdown of red blood cells), rhabdomyolysis, and subsequent hemoglobinuria and myoglobinuria (myoglobin in the urine) seen with major burns and electrical injury, can lead to renal failure. Other systemic responses to major burn injury are listed in Box 21-2.

Classifications of Burn Injury

Burns (body surface area involvement and depth) must be assessed and classified as accurately as possible in the field to ensure proper treatment and transport to an appropriate medical facility and to monitor progression of tissue damage. However, this typically is not possible in the prehospital setting because of the progressive nature of the injury. The amount of tissue damage may not be evident for hours or sometimes days after a burn injury

Depth of Burn Injury

Burns are classified in terms of depth as first, second, and third degree. First- and second-degree burns are superficial, and partial-thickness burns usually heal without surgery if uncomplicated by infection or shock. Third-degree burns are full thickness burns that usually require skin grafts.

First-degree Burns

First-degree burns characteristically are painful, red, and dry, and blanch with pressure. They typically occur secondary to prolonged exposure to low-intensity heat or a short-duration flash exposure to a heat source. In first-degree burns, only a superficial layer of epidermal cells is destroyed, and they slough (peel away from healthy tissue underneath the wound) without residual scarring. These injuries usually heal within 2 to 3 days. An example of a first-degree burn is sunburn.

Second-degree Burns

Second-degree burns may be divided into two groups: superficial partial-thickness and deep partial thickness wounds. The superficial partial-thickness injury is characterized by blisters and commonly is caused by skin contact with hot but not boiling water or other hot liquids, explosions producing flashburns, hot grease, and flame.

In superficial partial-thickness second-degree burns, injury extends through the epidermis to the dermis, but the basal layers of the skin are not destroyed, and the skin regenerates within a few days to a week. Edematous fluid infiltrates the dermal-epidermal junction, creating the blisters characteristic of this depth of wound. Intact blisters provide a seal that protects the wound from infection and excessive fluid loss. (For this reason, blisters should not be broken in the prehospital setting.) The injured area usually is red, wet, and painful and may blanch when the tissue around the injury is compressed. In the absence of infection, these wounds heal without scarring, usually within 14 days.

If the depth of the second-degree burn involves the basal layer of the dermis, it is considered a deep partial-thickness burn (Fig. 21-4). As in superficial partial-thickness burns, edema forms at the epidermal-dermal junction. Sensation in and around the wound may be diminished because of the destruction of basal-layer nerve endings. The injury may appear red and wet or white and dry, depending on the degree of vascular injury. Wound infection and subsequent sepsis and fluid loss are major complications of these injuries. If uncomplicated, deep partial-thickness burns generally heal within 3 to 4 weeks. Skin grafting may be necessary to promote timely healing and minimize thick scar tissue formation, which may severely restrict joint movements and cause persistent pain and disfigurement.

Third-degree Burns

In third-degree burns, the entire thickness of the epidermis and dermis is destroyed; thus skin grafts are necessary for timely and proper healing (Fig. 21-5). The wound is characterized by coagulation necrosis of the cells and appears pearly white, charred, or leathery. A definitive sign of third-degree burn is a translucent surface in the depths of which thrombosed veins are visible. Eschar, a tough, nonelastic coagulated collagen of the dermis, is present in these injuries.

Sensation and capillary refill are absent in third degree burns because small blood vessels and nerve endings are destroyed. This often results in large plasma volume loss, infection, and sepsis. Natural wound healing may produce contracture deformity

Rule of Nines

The rule of nines commonly is used in the prehospital setting. The measurement divides the total body surface area (TBSA) into segments that are multiples of 9%. This method provides a rough estimate of burn injury size and is most accurate for adults and children older than 10 years of age. Fig. 21-6 explains the rule of nines.

If the burn is irregularly shaped or has a scattered distribution throughout the body, the rule of nines is difficult to apply. In these situations, burn size can be estimated by visualizing the patient's palm as an indicator of percentage (the "rule of palms"). The surface of the patient's palm equals about 1% of the total body surface area.

Lund and Browder Chart

The Lund and Browder chart is a more accurate method of determining the area of burn injury because it assigns specific numbers to each body part. It is used to measure burns in infants and young children because it allows for developmental changes in percentages of body surface area. For example, the adult head is 9% of TBSA, but the newborn head is 18% TBSA.

American Burn Association Categorization

Using the criteria established by the American Burn Association, burn injuries are categorized as major, moderate, and minor.

In determining severity, factors such as the patient's age, the presence of concurrent medical or surgical problems, and the complications that accompany certain types of burns, such as those of the face and neck, hands and feet, and genitalia, also must be considered. For example, burns of the face and neck may cause respiratory compromise or interfere with the ability to eat or drink. Burns of the hands and feet may interfere with ambulation and activities of daily living. Perineal burns present a high risk of infection because of the contaminants in this region and may disrupt the normal patterns of elimination.

Burn Center Referral Criteria

Many EMS services use the categorizations previously described or other criteria as the basis for determining which patients need transport to specialized burn centers. According to the Committee on Trauma of the American College of Surgeons and the American Burn Association, burn injuries usually requiring referral to a burn center include the following 11 guidelines:

1. Second- and third-degree burns that in combination cover more than 10% of the body surface area in patients under 10 or over 50 years of age
2. Second- and third-degree burns that in combination cover more than 20% of the body surface area of patients in the other age groups
3. Second- and third-degree burns that involve the face, hands, feet, genitalia, or perineum or those that involve skin overlying major joints
4. Third-degree burns over more than 5% body

   surface area in any age group
5. Significant electrical burns, including lightning

   injury
6. Significant chemical burns
7. Inhalation injury
8. Burn injury in patients with pre-existing illnesses that could complicate management, prolong recovery, or affect mortality
9. Burns in any patient in whom concomitant trauma poses an increased risk of morbidity or mortality and who may be initially treated in a trauma center until stable before transfer to a burn center
10. Burns in children seen in hospitals without qualified personnel or equipment for their care (they should be transferred to a burn center with these capabilities)
11. Burn injuries in patients who require special social and emotional or long-term rehabilitative support, including cases involving suspected child abuse and neglect

Pathophysiology of Burn Shock

Shock can occur from large BSA burns. Shock results from local and systemic responses to thermal trauma that lead to edema and accumulation of vascular fluid in the tissues in the area of injury. Locally there is a brief initial decrease in blood flow to the area (the emergent phase) followed by a marked increase in arteriolar vasodilation. A concurrent release of vasoactive substances from the burned tissue causes increased capillary permeability, producing intravascular fluid loss and wound edema (the fluid shift phase). The fluid loss into the injured tissues and the marked increase in evaporative fluid loss secondary to the break in the epithelial barrier contribute to produce hypovolemia.

The greatest loss of intravascular fluid occurs in the first 8 to 12 hours, followed by a continued, moderate loss over the next 12 to 16 hours. At some point within 24 hours, the extravasation of fluid greatly diminishes (the resolution phase), and equilibrium between the intravascular space and the interstitial space is reached. Shock and organ failure (most commonly acute renal failure) can occur as a consequence of hypovolemia. In response to hypovolemia, the body attempts to compensate for diminished circulating blood volume with a reduction in cardiac output and an elevation in peripheral vascular resistance. With volume replacement, cardiac output can increase to levels above normal (the hypermetabolic phase of thermal injury).

Fluid Replacement

Within minutes of a major burn injury, all capillaries in the circulatory system (not just those in the area of the burn) lose their capillary seal. This increase in capillary permeability prevents the creation of an osmotic gradient between the intravascular and extravascular space, allowing colloid solutions to quickly equilibrate across the capillary barrier and into the interstitium. The process of burn shock continues for about 24 hours, at which time the capillary seal is restored. Therefore therapy for burn shock is aimed at supporting the patient through the period of hypovolemic shock. Crystalloid solution (e.g., lactated Ringer's solution) usually is considered the fluid of choice in initial resuscitation.

Assessment of the burn Patient

Emergency care for a burn patient, like any other trauma patient, begins with the initial assessment to recognize and treat life-threatening injuries. In burn patients, however, the dramatic appearance of burns, the patient's intense pain, and the characteristic odor of burnt flesh may easily distract the paramedic from life-threatening problems. It is important that the EMS provider should confidently assess and direct efforts away from the burn wound and toward the patient as a whole.

Initial Assessment

Evaluation of the patient's airway is a major concern in the initial assessment, particularly for the patient with an inhalation injury (described later in this chapter). The paramedic should observe for stridor (an ominous sign that indicates the patient's upper airway is at least 80% narrowed), facial burns, soot in the nose or mouth, singed facial or nasal hair, edema of lips and the oral cavity, coughing, inability to swallow secretions in the pharynx, hoarse voice, and circumferential neck burns. Airway management should be aggressive with these patients.

Breathing should be evaluated for rate, depth, and the presence of wheezes, crackles, or rhonchi. The patient's circulatory status should be evaluated by assessing the presence, rate, character, and rhythm of pulses; capillary refill; skin color and temperature; pulse oximetry, which may be inaccurate in the presence of carbon monoxide; and obvious arterial bleeding.

The patient's neurological status should be determined by using the AVPU scale or a similar method. Deviations from normal should be carefully evaluated for underlying cause. Abnormalities include hypoxia, decreased cerebral perfusion from hypovolemia, and cerebral injury resulting from head trauma. After the initial assessment is completed, a history of the event should be obtained while the physical examination is performed.

An accurate history from the patient or bystanders can help the paramedic determine the potential for inhalation injury, concomitant trauma, or preexisting conditions that may influence the physical examination or patient outcome. When obtaining the patient history, the following information should be ascertained:

What is the patient's chief complaint (e.g., pain, dyspnea)?

What were the circumstances of the injury?

- Did it occur in an enclosed space?
- Were explosive forces involved?

• Were hazardous chemicals involved?

• Is there related trauma?

3. What was the source of the burning agent (e.g., flame, metal, liquid, chemical)?
4. Does the patient have any significant medical history?
5. What medications does the patient take (including recent ingestion of illegal drugs or alcohol)?
6. Did the patient lose consciousness at any time? (Suspect inhalation injury.)
7. What is the status of tetanus immunization?

Physical Examination

At the beginning of the physical exam, a complete set of vital signs should be assessed. The blood pressure should be obtained in an unburned extremity, if available. If all extremities are burned, sterile gauze may be placed under the blood pressure cuff and an attempt made to auscultate a blood pressure. Patients with severe burns or preexisting cardiac or medical illness should be monitored by ECG. Lead placement may need to be modified to avoid placing electrodes over burned areas (see Chapter 28). Field care and hospital destination are determined by the depth, size, location, and extent of burned tissue and the presence of associated illness or injury.

General Principles in the burn Management

Goals for prehospital management of the severely burned patient include preventing further tissue injury, maintaining the airway, administering oxygen and ventilatory support, providing fluid resuscitation (per protocol), providing rapid transport to an appropriate medical facility, using clean technique to minimize the patient's exposure to infectious agents, and providing psychological and emotional support. Patients with burns also should be evaluated for other types of life-threatening trauma; some will have additional injuries associated with the burn event. Examples include blunt or penetrating trauma sustained in automobile crashes, blast injury, and skeletal or spinal injury from attempts to escape the thermal source or contact with electrical current.

Stopping the Burning Process

The first step in managing any burn is to stop the burning process. This step must be accomplished with the safety of the emergency crew in mind because it often occurs in close proximity to the source that caused the burn. With minor first-degree burns, the burning process can be terminated by cooling the local area with cold water. Ice, snow, or ointments should not be applied to the burn because these agents may increase the depth and severity of thermal injury. In addition, ointments may impair or delay assessment of the injury when the patient arrives in the emergency department.

In cases of severe burns, the patient should be rapidly and safely moved from the burning source to an area of safety if possible. A person whose clothing is in flames or smoldering should be placed on the floor or ground and rolled in a blanket to smother the flames and/or doused with large quantities of the cleanest available water. (Cold water to rapidly decrease skin temperature is preferred.) Contaminated water sources, such as a lake or river, should be avoided. These patients should never be allowed to run or remain standing. Running may fan the flame, and an upright position may increase the likelihood of the patient's hair being ignited.

The patient's clothing should be completely removed while cooling the burn so that heat is not trapped under the smoldering cloth. If pieces of smoldering cloth have adhered to the skin, they should be cut, not pulled, away. Melted synthetic fabrics that cannot be removed should be soaked in cold water to stop the burning process. After the burn is cooled, the patient with a large body surface area injury should be covered with a clean, preferably sterile sheet, over which blankets are placed when ambient temperatures are low.

Airway, Oxygen, and Ventilation

The adequacy of airway and ventilatory efforts should be evaluated in all burn patients. High concentration humidified oxygen should be administered if available to any patient with severe burns, and ventilation should be assisted as needed. If inhalation injury is suspected, the patient should be closely observed for signs of impending airway obstruction. Life-threatening laryngeal edema may be progressive and may make tracheal intubation difficult if not impossible. The decision to intubate these patients should not be delayed.

Circulation

The need for fluid resuscitation is based on the severity of the injury, the patient's vital signs, and transport time to the receiving hospital. Some authorities contend that prompt intervention of IV therapy in the critically burned patient is essential to prevent long-term complications such as burn shock and renal failure. (The paramedic should consult with medical direction and follow local protocol regarding fluid replacement.)

If IV therapy is to be performed, it should be initiated with a large-bore catheter in a peripheral vein in an unburned extremity. (The arm is the preferred site.) If an unburned site is not available, the catheter may be inserted through burned tissue, although the risk of subsequent infection is greater.

Care should be taken to secure the catheter with a dressing; tape may not adhere to the injured area as it begins to leak fluid.

If transport of the burn patient is delayed or a lengthy interfacility transport is anticipated, other patient care procedures may be required. These include the placement of a nasogastric tube to prevent gastric distention or vomiting and placement of an indwelling urinary catheter to measure urine output and to maintain patency of the urethra in patients with burns to the genitalia.

Special Considerations

Although all burn injuries warrant good patient assessment and care, burns of specific body regions require special consideration. These include burns to the face and extremities and circumferential burns.

Burns of the face swell rapidly and may be associated with airway compromise. The head of the ambulance stretcher should be elevated at least 30 degrees if not contraindicated by spinal trauma to minimize the edema. If the patient's ears are burned, the use of a pillow should be avoided to minimize additional injury to the area.

If burns involve the extremities or large areas of the body, all rings, watches, and other jewelry should be removed as soon as possible to prevent "vascular compromise with increased wound edema. Peripheral pulses should be reassessed frequently, and the burned limb should be elevated above the patient's heart if possible.

Burn injuries that encircle a body region can pose a threat to the patient's life or limbs. Circumferential burns that occur to an extremity may produce a tourniquet-like effect, which may quickly compromise circulation and cause irreversible damage to the limb. Circumferential burns of the chest can severely restrict movement of the thorax and may significantly impair chest wall compliance. If this occurs, the depth of respirations is reduced, tidal volume is decreased, and the patient's lungs may become difficult to ventilate, even by mechanical means. Definitive treatment for circumferential burns involves an in-hospital surgical procedure known as escharotomy, whereby incisions are made through deep burns to reduce compartment pressure and allow adequate blood volume to flow to and from the affected limb or thorax.

Inhalations Burn Injury

Smoke inhalation injury is present in about 20% to 35% of all patients admitted to burn centers'; more than 50% of the 12,000 fire deaths each year are directly related to smoke inhalation or inhalation injury.' Prehospital considerations in caring for patients with inhalation injury include recognition of the dangers inherent in the fire environment, pathophysiology of inhalation injury, and early detection and treatment of impending airway or respiratory problems.

Smoke inhalation most commonly occurs in a closed environment such as a building, an automobile, or an airplane and is caused by the accumulation of toxic byproducts of combustion. Inhalation injury also can occur in an open space; therefore all burn victims should be evaluated for this injury. Dangers that contribute to inhalation injury in a fire environment are as follows:

- Heat
- Consumption of oxygen by the fire
- Production of carbon monoxide
- Production of other toxic gases

Pathophysiology

Smoke inhalation and inhalation injury compose a broad group of consequences secondary to combustion. For this text, these consequences are classified as carbon monoxide poisoning, inhalation injury above the glottis (supraglottic), and inhalation injury below the glottis (infraglottic).

Carbon Monoxide Poisoning

Carbon monoxide is a colorless, odorless, tasteless gas produced by incomplete combustion of carbon containing fuels. Carbon monoxide does not physically harm lung tissue, but it causes a reversible displacement of oxygen on the hemoglobin molecule, forming carboxyhemoglobin (COHb). The result is low circulating volumes of oxygen despite normal partial pressures. In addition, the presence of COHb requires that tissues be very hypoxic before oxygen is released from the hemoglobin to fuel the cells.

Carbon monoxide has about 250 times the affinity for hemoglobin that oxygen has. Therefore small concentrations of carbon monoxide in inspired air can result in severe physiological impairments, including tissue hypoxia, inadequate cellular oxygenation, inadequate cellular and organ function, and eventually death. The physical effects of carbon monoxide poisoning are related to the level of COHb in the blood (see the box below).

Treatment of the patient with carbon monoxide poisoning includes ensuring a patent airway, providing adequate ventilation, administering high concentration oxygen, and possible pharmacological therapy (sodium thiosulfate, 12.5 g) for severely poisoned patients. The half-life of carbon monoxide at room air is about 4 hours. This can be reduced to 30 to 40 minutes if 100% oxygen and adequate ventilation are provided. The use of hyperbaric oxygen therapy to promote increased oxygen uptake on parts of the hemoglobin molecule not yet bound by carbon monoxide is controversial in treating carbon monoxide poisoning. The paramedic should follow local protocol.

In addition to carbon monoxide, other volatile byproducts (e.g., cyanide, hydrogen sulfide) may be released when some materials are burned. Inhalation of these toxins can result in inhalation poisoning (e.g., thiocyanate intoxication) and may require pharmacological therapy (e.g., Pasadena cyanide antidote kit, formerly the Lily Cyanide Poison Kit).

Inhalation Injury Above the Glottis

The structure and function of the airway superior to the glottis make it particularly susceptible to injury if exposed to high temperatures. The upper airway is very vascular and has a large surface area, which allows it to normalize temperatures of inspired air. Because of this design, actual thermal injury to the lower airway is rare because the upper airway sustains the impact of injury when environmental air is superheated.

Thermal injury to the airway can result in immediate edema of the pharynx and larynx (above the level of the true vocal cords), which can rapidly progress to complete airway obstruction. Signs and symptoms of upper airway inhalation injury include the following:

- Facial burns
- Singed nasal or facial hairs
- Carbonaceous sputum
- Odema of the face, oropharyngeal cavity, or both
- Signs of hypoxemia
- Hoarse voice
- Stridor
- Brassy cough
- Grunting respirations

Prompt recognition and protection of the airway are critical in these patients. If impending airway obstruction is suspected, early nasotracheal or orotracheal intubation may be warranted because progressive edema can make emergency intubation extremely hazardous if not impossible.

Inhalation Injury Below the Glottis

The two primary mechanisms of direct injury to the lung parenchyma are heat and toxic material inhalation. Thermal injury to the lower airway is rare; causes include inhalation of superheated steam, which has 4000 times the heat-carrying capacity of dry air; aspiration of scalding liquids; and explosions, which occur as the patient is breathing high concentrations of oxygen under pressure.

Most fire-related lower-airway injuries result from the inhalation of toxic chemicals such as the gaseous byproducts of burning materials. Signs and symptoms of lower-airway injury may be immediate but more frequently are delayed, beginning several hours after the exposure. These include the following:

- Wheezes
- Crackles or rhonchi
- Productive cough
- Signs of hypoxemia
- Spasm of bronchi and bronchioles

Prehospital care should be directed at ensuring a patent airway and providing high-concentration oxygen and ventilatory support. Specific airway and ventilatory management, which may include nasal or oral tracheal intubation and pharmacological therapy with bronchodilators, should be coordinated with on-line/direct medical direction.

Chemical injury

Caustic chemicals frequently are present in the home and workplace, and unintentional exposure is common. Three types of caustic agents frequently are associated with burn injuries: alkalis, acids, and organic compounds. Alkalis (strong bases with a high pH), occur in hydroxides and carbonates of sodium, potassium, ammonium, lithium, barium, and calcium. These compounds commonly are found in oven cleaners, household drain cleaners, fertilizers, heavy industrial cleaners, and the structural bonds of cement and concrete. Strong acids are in many household cleaners, such as rust removers, bathroom cleaners, and swimming pool acidifiers.

Organic compounds are chemicals that contain carbon. Most organic compounds, such as wood and coal, are harmless chemicals. However, several organic compounds produce caustic injury to human tissue. These include phenols and creosote and petroleum products such as gasoline. In addition to their role in producing chemical burns, organic compounds may be absorbed by the skin, causing serious systemic effects. The severity of chemical injury is related to the chemical agent, concentration and volume of the chemical, and duration of contact.

Assessment

Exposure factors often can be assessed during the patient history. When dealing with a chemical exposure, the paramedic should ascertain the following:

- Type of chemical substance. If the container is

available and can be safely transported, it should be taken to the medical facility.

• Concentration of chemical substance

• Volume of chemical substance

• Mechanism of injury (local immersion of a body part, injection, splash)

• Time of contamination

• First aid administered before EMS arrival

• Appearance (chemical burns vary in color)

• Pain

Management

As with all burn injuries, the safety of the rescuers must be the first consideration in managing the victim of chemical injury. (Law enforcement, fire service, and special rescue personnel may be needed to secure the scene before entry.) The paramedic must consider the use of protective gear before approaching the scene. Depending on the scene and the chemical agent(s) involved, personal protection may include gloves, eye shields, protective garments, and appropriate breathing apparatus. The treatment of chemical injuries varies little from that of thermal burns during the initial assessment. Treatment is directed at stopping the burning process. This can best be accomplished by the following:

1. Remove all clothing, including shoes, which can trap concentrated chemicals.
2. Brush off powdered chemicals.
3. Irrigate the affected area with copious amounts of water.

In otherwise stable patients, irrigation takes priority over transportation unless irrigation can be continued en route to the emergency department.

If a large body surface area is involved, a shower should be used for irrigation, if readily available.

Chemical Burn Injury of the Eyes

Chemical exposure to the eyes (e.g., from mace, pepper spray, other irritants) may cause damage ranging from superficial inflammation (chemical conjunctivitis) to severe burns. Patients with these conditions have local pain, visual disturbance, lacrimation (tearing), edema, and redness of surrounding tissues. Management guidelines include flushing the eyes with water by using a mild flow from a hose, intravenous tubing, or water from a container. (The affected eye should be irrigated from the medial to the lateral aspect to avoid flushing the chemical into the unaffected eye.) Irrigation should be continued during transport. If contact lenses are present, they should be removed.

Some EMS services use nasal cannulas to irrigate both eyes simultaneously. The cannula is placed over the bridge of the nose, with the nasal prongs pointing down toward the eyes. The cannula is attached to an intravenous administration set using either normal saline or lactated Ringer's solution and run continually into both eyes. Irrigation lenses (e.g., Morgan Therapeutic Lens) may be useful for prolonged eye irrigation in adults, provided that edema is absent and there are no lacerations or penetrating wounds of the globe or eyelids.

The use of these devices in the prehospital setting is controversial and requires special training and authorization from medical direction.

Use of Antidotes or Neutralizing Agents

According to the American Burn Association, no agent has been found to be superior to water for treating most chemical burns.' Consequently the use of antidotes or neutralizing agents should be avoided in initial prehospital management of most burn injuries. Many neutralizing agents produce heat and may increase injury when applied to the wound.

In special circumstances, such as when an industrial complex within a response area is known to use a chemical agent with a specific antidote, medical direction may elect to have the EMS stock the neutralizer. In this situation, paramedics should receive special training on the indications, contraindications, use, and side effects of these agents.

Specific Chemical Injuries

Although the primary treatment for most chemical burns is copious irrigation with water, several specific chemical injuries warrant further discussion. These include petroleum, hydrofluoric acid, phenols, ammonia, and alkali metals.

Petroleum

In the absence of flame, products such as gasoline and diesel fuel can cause significant chemical burns if prolonged contact occurs (e.g., entrapment in a motor vehicle crash surrounded by spilled gasoline). Initially the injury appears to be only a first- or second-degree burn when in fact it may be a full-thickness injury. Systemic effects such as central nervous system depression, organ failure, and death may result from the absorption of various hydrocarbons. In addition, lead toxicity can occur if the exposure was from gasoline containing tetraethyl lead.

Hydrofluoric Acid

Hydrofluoric acid, one of the most corrosive materials known, is used in industry for cleaning fabrics and metals, for glass etching, and in the manufacture of silicone chips for electronic equipment. Both the hydrogen ion and fluoride ion are damaging to tissue. Fluoride inhibits several chemical reactions essential to cell survival, and it continues to penetrate and kill cells when it is neutralized by binding to calcium or magnesium. Thus endogenous or exogenous hydrofluoric acid has the potential to produce very deep, painful, and severe injuries. If large body surface areas are involved or there has been exposure to high concentrations of the acid, the patient may experience severe hypocalcemia and even death. Even the most minor-appearing wounds that involve hydrofluoric acid should be evaluated at an appropriate medical facility.

Irrigation of the exposed area with copious amounts of water should be initiated in the prehospital setting. On arrival in the emergency department, patient treatment may include subcutaneous administration of a 10% calcium gluconate solution directly into the burn site.

Phenol

Phenol (carbolic acid) is an aromatic hydrocarbon derived from coal tar. It is widely used in industry as a disinfectant in cleaning agents and in the manufacture of plastics, dyes, fertilizers, and explosives. Skin contact with phenol can result in local tissue coagulation and systemic toxicity if the agent is absorbed. A soft tissue injury from phenol exposure may be painless because of the agent's anesthetic properties. Minor exposures may cause central nervous system depression and dysrhythmias. Patients with significant exposures (10% to 15% TBSA) may require systemic support and should be carefully observed for signs of respiratory failure.

Wounds should be copiously irrigated with large volumes of water. After irrigation, medical direction may recommend that the wound be swabbed with a suitable solvent such as glycerol, vegetable oil, or soap and water to bind phenol and prevent its Systemic absorption.

Ammonia

Ammonia is a noxious, irritating gas and strong alkali that is very soluble in water. It is an extremely hazardous solution if introduced into the eye and may result in tissue necrosis and blindness. The patient with an ammonia "burn" to the eye will probably have swelling or spasm of the eyelids. These patient injuries must be irrigated with water or a balanced salt solution for up to 24 hours.

Respiratory injury from ammonia vapors depends on the concentration and duration of exposure. For example, short-term, high-concentration exposure usually results in upper-airway edema, whereas long-term low-concentration exposure may damage the lower respiratory tract. Initial care for patients with respiratory injury includes high-concentration oxygen administration, ventilatory support as needed, and rapid transport to an appropriate medical facility.

Alkali Metals

Sodium and potassium are highly reactive metals that can ignite spontaneously. Water is generally contraindicated when these metals are imbedded in th6 skin because they react with water and produce large amounts of heat. Physically removing the metal or covering it with oil minimizes the thermal injury.

Electrical Burn Injuries

Electrical injuries account for 4% to 6.5% of admissions to burn centers and are responsible for about 500 deaths each year.' An understanding of the principles of current and the path of destruction it may produce in the body is essential for good patient care and personal safety at the scene of an electrocution (see the box on p. 612).

Types of Electrical Injury

Three basic types of injury may occur as a result of contact with electric current: direct contact burns, arc injuries, and flash burns. Direct contact burns occur when electric current directly penetrates the resistance of the skin and underlying tissues. The hand and wrist are common entrance sites, and the foot is a common exit site (Fig. 21-13). Although the skin may initially resist current flow, continued contact with the source lessens resistance and permits increased current flow. The greatest tissue damage occurs directly under and adjacent to the contact points and may include fat, fascia, muscle, and bone. Tissue destruction may be massive at the entrance and exit sites; however, it is the area between these wounds that poses the greatest threat to the patient's life.

Arc injuries occur when a person is close enough to a high-voltage source that the current between two contact points near the skin overcomes the resistance in the air, passing the current flow through the air to the bystander. Temperatures generated by these sources can be as high as 2000° C to 4000° C (3632° F to 7232° F), and the arc may jump as far as 10 feet.

Flame and flash burn injuries can occur when the heat of electric current ignites a nearby combustible source. Common injury sites include the face and eyes (Welder's flash). Flash burns also may ignite a person's clothing or cause fire in the surrounding environment. No electrical current passes through the body in this type of burn.

Effects of Electrical Injury

Electrical injuries often are unpredictable and vary according to the parameters described. However, certain physiological effects should be anticipated by the paramedic crew.

The skin is almost always the first point of contact with electrical current. Direct contact and passage of current through tissue may produce extensive areas of coagulation necrosis. The entrance site is often a characteristic "bull's-eye" wound and may appear dry, leathery, charred, or depressed. The exit wound may be ulcerated and may have an "exploded" appearance where areas of tissue are missing.

Oral burns frequently are seen in children under 2 years of age. These wounds typically are caused by chewing or sucking on a low-tension electrical cord. Oral burns may be associated with injury to the tongue, palate, and face.

Hypertension and tachycardia associated with a large release of catecholamines is a common finding in electrical injury. Electrical current also may cause significant

dysrhythmias (including ventricular fibrillation and asystole) and damage to the myocardium as it passes through the body. If the patient has suffered cardiac arrest and early rescue and resuscitation can be initiated by the paramedic, success rates are high.

Nerve tissue is an excellent conductor of electrical current and may therefore be commonly affected in electrical injuries. Central nervous system damage may result in seizures or coma with or without focal neurological findings; peripheral nerve injury may lead to motor or sensory deficits, which may be permanent. If the current passes through the brain stem, respiratory arrest or depression, cerebral edema, or hemorrhage may rapidly lead to death.

Electrical injury can cause extensive necrosis of blood vessels. These injuries, although they may not be evident on EMS arrival, can cause immediate or delayed internal hemorrhage or arterial or venous thrombosis and embolism with subsequent complications.

Damage within the extremities after an electrical burn is similar to crush injury (described in Chapter 20) in that severe muscle necrosis releases myoglobin, and hemolysis releases hemoglobin, which can precipitate in the renal tubules, producing acute renal failure. (Some patients may require amputation of the affected extremity as a result of decreased circulation and compartment syndrome.) In the electrocuted patient, severe muscle spasms can produce bony fractures and dislocations, even of major joints. In addition, a patient may fall after the electrical shock and sustain significant skeletal trauma, including damage to the cervical spine.

Acute renal failure is a serious complication that affects about 10% of significant direct-contact electrical injuries. It may result from a combination of myoglobin or hemoglobin sludging in the renal tubules, disseminated intravascular coagulation secondary to tissue damage, hypovolemic shock, and DC damage. Although acute renal failure is not of immediate consequence in the prehospital environment, prompt fluid resuscitation and management of shock may have a positive impact on a significant number of these patients.

Ventilation may be impaired when electrical burns produce central nervous system injury or chest wall dysfunction. If the respiratory center is disrupted, hypoventilation can lead to immediate patient death. Contact with any AC sources has also been documented to produce respiratory arrest and death from tetany of the muscles of respiration.

Conjunctival and corneal burns and ruptured tympanic membranes are common in some electrical injuries. Cataracts and hearing loss also may appear as late as 1 year after the event.

Numerous other internal structures may be damaged secondary to electrical injury, including the abdominal organs and urinary bladder. Submucosal hemorrhage may occur in the bowel, and various forms of ulceration are possible. Each patient requires a thorough physical assessment and a high degree of suspicion for associated trauma.

Assessment and Management

Patient assessment should begin by ensuring that no hazards exist for the rescuers or bystanders. If the patient is still in contact with the electrical source, the electric company, fire department, or other specially trained personnel should be summoned before approaching the patient. Once the scene is safe, patient intervention may begin.

Initial Assessment

The initial assessment should proceed as for all other trauma patients, with particular care taken to immobilize the cervical spine. If the patient is not breathing, assisted ventilation should proceed immediately. Intubation should be performed as soon as possible because apnea may persist for lengthy periods. A patient who is breathing should have a patent airway maintained and respirations supported with supplemental high-concentration oxygen. If the patient is in cardiac arrest, resuscitation efforts should be implemented according to protocol. If possible, a history should be obtained, including the following:

- Patient's chief complaint (e.g., injury,disoriention
- Source, voltage, and amperage of the electrical injury
- Duration of contact
- Level of consciousness before and after the injury
- Past significant medical history

Physical Examination

The physical exam should be particularly thorough to search for entrance and exit wounds or any associated trauma caused by tetany or a fall. The paramedic should remember that there may have been multiple pathways of current and therefore multiple wounds. All of the patient's clothing and jewelry should be removed and the areas between the patient's fingers and toes should be examined for sites of entry or exit. Distal pulses, motor function, and sensation should be carefully assessed in all extremities and well documented to monitor for possible development of compartment syndrome. Entrance and exit wounds should be covered with sterile dressings, and any associated trauma should be managed appropriately.

Internal damage from electrical current may be much more significant than external wounds, and frequent reassessment is necessary because of the progressive nature of electrical injury. In addition, ECG monitoring should be implemented at the scene and continued during patient transport. As previously discussed, electrical injury may cause a variety of dysrhythmias, some of which can be lethal.

Management

Early fluid resuscitation is critical in managing patients with severe electrical injury to prevent hypovolemia and subsequent renal failure. If possible, two large-bore intravenous lines should be established in an extremity without entry or exit wounds. The fluid of choice generally is lactated Ringer's solution or normal saline without glucose, and the flow rate should be determined by the patient's clinical status.

In the emergency department or during interhospital transfer, the patient's intravenous fluid rates will be regulated to maintain a urine output of 75 to 100 mL/hr, which decreases the potential for renal damage caused by myoglobin. In addition, emergency department management may include administration of sodium bicarbonate to maintain an alkaline urine, which increases the solubility of hemoglobin and myoglobin and thus minimizes the incidence of renal failure.

Lightning Injury

Lightning strikes the earth about 7.4 million times each year and accounts for about 90 deaths each year.' It comprises DC of up to 200,000 amps at a potential of 100 million or more volts, with temperatures that vary between 16,000° F and 60,000° F (8871°C and 33,315°C). Lightning injuries can occur from a direct strike or by a side flash (splash) between a victim and a nearby object that has been struck by lightning. About 30% of those struck by lightning die.

Lightning strikes produce tissue injuries that differ from other types of electrical injury because the pathway of tissue damage often is over rather than through the skin (Fig. 21-14). Because the duration of the lightning is short (1/100 to 1/1000 second), skin burns are less severe than those seen with other highvoltage current, and third-degree burns are rare. Common lightning burns are linear, feathery, and punctate (pinpoint) in appearance. In addition, depending on the severity of the strike, the patient may suffer cardiac and respiratory arrest, which are the most common causes of death in lightning injuries.

Lightning injuries may be classified as minor, moderate, or severe. Patients with minor lightning injuries usually are conscious and frequently are confused and amnestic. Burns or other signs of injury are rare, and vital signs usually are stable.

Patients with moderate injury may be combative or comatose and may have associated injuries from the impact of the lightning strike. First- and seconddegree burns are common, as is tympanic membrane rupture. These patients may have serious internal organ damage and should be carefully observed for signs and symptoms of cardiorespiratory dysfunction.

Severe lightning injuries include those that cause immediate brain damage, seizures, respiratory paralysis, and cardiac arrest. Prehospital care is directed at basic and advanced life support measures and rapid transport to an appropriate medical facility.

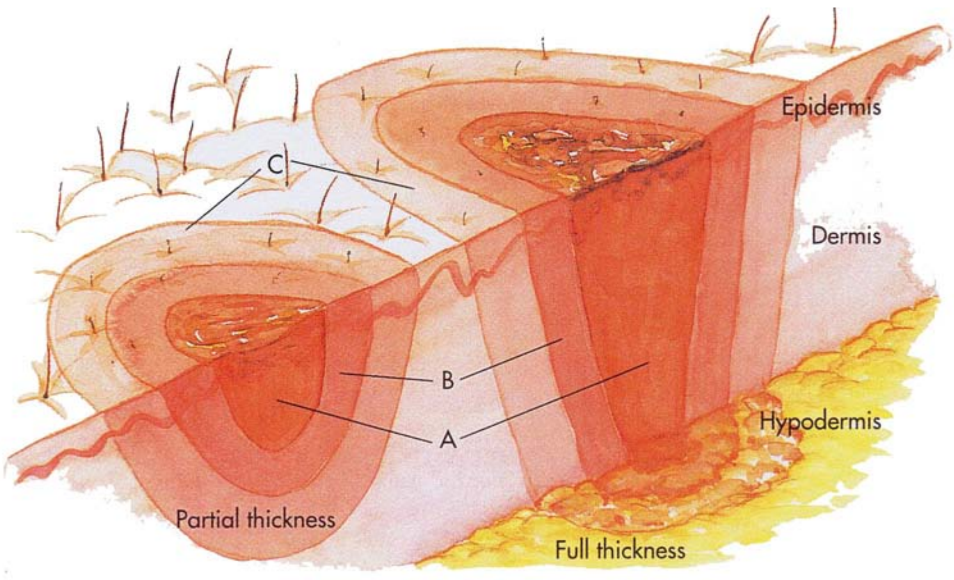
Assessment and Management

Like all other emergency responses, scene safety is the first priority. If the electrical storm is still in progress, all patient care activities should take place in a sheltered area. To prevent injury from subsequent lightning strikes, the paramedic crew should stay away from objects that project from the ground, including trees, fences, and high buildings, and avoid areas of open water. If rescue attempts in an open area are necessary, the paramedic should stay low to the ground.

Prehospital management of lightning injuries is the same as for other severe electrical injuries. Initial patient care is directed at airway and ventilatory support; basic and advanced life support; patient immobilization; fluid resuscitation to prevent hypovolemia and renal failure; pharmacological therapy (per protocol) to manage seizures (if present) and promote excretion of myoglobin and to treat dysrhythmias; wound care; and rapid transport to an appropriate medical facility.

Schemas and tables

Figure 1: Three zones of intensity (a) zone of hyperemia (peripheral) (b) zone of stasis (intermediate) (c) zone of coagulation (central).



LESSON 2_05 SEIZURE AND CONVULSIONS

Seizure Disorders

A seizure is a temporary alteration in behaviour or consciousness caused by abnormal electrical activity of one or more groups of neurons in the brain. The annual incidence of seizure is estimated to be about one-half of 1% of the U.S. population, with the highest incidence among feverish children under 5 years of age.

Although the underlying Neuro Pathophysiology of seizures is not well understood, a seizure is generally believed to result from alterations in neuronal membrane permeability secondary to structural lesion or metabolic derangement. The increased membrane permeability to sodium and potassium ions enhances the ability of the neurons to depolarise and emit an electrical charge, sometimes resulting in seizure activity. Seizures may be caused by multiple factors, including:

- Stroke
- Head trauma
- Toxins, including alcohol or other drug with-
  drawal
- Hypoxia
- Hypoperfusion
- Hypoglycemia
- Infection
- Metabolic abnormalities
- Brain tumor or abscess
- Vascular disorders
- Eclampsia – Bleeding during pregnance
- Drug overdose

In the prehospital setting, determining the origin of seizure activity is less important than managing the complications and recognizing whether the seizure is reversible with therapy (e.g., resulting from hypoglycemia). A tendency toward recurrent seizures (excluding those that arise from correctable or avoidable circumstances [e.g., alcohol withdrawal]) is called epilepsy.

Types of Seizures

All seizures are pathological. They may arise from almost any region of the brain and therefore have many clinical manifestations. The two most common seizure types are generalized and partial (focal).

Generalized seizures. As the name implies, generalized seizures do not have a definable origin (focus) in the brain, although focal seizures may progress to generalized seizures. This class includes petit mal (absence seizures) and grand mal (tonic-clonic) seizures. Petit mal seizures occur most. often in children between the ages of 4 and 12. They are characterized by brief lapses of consciousness without loss of posture. Often there is no motor activity, although some children have eye blinking, lip smacking, or isolated clonic activity. These seizures usually last less than 15 seconds, during which time the patient is unaware of the surroundings, and are followed by the patient's immediate return to normal environmental contact. Most patients have remission by age 20 but may subsequently develop grand mal seizures.

Grand mal seizures - Grand mal seizures are common and are associated with significant morbidity and mortality. Grand mal seizures may be preceded by an aura (olfactory or auditory sensation), which often is recognized by the patient as a warning of the imminent convulsion. The seizure itself is characterized by a sudden loss of consciousness associated with loss of organized muscle tone and a tonic phase in which there is a sequence of extensor muscle tone activity (sometimes flexion) and apnea.

During the tonic phase of a grand mal seizure, tongue biting and bladder or bowel incontinence may occur. After the tonic phase, which lasts only seconds, the patient experiences a bilateral clonic phase (rigidity alternating with relaxation), which usually lasts 1 to 3 minutes. During this phase of the seizure, there is a massive autonomic discharge that results in hyperventilation, salivation, and tachycardia. After the seizure, the patient usually experiences a period of drowsiness or unconsciousness resolving over minutes to hours. On regaining consciousness, the patient often is confused and fatigued and may demonstrate a transient neurological deficit. This phase of the seizure is known as the postictal phase. Grand mal seizures may be prolonged or recur before the patient regains consciousness. When this occurs, the patient is said to be in status epilepticus (see discussion on status epilepticus).

Partial seizures - Partial seizures. In contrast to generalized seizures, in which a specific seizure focus is unknown, partial seizures arise from identifiable cortical lesions. Partial seizures may be classified as simple or complex. Simple partial seizures result mainly from seizure activity in the motor or sensory cortex. Simple motor seizures usually manifest as clonic activity limited to one specific body part (such as one hand, one arm or leg, or one side of the face). Simple sensory seizures result in symptoms such as tingling or numbness of a body part or abnormal visual, auditory, olfactory, or taste symptoms. Patients with partial seizures generally do not lose consciousness and maintain a relatively normal mental status. However, the seizure focus may subsequently spread and lead to a generalized tonic-clonic seizure. Partial seizure activity that spreads in an orderly fashion to surrounding areas is known as a Jacksonian seizure.

Complex partial seizures arise from focal seizures in the temporal lobe (psychomotor) and manifest primarily as changes in behavior. The classic complex partial seizure is preceded by an aura, followed by abnormal repetitive motor behavior (automatisms), such as lip smacking, chewing, or swallowing, during which time the patient is amnestic. These seizures typically are brief (less than 1 minute), and the patient usually regains normal mental status quickly. Like simple partial seizures, complex partial seizures also may progress to a generalized tonic-clonic seizure.

Assessment

Prehospital assessment is determined by the patient's seizure status on EMS arrival. In most cases, the patient's seizure activity has ceased before the paramedic crew arrives. If possible, the assessment should include a thorough history and physical examination, including a neurological evaluation.

History

If the patient is postictal, information can be gathered from family members or bystanders who witnessed the event. Important components of the patient history include the following:

1. History of seizures

    a. Frequency

b. Compliance in taking prescribed medications (e.g., phenytoin [Dilantin], phenobarbital [Luminal])

2. Description of seizure activity

    a. Duration of seizure

b. Typical or atypical pattern of seizure for the

    patient

    c. Presence of aura

    d. Generalized or focal

    e. Incontinence

    f. Tongue biting

3. Recent or past history of head trauma

4. Recent history of fever, headache, nuchal rigidity

    (suggesting meningeal irritation)

5. Past significant medical history

    a. Diabetes

    b. Heart disease

    c. Stroke

Physical examination

In conducting the physical examination, maintaining a patent airway is always of primary importance. The paramedic also should be alert to signs of trauma (head and neck trauma, tongue injury, oral lacerations) that may have occurred before or during the seizure activity. In addition, the patient's gums should be inspected for gingival hypertrophy (swelling of the gums), which is a sign of chronic phenytoin (Dilantin) therapy. Other components of the physical examination include:

- Level of sensorium, including presence or absence of amnesia
- Cranial nerve evaluation, particularly papillary findings .
- Motor and sensory evaluation, including coordination (Abnormalities may be caused by metabolic disturbances, meningitis, intracranial hemorrhage, and drug use.)
- An evaluation for hypotension and hypoxia

- Presence of urine or feces (suggesting bladder or bowel incontinence)
- Automatisms
- Cardiac dysrhythmias

Syncope versus seizure

It may be difficult to determine whether the patient experienced a syncopal episode or a seizure, because the main differentiating characteristics are in the symptoms before and after the event.

CHARACTERISTICS	SYNCOPE	SEIZURE
Position	The syncope usually starts in a standing position	The seizure may start in any position
Warning	There is usually a warning period of lightheadedness	There is little or no warning.
Level of consciousness	The patient usually regains consciousness immediately on becoming supine; fatigue, confusion, and headache last less than 15 minutes.	The patient may remain unconscious for minutes to hours; fatigue, confusion, and headache last longer than 15 minutes.
Clonic-tonic activity	Clonic movements (if present) are of short duration.	Tonic-clonic movements occur during unconscious state.
ECG analysis	Bradycardia is caused by increased vagal tone associated with syncope.	Tachycardia is caused by muscular exertion associated with seizure activity.

Management

The first step in managing a patient with seizure activity is to prevent the patient from sustaining physical injury. This is best accomplished by removing obstacles in the patient's immediate area or, if necessary, moving the patient to a safe environment such as a carpeted or soft, grassy area. At no time should a patient with seizure activity be restrained, nor should objects be forced between the patient's teeth to maintain an airway. Restraining activity may harm the patient or paramedic crew. Forcing objects into the oral cavity in an effort to secure an airway or prevent the patient from biting his or her tongue may evoke vomiting, aspiration, or spasm of the larynx.

Most patients with an isolated seizure can be appropriately managed in the postictal phase by being placed in a lateral recumbent position to allow drainage of oral secretions and to facilitate suctioning (if needed). Supplemental oxygen should be administered via a nonrebreather mask, and the patient should be moved to a quiet environment (away from onlookers). Patients commonly are embarrassed or self-conscious after a seizure, particularly if incontinence has occurred. Therefore the paramedic should be sensitive to the physical and emotional needs of the patient.

Patients with a history of seizures who have experienced an atypical seizure or one that was complicated by an unusual event (e.g., trauma), and all others who have experienced a seizure for the first time should be transported to the emergency department for physician evaluation. Depending on the patient's status and seizure history, medical direction may recommend that an IV line be established if medication therapy becomes necessary. However, few patients who experience an isolated seizure require pharmacological agents in the prehospital setting.

Status epilepticus

Status epilepticus is continuous seizure activity lasting 30 minutes or longer or a recurrent seizure without an intervening period of consciousness. The condition is a true emergency; without immediate management, it can result in permanent neurological damage, respiratory failure, and death. Associated complications of status epilepticus include aspiration, brain damage, and fracture of long bones and the spine. The most common precipitating cause of this condition in adults is failure to take prescribed anticonvulsant medications.

Management. As in all patients with seizures, management priorities include managing the airway and providing ventilatory support, protecting the patient from injury, and; if indicated, transporting the patient to a medical facility for physician evaluation. In addition, management of a status seizure includes stopping the seizure activity with anticonvulsant medications (e.g., diazepam [Valium], lorazepam [Ativan], phenytoin [Dilantin]).

After the airway is secured with oral or nasal adjuncts (or intubation of the patient's trachea during the flaccid period between seizures), oxygen should be administered in high concentration and ventilation should be supported with a bag-valve device. An IV line should be established to keep the vein open, and secured well with tape and roller bandage. A sample of the patient's blood should be drawn for laboratory analysis (per protocol). With authorization from medical direction, administration of the following medications may be considered:

- 50% dextrose by slow IV infusion (controversial unless hypoglycemia is suspected) to replace blood glucose lost during seizure activity or correct hypoglycemia that caused the seizure.

- Administration of lorazepam (Ativan) IV or diazepam (Valium) IV to stop the spread of the seizure focus; seizure activity may require phenytoin (Dilantin).

While administering anticonvulsants, the paramedic should closely monitor the patient's blood pressure and respiratory status and be prepared for aggressive airway control and ventilatory assistance. If the patient's blood pressure begins to fall or if the respiratory rate or effort decreases, drug therapy should cease and the paramedic should consult with medical direction.

LESSON 2_06 MONITORING VITAL SIGNS

Vital signs generally are considered to include pulse, blood pressure, respirations, skin condition, and pupil size and reactivity.

Pulse

A normal resting pulse rate for an adult is usually between 60 and 100 beats per minute; it may be affected by the patient's age and physical condition. A child's pulse rate may be 80 to 100 beats per minute, for example, and a well-trained athlete's pulse rate may be 50 to 60 beats per minute. Factors such as pregnancy, anxiety, and fear also may produce a higher-than-normal pulse rate in healthy individuals.

Pulse rates may be obtained at the carotid artery in the neck or at any pulse site where the artery lies close to the skin surface. To evaluate the radial pulse, the pads of the paramedic's index and middle fingers are placed at the distal end of the patient's wrist, just medial to the radial styloid. If pulsations are regular, they should be counted for 15 seconds and multiplied by four to determine the number of beats per minute. In addition to the number of times the heart beats per minute, the regularity and strength of the pulse should be assessed. For example, the pulse can be characterized as regular or irregular, weak or strong. Application of an ECG monitor also may be useful in evaluating cardiovascular status after initial assessment of the pulse.

Blood pressure

The systolic blood pressure is the reading that identifies the amount of pressure exerted against the arterial walls when the heart contracts. Diastolic blood pressure is the amount of pressure exerted against the arterial walls during relaxation of the heart. For all age groups, normal systolic blood pressure is considered to be less than 140 mm Hg; normal diastolic pressure should be less than 90 mm Hg.

Blood pressure is best measured by auscultation. The blood pressure cuff is placed on the patient's arm with the lower end of the cuff positioned 1 to 2 inches (2 to 5 cm) above the antecubital space. The cuff is inflated to a point approximately 30 mm Hg above where the brachial pulse can no longer be palpated. The stethoscope is placed over the brachial artery, and the cuff is slowly deflated at a rate of 2 to 3 mm Hg per second. As the pressure falls, the paramedic should observe the gauge and note where the first sound or pulsation is heard. This is the patient's systolic pressure. The point at which the sounds change in quality or become muffled is noted as the patient's diastolic pressure.

Determining accurate diastolic pressure sometimes is difficult. The difference between the point of muffled tones and the complete disappearance of pulsations varies by individual. In some persons the difference is a few mm Hg; at the opposite end of the range are people whose pulsations never totally disappear. The ability to measure accurate diastolic pressures develops from experience and requires careful listening in a quiet environment.

Blood pressure may be estimated by palpation when vascular sounds are difficult to hear with a stethoscope because of environmental noise, but this method is less accurate than auscultation and can only estimate systolic pressure. To estimate blood pressure by palpation, the paramedic should locate the brachial or radial pulse and apply the blood pressure cuff as previously described. Finger contact is maintained at the pulse location as the cuff slowly deflates. When the pulse becomes palpable, the gauge reading denotes the systolic pressure. Like pulse rates, a patient's blood pressure may be unusually high because of fear or anxiety. Other factors, such as a patient's age and normal level of physical activity, may be responsible for unusual blood pressure readings.

Respirations

The normal respiratory rate for adults is between 12 and 24 breaths per minute. The respiratory rate is obtained by watching the patient breathe, by feeling for chest movement, or by auscultating the patient's lungs. The paramedic should count the patient's respirations for 30 seconds and multiply by two to determine breaths per minute. Rhythm and depth of respirations are assessed by visualization and auscultation of the thorax. Abnormal findings include shallow, rapid, noisy, or deep breathing; asymmetrical chest wall movement; accessory respiratory muscle involvement; or congested, unequal, or diminished breath sounds.

Skin

Skin colour, temperature, and moisture provide additional information about the patient's status. As previously discussed, a patient's skin colour and the presence of bruises, lesions, or rashes may indicate serious illness or injury.

Skin temperature may be normal (warm), hot, or cold. Skin that is hot to the touch indicates a possible fever or heat-related illness or injury. Cold skin may indicate decreased tissue perfusion and cold related illness or injury. The dorsal surface of the hand is more sensitive than the palmar surface and should be used to estimate body temperature. Body temperature can be measured more accurately by applying plastic heat-sensitive tape to the patient's skin or by using standard mercury clinical thermometers, electronic thermometers, or tympanic membrane thermometers. Evaluations of body temperature may have specific applications in emergencies, such as febrile seizures and hyperthermic and hypothermic emergencies.

Many EMS services use tympanic membrane thermometers or electronic thermometers that obtain readings within seconds. With a standard thermometer, temperature readings are obtained by placing the thermometer under the conscious patient's tongue for 4 to 6 minutes, under the patient's armpit for 10 minutes, or in the patient's rectum for 5 to 8 minutes. (Rectal readings provide the most accurate assessment but may be impractical for prehospital use.) Normal body temperature is 37°C (98.6°F). Standard clinical thermometers record body temperatures from 34.4°C (94°F) to 40°C (106°F).

Skin moisture usually is classified as dry (normal) or wet (clammy or diaphoretic). Diaphoretic skin may indicate a homodynamic deficit, such as hypovolemia, or another illness or injury that results in decreased tissue perfusion or increased sweat gland activity. Examples are cardiovascular and heat-related emergencies, respectively.

Pupils

Examining the pupils for response to light may yield information on the neurological status of some patients. Normally, the pupils are equal and constrict when exposed to light. (The acronym PERRL indicates that the pupils are equal, round, and react to light.) When testing the pupils for light response, the paramedic shines a penlight directly into one eye. The normal reaction is for the pupil exposed to the light to constrict with a consensual constriction of the opposite eye.

LESSON 2_07 FIRST AID KITS AT DIVING OPERATION SITES

- Airways
  - Nasal
  - Oral airways
    - Berman Oral Airway Kit
    - Color Coded Guedel Airway Kit
- Ammonia Inhalants
- Aspirators (suction)
  - Res-Q-Vac Hand Powered Emergency Suction
- Bag Valve Mask (BVM) Resuscitators
- Bags (equipment)
  - Pacific Emergency Products bags and cases
  - Professional Nylon Medical Bags
- Bandages and dressings
  - Butterfly closures
  - Compression
  - Elastic
  - Gauze
  - Occlusive dressing
    - ACS™ (Asherman Chest Seal)
    - Sterile aluminum foil
  - Triangular
- Betadine solution
- Blankets
  - Polyester blanket (72" x 90")
  - Emergency blanket (aluminized)
  - Sterile burn sheet
- Blood pressure cuffs (aneroid sphygmomanometers)
- Butterfly closures
- Cannula, nasal
- Cervical collars
- CPR mask
  - CPR barrier mask
  - CPR PTP Valve-Mask
  - RespAide CPR Isolation Mask
- Extrication collars
- Eyewash stations
- Eyewear
- Field guides (see Reference material below)
- First Aid kits
  - Plastic case first aid kits
  - Outdoor first aid kits in soft cases
  - Rescue Response Kit
  - Dia-Pak diabetics carrying cases
  - Sawyer Extractor snake bite and sting kit
- First Responder emblems: pin and patch
  - Emergency Medical Technician patch

    - EMT Rescue patch
- Flashlight (penlight)
    - Aluminum flashlights (D cell)
- Gauze pads and rolls
- Gloves
- Holster sets
    - EMT padded nylon holster set with tools
    - First Responder holster set with stethoscope and shears
- Nasal cannula
- OB kits
    - Foil baby bunting
- Oral glucose (Insta-Glucose)
- Oxygen system
- Patches:
    - Emergency Medical Technician patch
    - EMT Paramedic *Fallen Brothers* 9-11 patch
    - EMT Rescue patch
    - First Responder patch
- Personal protection products
- Reference material
    - Field Guides for EMS/EMTs (Jones and Bartlett Publishers)
    - ALS Version EMS Field Guide
    - Basic & Intermediate Version EMS Field Guide
    - Fire & Rescue Field Guide
    - First Responder Patient Information Field Notes
    - Advanced Life Support Patient Information Field Notes
    - Emergency & Critical Care Pocket Guide
    - Survival Spanish for EMS: A Pocket Field Guide for EMS Professionals
- Rescue Response Kit (EMT/First Responder first aid kit)
- Resuscitators
    - BVM (Bag Valve Mask)
- Scissors (bandage, EMT/EMS)
- Seat belt cutter
- Splints
    - SAM splint
    - Rolled Wire Splint
    - Ladder Splint
- Stethoscopes
- Suction devices/equipment:
    - Res-Q-Vac Hand Powered Emergency Suction
- Tape
- Tongue depressors
- Tools:
    - 4-in-1 Emergency tool
    - 4-in-1 S.O.S. Emergency hammer (w/seat belt cutter)
    - EMT padded nylon holster set with tools
    - First Responder holster set with stethoscope and shears
    - Seat belt cutter
    - Window punch
- Towelettes, antimicrobial
- Window punch

LESSON 3_03 CATHETERIZATION

Passing a Urinary Catheter

Learning Objectives:

To be confident and competent to catheterise the bladder safely with minimum distress to the patient.

To be aware of the anatomical abnormalities which may have led to urinary retention and how these may impact on the procedure.

To be able to formulate a plan in the event of failure to catheterise the bladder.

Equipment

Clean procedure trolley with 'catheter pack' or similar

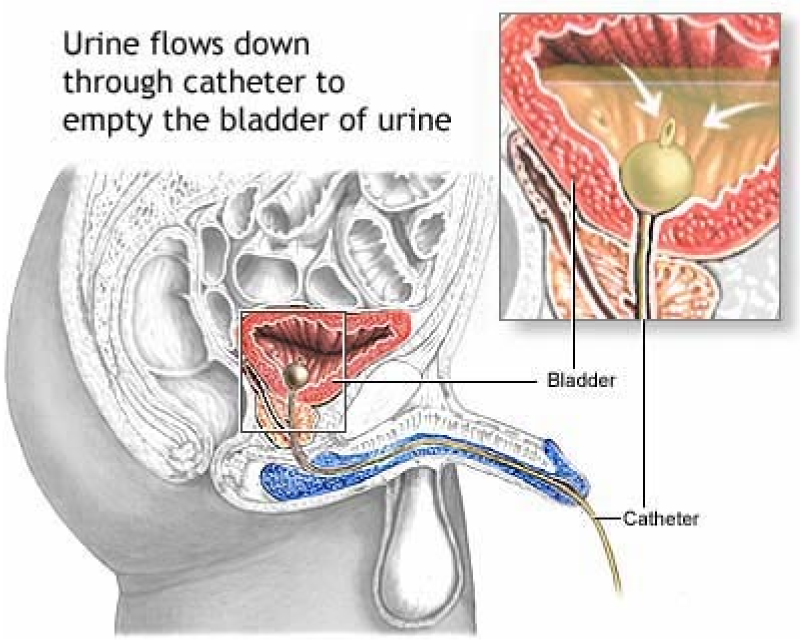
Selection of sizes of Foley catheters (from 12 to 16 French)

Savlon type skin prep. (NOT iodine, NOT spirit)

Saline and 10 ml syringe to fill balloon.

Topical lignocaine gel

Procedure male



Introduce yourself. Explain what you are going to do and why. Listen to the patients concerns.

Wash and dry hands with liquid soap or alcohol rub.

Wearing sterile gloves and set-up the 'catheter pack' aseptically.

Place sterile towels across the patient's thighs and under buttocks.

Place a collecting vessel for urine between the patient's legs.

Wrap a sterile swab around the penis and use this to hold the shaft without contaminating your gloves. Retract the foreskin, if necessary, and clean the glans penis with saline or antiseptic (Savlon type) solution.

Instil all the 10mls of 2% lignocaine gel into the urethra to achieve topical anaesthesia.

Hold the urethral meatus of the glans penis firmly closed to prevent the gel being released and wipe the underside of the penile shaft in a downward direction several times with a dry swab to move the gel towards the prostatic urethra. Wait 2-3 mins for the anaesthetic to work.

Grasp the shaft of penis with the non-dominant hand, raising it until totally extended.

Hold the catheter in the dominant hand and gently pass it into the urethral meatus. Continue slowly and smoothly to pass the catheter through the urethra into the bladder. If resistance is felt at the prosthetic urethra/sphincter region, ask the patient to relax the muscle as if he were going to void urine or cough.

Once the urine starts to flow, pass the catheter a further 5 cm to ensure balloon is in the bladder before slowly inflating the balloon with 10mls of sterile water or saline.

Pull the catheter gently. It should withdraw a few cm until the balloon prevents further egress.

Attach catheter to appropriate draining system and tape catheter laterally to thigh.

Ensure that the glans penis is clean and then reposition the foreskin.

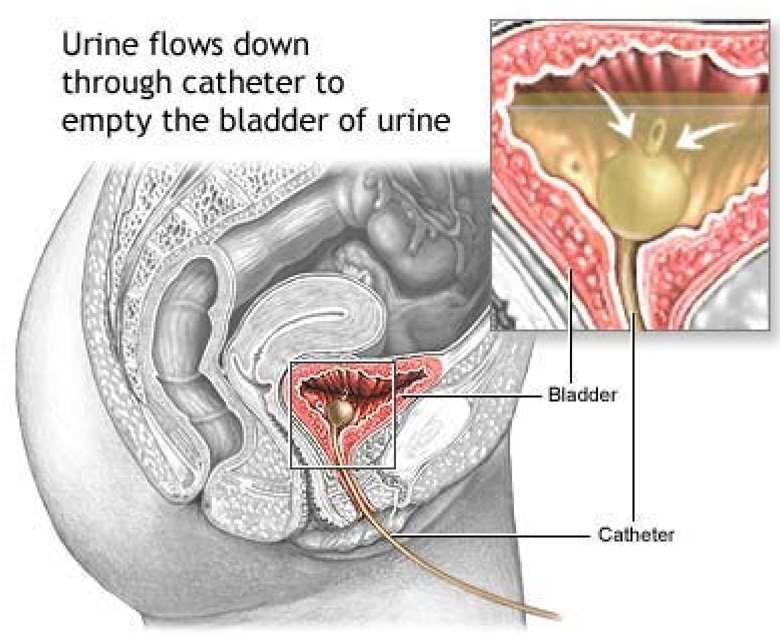
Make the patient comfortable and thank him for his co-operation.

Dispose of waste materials in yellow clinical waste bag.

Wash hands.

Record procedure in patient's notes.

Procedure female



Introduce yourself and explain what you are going to do and why.

Wearing double sterile gloves, place sterile towels across the patient's thighs and under the buttocks.

Place a collecting vessel for urine between the patient's legs.

Separate the labia minora so that the urethral meatus is seen, Using non-lint gauze swabs, one hand should be used to maintain labial separation until catheterisation is completed.

Clean around the urethral orifice with normal saline or an antiseptic solution, using single downward strokes, discarding the swab after each stroke.

Discard outer gloves.

Lubricate the catheter with a sterile anaesthetic lubricating jelly.

Introduce the tip of the catheter into the urethral orifice in an upward and backward direction.

Advance the catheter until 5-6cms have been inserted.

Advance the catheter 6-8cms.

Inflate the balloon according to the manufacturer's instructions, having ensured that the catheter is draining adequately.

Withdraw the catheter slightly and connect it to the drainage system.

Tape the catheter and drainage system to the thigh.

Make the patient comfortable and ensure that the area is dry.

Thank the patient for their co-operation

Dispose of equipment in a disposable plastic bag.

Make an entry in the notes detailing the procedure.

Check points

Male: If it is not possible to advance the catheter up the urethra, do not force it. Try a smaller size or stiffer catheter. Re-orientate the penile shaft and try again. If it is still impossible, specialist assistance may be required. If catherisation is a matter of urgency in an obstructed patient, and attempts per urethram have failed, you should consider and plan for (but not attempt yourself) a percutaneous suprapubic catheterisation.

Female: In a large patient, it may be difficult to separate the legs and labia and hold the catheter single-handedly. Request assistance to act as another pair of hands to part the labia.

It is important not to inflate the balloon unless you are sure it is well inside the bladder and not inside the urethra. Once inflated, ability to withdraw the catheter a few cm before it comes to a halt confirms that the balloon is correctly positioned. If you cannot do this, deflate the balloon and reposition.

Bladder emptying .Rapid emptying of a chronically distended and obstructed bladder may cause autonomic disturbance and may even disrupt the bladder epithelium causing haematuria. Consequently, in these circumstances the bladder should be drained slowly and in stages.

LESSON 3_04 METHOD OF COMMUNICATING WITH MEDICAL SERVICES

International phone and fax communication is needed, as well as base to-well site radio communication. Generally, a communication system exists to support operations prior to the blowout. This communication system forms the nucleus for an expanded system that is needed to control a blowout. Pre-planning for expanded communication capability when setting up the system for normal operations is needed. Capability to have additional telephone lines, microwave and radio frequencies should be built into original communication plans for an area. Communication equipment and computers require an uninterruptible power system (UPS) if generator power is used.

Onsite. Site communication is best handled with 5-Watt, intrinsically safe handheld radios. Head sets that work under hard-hats in high noise environments are available. Many radios and multiple channels may be required for large operations. Use of repeaters can give low-power FM radios good range in flat areas.

Long distance. If the support base is distant, it may require repeaters or larger 25 to 30-Watt radios that work with 5-Watt radios, but have greater range. More powerful FM radios are generally used in base or vehicle mounts. Single side band (SSB) or short wave radios can communicate over greater distances. Use of radios and allowable frequencies are con trolled by many governments. Operators should fully understand local regulations . International. Fax capability over radio exists and can be effective if the right equipment is used. If existing international phone capability does not exist at the well site, portable satellite systems are available for rent or purchase that can be carried in by blowout specialists. These systems are remarkably compact and can be checked as luggage. Essentially, these systems are an international phone and fax in a suitcase.

Communications

A first-class system of communications is very important in offshore medicine. There should be a direct link between whoever is managing the case offshore (normally a rig medic) and the doctor onshore.

Any communication by voice should always be followed by an exchange of telexes to prevent misunderstandings. Communicating by telex gives thinking time to both parties, allows for the careful formation of the message, helps to eliminate ambiguity and provides a permanent record of the management of the case for future analysis and reference.

There are occasions, though, when medical discussions which can be relayed by telex are difficult to transmit initially by voice. Problems with radio communication include poor quality of transmission, the degree of privacy of the conversation and whether the participants in the conversation know each other well enough to be relaxed.

It cannot be overemphasized that the medical link between the man managing the casualty offshore and the onshore doctor supporting him must, if possible, be direct.

Communicating with the doctor

It is very important that the doctor is given relevant, accurate information about the casualty. He can then decide what treatment is best for the casualty. For example, if he is asked about a man with a severe headache and given no more information, the doctor may tell the first aider to give the patient two aspirins and report back in the morning. That would be the correct decision if the headache resulted from eye strain or fatigue but it may cost a young man his life if the headache is caused by a slow internal haemorrhage from a blood vessel in his head. Such a disaster could be prevented by sending everyone who has a headache ashore, but each time this is done the

emergency helicopter costs would be roughly equivalent to at least one year's salary for a rig worker.

Another example of bad communication occurred one winter morning in 1982 when there was a call for a doctor from a ship in the northern North Sea because a man had been shot. No other relevant details were given. In atrocious weather conditions a doctor, a very experienced rig medic and four others took off in a helicopter on an errand of mercy. The helicopter ditched and they were all killed, while the shot man was little the worse for his experience having only sustained a trivial air-hose injury.

To help prevent such misunderstandings, it is vital to practise communication techniques.

Communication with saturation divers

This is a special and more difficult problem because the sick diver and his attendants are locked in a pressure chamber, and the helium in the breathing mixture distorts the voice. The chain of communication will be longer because more people are involved, and so even greater care must be taken to report everything accurately. See page 178 for more details about communicating with divers.

Future developments

Medical conferencing with slow-scan television and telemedicine via satellite systems is already in limited use but may become widely employed in offshore health care over the next few years. When this technology is fully developed it should be possible for medical personnel onshore to monitor the heart's activity by means of electrocardiogram (ECG) tracings, and to see X-ray pictures and even the patient on a television screen. Much of this technology was originally developed for space exploration.

LESSON 3_05 ADMINISTRATION OF OXYGEN

Oxygen Delivery Devices

Several oxygen delivery devices can be used to provide supplemental oxygen to prehospital patients who have spontaneous respirations. They are the nasal cannula, simple face mask, partial rebreather mask, nonrebreather mask, and Venturi mask (Table 11-3).
The nasal cannula delivers low-concentration oxygen to patients by way of two small plastic prongs placed into the nostrils. Nasal canulae are contraindicated for patients with poor respiratory effort, severe hypoxia, and apnea and for those who breathe primarily through the mouth. As a rule, the nasal cannula is well tolerated, but it does not deliver high volume/high concentration oxygen.

The simple face mask is a soft, clear plastic mask that conforms to the patient's face.

Small perforations in the mask allow atmospheric gas to be mixed with oxygen during inhalation and permit the patient's exhaled air to escape. Oxygen concentrations of 35% to 60% can be delivered through this device with a flow rate of 6 to 8 L/min. Because a flow rate of less than 6 L/min can produce an accumulation of carbon dioxide in the mask, oxygen delivery through any face mask should always exceed this minimum. Flow rates beyond 10 L/min do not enhance oxygen concentration.

The partial rebreather mask has an attached oxygen reservoir bag that should be filled before the patient uses the mask. This device has vent ports covered by one-way disks that allow a portion of the patient's exhaled gas to enter the reservoir bag and be reused. The remainder of the carbon dioxide-loaded gas escapes to the atmosphere. Oxygen concentrations of 35% to 60% can be delivered with a flow rate that prevents the reservoir bag from collapsing completely on inspiration. Partial rebreather masks are contraindicated for patients with apnea or poor respiratory effort. As with the simple face mask, delivery of volumes above 10 L/min through this device does not enhance oxygen concentration.

The nonrebreather mask is similar in design to the partial nonrebreather. However, a flutter valve assembly in the mask piece prevents the patient's exhaled air from returning to the reservoir bag. This device delivers oxygen concentrations ranging above 95% with an adequate flow rate that keeps the reservoir bag partly inflated during inspiration. The paramedic should ensure that the mask is seated firmly over the patient's mouth and nose and that the reservoir bag is never less than two thirds full. This device most commonly is used in patients who require high-concentration oxygen delivery (10 to 15 L/min). Like other masks, it is contraindicated for patients with apnea or poor respiratory effort.

The Venturi mask is a high-airflow oxygen entrainment delivery device that delivers a precise fraction of inspired oxygen (FIO^2) at typically low concentrations. The device was originally designed to deliver 30% to 40% concentrations but has since been adapted to deliver higher oxygen percentages. The Venturi mask uses "jet mixing" of atmospheric gas and oxygen to achieve the desired mixture.

Various sized color-coded adapters are attached to the mask to control the oxygen flow rate. (Standard size adapters are 3-, 4-, and 6-L/min.) The color codes and adapters state the exact liter flow to use to obtain the precise Fio2. Choosing a different liter flow drastically alters the Fio2 delivered. The various Venturi masks deliver 24% to 50% oxygen and are recommended for patients who rely on a hypoxic respiratory drive (e.g., those with chronic obstructive pulmonary disease). The main benefit of the Venturi mask is that it allows precise regulation of Fio2. In addition, its use permits the paramedic to titrate oxygen for the patient with COPD so as not to exceed the patient's hypoxic drive while allowing enrichment of supplemental oxygen.

Ventilation

Patient ventilation can be provided by several methods in the prehospital setting, including rescue breathing (mouth to mouth, mouth to nose, mouth to stoma), mouth to mask breathing, bag-valve devices, flow-restricted oxygen-powered ventilation devices, and automatic transport ventilators.

Rescue Breathing

As previously discussed, inspired air has an oxygen concentration of about 21%. Of this 21% approximately 4% is used by the body, and the remaining 17% is exhaled. Ventilation by rescue breathing can accordingly provide adequate oxygenation to a patient with respiratory insufficiency.

The advantages of rescue breathing are that it requires no equipment and it is immediately available. The disadvantages are the limitation of the vital capacity of the rescuer (about 800 to 1200 mL are needed to effectively ventilate an adult patient) and the low concentration of oxygen in expired air compared with other methods of ventilation with supplemental oxygen delivery. It also may be difficult for the rescuer to force air past obstructions in the airway. A risk exists of disease transmission through direct body fluid contact and of unknown communicable disease at the time of the event. Complications common to all rescue breathing techniques include the following:

• Hyperinflation of the patient's lungs

• Gastric distention

• Blood/body fluid contact concerns

• Rescuer hyperventilation

Mouth-to-Mouth Method

The following guidelines should be observed when delivering ventilations mouth to mouth:

1. If no spinal injury is suspected, position the patient with optimal head-tilt and chin-lift. (If spinal injury is suspected, maintain in-line stabilization and maintain an open airway through the jaw-thrust without head-tilt technique, described later in this chapter.) If necessary, clear the airway of vomitus, body fluids, and foreign objects.

   Pinch the patient's nostrils closed.

   Inhale a deep breath.

4. Seal your mouth over the patient's mouth, which should be slightly open.

   Exhale into the patient's mouth until the chest rises and resistance is produced by the patient's lung expansion.

6. Break contact with the patient's mouth to allow for passive exhalation.

7. Repeat the process, providing a full ventilation of 800 to 1200 mL (1 1/2 to 2 seconds in duration) every 5 to 6 seconds as needed.

Mouth-to-Nose Method

Mouth-to-nose ventilation is very similar to the technique described for mouth-to-mouth rescue breathing. The differences in the mouth-to-nose method are as follows:

- If no spinal injury is suspected, one hand must be kept on the patient's forehead to maintain an open airway while the rescuer's other hand is used to close the patient's mouth. (If a spinal injury is suspected, the jaw-thrust without head-tilt technique should be used, and the rescuer's cheek is used to seal the patient's mouth.)
- The patient's nose is left open.
- The rescuer's mouth is placed over the patient's

  nose with as tight a seal as possible.
- During passive exhalation by the patient, the rescuer's mouth is removed from the patient's nose and the patient's mouth is opened for exhalation. The head-tilt or jaw-thrust position must be maintained to ensure an open airway.
- Mouth-to-nose ventilation may be appropriate for patients who have injuries to the mouth and lower jaw and for patients with missing teeth or dentures (which makes a tight seal around the mouth difficult). It also may overcome psychological barriers in having mouth-to-mouth contact with a patient

Mouth-to-Mask Devices

Mouth-to-mask devices have become popular as an alternative to mouth-to-mouth methods of ventilation. These masks are of a clear, flexible construction and are available with one-way valves, bacterial filters, and ports for supplemental oxygen delivery (Fig. 11-23). They are produced by a number of manufacturers and are available in a variety of sizes. The mouth-to-mask technique offers several advantages:

- It eliminates direct contact with the patient's mouth and nose.
- Supplemental oxygen delivery is possible.
- The one-way valve eliminates exposure to exhaled gases and sputum.
- It is easy to apply.
- It provides more effective ventilation than the mouth-to-mouth method or a bag-valve-mask device.
- It is aesthetically more acceptable than mouth-to-mouth ventilation.

Technique

The mask device can be used in patients with or without spontaneous respirations. If immediately available, mouth-to-mask is the preferred method of initial. To apply the mask, follow these steps:

1. If no spinal injury is suspected, position the patient with optimal head-tilt and chin-lift. The use of an oropharyngeal or nasopharyngeal airway is indicated in an unconscious patient. (If a spinal injury is suspected, spinal precautions should be used.)

2. Connect the one-way valve to the mask. Oxygen tubing should be connected to the inlet port with an oxygen flow rate of 15 L/min. Using supplemental oxygen provides a higher concentration of oxygen in the inspired air. An oxygen flow rate of 10 L/min, combined with rescuer ventilations, can supply an oxygen concentration of 50%. An oxygen flow rate of 15 L/min provides an inspired oxygen concentration of about 80%.

3. Position yourself at the patient's head. If necessary, clear the airway of secretions, vomitus, and foreign objects. Place the mask on the patient's face, creating an airtight seal. With the thumb side of the palm of both hands, apply pressure to the sides of the mask. Apply upward pressure to the

mandible just in front of the ear lobes, using the index, middle, and ring fingers of both hands while maintaining head-tilt.

Blow into the opening of the mask, observing chest rise and fall. If available, a second rescuer should apply cricoid pressure (Sellick's maneuver) to help prevent gastric inflation during positive pressure ventilation and to reduce the possibility of regurgitation and aspiration

Remove the mask from the patient's face to allow for passive exhalation.

Bag-Valve Devices

Bag-valve devices consist of a self-inflating bag and a nonrebreathing valve.

They can be used with a mask, an ET tube, or another invasive airway device. An adequate bag-valve unit should have (1) a self-refilling bag that is disposable or easily cleaned or sterilized, (2) a nonjam valve system that allows a minimum oxygen inlet flow of 15 L/min, (3) a nonpop-off valve, (4) standard 15- and 22-mm fittings, (5) a system for delivering high-concentration oxygen through an inlet port at the back of the bag or by an oxygen reservoir, and (6) a nonrebreathing valve.

The device also should perform under all common environmental conditions and extremes of temperature and should be available in both adult and pediatric sizes.

When the bag-valve device is compressed, air is delivered to the patient through a one-way valve. The air inlet to the bag is closed during delivery. When the bag is released, the patient's expired gas passes through an exhalation valve into the atmosphere, preventing the patient's gas from reentering the bag-valve device. As the patient exhales, atmospheric air and supplemental oxygen from the reservoir refill the bag.

Use of the bag-valve device with a mask is difficult because of the problem of creating an effective mask seal on the patient's face while maintaining an open airway. For this reason, a bag-valve-mask device should be used only by well-trained and experienced personnel. It has been recommended that two rescuers use the device, one holding the mask and maintaining the airway while the second compresses the bag with two hands. If three rescuers are available, one rescuer can be solely responsible for maintaining the mask seal while providing spinal precautions as indicated.

When properly used, the bag-valve device has many benefits. The rescuer can provide a wide range of inspiratory pressures and volumes to adequately ventilate patients of varying sizes and underlying pathological conditions: It can be used to assist patients with shallow respirations, it performs adequately in extremes of environmental temperatures, and oxygen concentrations ranging from 21% (room air concentration) to nearly 100% (using supplemental oxygen and a reservoir) can be achieved. In addition, manual compression of the bag can give the rescuer a sense of the patient's lung compliance, which is an advantage over mechanical methods of ventilation (e.g., the demand valve).

Technique

Ventilation with the bag-valve device is best accomplished when the patient has been intubated. If the patient has not been intubated, the bag-valve device may be used with a mask. The following technique is recommended for use with the bag-valve-mask (BVM) device:

1. The rescuer is positioned at the top of the patients head

If no spinal injury is suspected, the patient should be in the optimal head-tilt chin-lift position, and the patient's head should be elevated in extension. If a spinal injury is suspected, spinal precautions should be used.

3. If necessary, the airway should be cleared of secretions, vomitus, and foreign objects. If the patient is unconscious, an oropharyngeal or nasopharyngeal airway should be inserted. The patient's mouth should remain open under the mask.

4. An oxygen source is connected, and the reservoir

is flushed with high-concentration oxygen.

The mask is placed on the patient's face, making a tight seal. This can be accomplished by placing the thumb on the nose area, placing an index finger on the chin, and spreading the remaining fingers along the mandible. The anterior displacement of the mandible must be maintained. To compress the bag, the rescuer's other hand presses the bag against his or her body (e.g., the thigh), or another rescuer compresses the bag with two hands as recommended by the American Heart Association (AHA). The bag should be compressed smoothly, delivering 10 to 15 mL/kg of air (800 to 1200 mL for the average adult) over 2 seconds. (A third rescuer may provide cricoid pressure.)

Flow-Restricted, Oxygen-Powered Ventilation Devices

Flow-restricted, oxygen-powered ventilation devices allow for positive-pressure ventilation, delivering nearly 100% oxygen with a tight mask seal. These devices consist of high-pressure tubing that connects to an oxygen supply (under pressure of 50 psi). They are easily connected to a mask, tracheostomy tube, esophageal airway, or ET tube. A valve on the device is activated by a lever or push button, allowing oxygen to flow to the patient.

Oxygen-powered, manually triggered devices should provide (1) a constant flow rate of 100% oxygen at less than 40 L/min, (2) an inspiratory pressure relief valve that opens at 60 to 80 cm of water and vents any remaining volume to the atmosphere or stops gas flow, (3) an audible alarm that sounds whenever the relief valve pressure is exceeded to alert the rescuer that the patient requires high inflation pressures and may not be receiving adequate ventilatory volumes, (4) satisfactory operation under environmental extremes, and (5) a demand flow system that does not impose additional work.

When using these devices, the paramedic must be alert for adequate rise and fall of the patient's chest, making sure not to deliver too much or too little ventilatory volume. Gastric distention is common because of the high inspiratory flow rates. Therefore the paramedic must carefully observe the patient for signs of a distended abdomen, which could lead to regurgitation and aspiration. Many oxygen-powered breathing devices have restricted flow rates of 40 L/min and require unacceptably high triggering pressures in the demand mode. This type of device can be used in the spontaneously breathing patient. The valve is opened by the negative pressure generated by the inspiratory effort of the patient; flow ceases when the negative pressure ends.

Automatic Transport Ventilators

Several time-cycled, gas-powered, automatic transport ventilators (ATVs) are available for field use or intrahospital transport when caring for patients who require ventilatory support Most of these ventilators consist of a plastic control module connected by tubing to any 50-psi gas source (e.g., air or different concentrations of oxygen, including 100% oxygen). The exit valve of the control module is connected by one or two tubes (based on the model) to the patient valve assembly to deliver selected tidal volumes (400 to 1200 mL for adults, 200 to 600 mL for children). Another control selects respiratory rates from 8 to 22 breaths per minute for adults and 8 to 30 breaths per minute for children. (Most ATVs are not to be used in children under 5 years of age.) Most units provide a 40 L/min flow of oxygen, which remains constant regardless of changes in the patient's airway or lung compliance.

The volume of gas delivered by the automatic ventilator is determined by the length of time the manual trigger is depressed or by the inspiratory effort of the spontaneously breathing patient. Most units are designed to limit the inspiratory pressure to 60 to 80 cm of water. When this pressure is reached, an audible alarm sounds, and excess gas flow is vented off, preventing possible lung damage. ATVs allow the paramedic to use both hands to obtain a tight mask seal on a patient who has not been intubated and to perform other tasks when the ventilator is used with ET intubation. Cricoid pressure also can be applied with one hand while the other hand seals the mask on the face. Most ATVs are contraindicated for patients who are awake, who have obstructed airways, and or who have increased airway resistance (e.g., pneumothorax, asthma, pulmonary edema).

LESSON 3_013_02 SYSTEMATIC EXAMINATION OF THE ILL OR INJURED DIVER

The diver medic technician must have a wide range of knowledge and skills to perform a comprehensive physical examination and to make effective clinical patient care decisions. This chapter presents the techniques of a general physical examination and discusses the relevant pathophysiological significance of the physical findings. Some of the examination techniques presented in this chapter will not routinely be used when assessing patients in the prehospital setting. Although some techniques will have application to examinations performed on the diving site, others will more likely be performed in the expanded scope of practice activities.

Physical Examination: Approach and Overview

The physical examination consists of examination techniques, measurement of vital signs, an assessment of height and weight, and the skillful use of examination equipment.

Examination Techniques

The examination techniques commonly used in the physical examination are inspection, palpation, percussion, and auscultation. These terms are referred to frequently throughout this text as they relate to the evaluation of specific body systems. Depending on the situation, these examination techniques may be the sole method available for patient evaluation (e.g., assessment of an unconscious trauma patient) or may be integrated with history taking and other patient care procedures. If time permits, the Diver medic should explain each examination technique that requires touch to the patient before initiating it.

Inspection

Inspection is the visual assessment of the patient and surroundings. This examination technique can alert the paramedic to the patient's mental status and possible injury or underlying illness. Patient hygiene, clothing, eye gaze, body language, body position, skin colour, and odour are significant inspection findings. If the emergency response was to the patient's home, the Diver medic should make a visual inspection for cleanliness, prescription medicines, illegal drug paraphernalia, weapons, and signs of alcohol use. These and other observations can play an important role in determining patient care activities.

Palpation

Palpation is a technique in which the Diver medic uses the hands and fingers to gather information by touch. Generally, the palmar surface of the fingers and the finger pads are used to palpate for texture, masses, fluid, and crepitus, and to assess skin temperature. Palpation may be either superficial or deep; the applications for each are addressed throughout this chapter. Examining a patient by palpation is a form of invasion of the patient's body, so the approach should be gentle and initiated with respect.

Percussion

Percussion is used to evaluate the presence of air or fluid in body tissues. The technique is performed by the Diver medic's striking one finger against another to produce vibrations and sound waves of underlying tissue. Sound waves are heard as percussion tones (resonance) and are determined by the density of the tissue being examined. The denser the body area, the lower the pitch of the percussion tone. To percuss, the Diver medic places the first joint of the middle finger of the dominant hand on the patient, keeping the rest of the hand poised above the skin. The fingers of the other hand should be flexed and the wrist action loose. The wrist of the dominant hand is then snapped downward with the tip of the middle finger tapping the joint of the finger that is on the body surface. The tap should be sharp and rigid, percussing the same area several times to interpret the tone.

Auscultation

Auscultation requires the use of a stethoscope and is used to assess body sounds produced by the movement of various fluids or gases in the patient's organs or tissues. Auscultation is best performed in a relatively quiet environment where attention can be focused on each body sound being assessed. The Diver medic should isolate a particular area to note characteristics of intensity pitch, duration, and quality. In the prehospital setting, auscultation is most often used to assess blood pressure and to evaluate breath sounds, heart sounds, and bowel sounds. To auscultate, the diaphragm of the stethoscope should be placed firmly against the patient's skin for stabilization. If a bell endpiece is used, it should be positioned lightly on the body surface to prevent the damping of vibrations.

Examination Equipment

Equipment used during the comprehensive physical examination includes the stethoscope, ophthalmoscope, otoscope, and blood pressure cuff. The ophthalmoscope and otoscope are "nontraditional" EMS tools that are being introduced to the Diver medic with expanded scope of practice. These devices will not routinely be used when assessing patients in the prehospital setting.

Stethoscope

The stethoscope is used to evaluate sounds created by the cardiovascular, respiratory, and gastrointestinal systems. There are three major types of stethoscopes: acoustic stethoscopes, magnetic stethoscopes, and electronic stethoscopes.

Acoustic stethoscopes transmit sound waves from the source to the Diver medic's ears. Most have a rigid diaphragm that transmits high-pitched sounds and a bell endpiece that transmits lowpitched sounds.

Magnetic stethoscopes have a single diaphragm endpiece that contains an iron disc and a permanent magnet. The air column of the diaphragm is activated as magnetic attraction is established between the iron disc and the magnet. A frequency dial adjusts for high-, low-, and full-frequency sounds.

Electronic stethoscopes convert sound vibrations into electrical impulses. These impulses are amplified and transmitted to a speaker where they are converted to sound. These devices may be advantageous for use in the prehospital setting to compensate for environmental noise.

Ophthalmoscope

The ophthalmoscope is used to inspect structures of the eye, including the retina, choroid, optic nerve disc, macula (an oval, yellow spot at the center of the retina), and retinal vessels. The device has a battery light source, two dials, and a viewer. The dial at the top of the battery changes the light image. The dial at the top of the viewer allows for the selection of lenses. (Five lenses are available, but the large white light generally is used.)

Otoscope

The otoscope is used to examine deep structures of the external and middle ear. The device is essentially an ophthalmoscope with a special ear speculum attached to the battery tube. Ear speculums come in a number of sizes to conform to various ear canals. (The Diver medic should choose the largest speculum that fits comfortably in the patient's ear.) The light from the otoscope allows for visualization of the tympanic membrane.

Blood Pressure Cuff

The blood pressure cuff (sphygmomanometer) most commonly is used (along with the stethoscope) to measure systolic and diastolic blood pressure. The common blood pressure cuff used in the prehospital setting consists of a pressure gauge that registers millimeter calibrations, a synthetic plastic cuff with velcro closures that encloses an inflatable rubber bladder, and a pressure bulb with a release valve. Blood pressure cuffs are available in a number of sizes. Adult widths should be one third to one half the circumference of the limb. For children, the width should cover about two thirds of the upper arm or thigh. (Blood pressure cuffs that are too large will give a falsely low reading; cuffs that are too small will give a falsely high reading.)

General Approach to the Physical Examination

The physical examination is performed systematically, with special emphasis placed on the patient's present illness and chief complaint. The Diver medic should remember that most patients view a physical exam with some apprehension and anxiety Often, they will initially feel vulnerable and exposed. Establishing a professional trust early in the Diver medic-patient encounter and ensuring the patient's privacy when possible are very important

Overview of a Comprehensive Physical Examination

The physical examination is a systematic assessment of the body that includes the following components:

Mental status

General survey

Vital signs

Skin

Head, eyes, ears, nose, and throat (HEENT)

Chest

Abdomen

Posterior body

Extremities (peripheral vascular and musculoskeletal)

Neurological exam

Mental Status

The first step in any patient-care encounter is to note the patient's appearance and behaviour and to assess for level of consciousness. A healthy patient is expected to be alert and responsive to touch verbal instruction, and painful stimuli.

Appearance and Behaviour

As previously mentioned, a visual assessment of the patient can provide important information. Abnormal findings may include drowsiness, obtundation, stupor, or coma. A patient who is obtunded is insensitive to unpleasant or painful stimuli from a reduced level of consciousness, usually produced by anesthetic or analgesics. Stupor is a state of lethargy and unresponsiveness. Stuporous patients usually are unaware of their surroundings. Coma is a state of profound unconsciousness. A patient in coma has no spontaneous eye movements, does not respond to verbal or painful stimuli, and cannot be aroused.

Posture, Gait, and Motor Activity

The Diver medic should observe the patient's posture, gait, and motor activity by assessing pace, range, character, and appropriateness of movement. For example, most patients without physical disabilities can walk with good balance and without a limp, discomfort, or fear of falling. Abnormal findings may include ataxia (uncoordinated movement), paralysis, restlessness, agitation, bizarre body posture, immobility, and involuntary movements.

Dress, Grooming, Personal Hygiene, and Breath or Body Odours

Dress, grooming, and personal hygiene should be appropriate for the patient's age, lifestyle, occupation, and socio-economic group. Dress should be appropriate for environmental temperature and weather conditions. (Older adults and children who are improperly dressed for environmental temperatures or who have poor physical hygiene may be victims of neglect by a caregiver.) Medical jewellery (e.g., copper bracelets for arthritis, medical identification insignias) should be noted. Hair, fingernails, and cosmetics may reflect the patient's lifestyle, mood, and personality. These findings can indicate a decreased interest in appearance (e.g., grown-out hair or faded nail polish) that may help estimate the length of an illness.

Breath or body odours can indicate underlying conditions or illness. Examples of breath odours include alcohol, acetone (seen with some diabetic conditions), feces (seen with bowel obstruction), and halitosis from throat infections and poor dental and oral hygiene. Renal and liver disease and poor physical hygiene also may result in body odour.

Facial Expression

Facial expressions may reveal anxiety, depression, elation, anger, or withdrawal. The Diver medic should be alert to changes in facial expression while the patient is at rest, during conversation, during the examination, and when questions are asked. Facial expressions should be appropriate to the situation.

Mood, Affect, and Relation to Person and Things

Like facial expression, the patient's mood and affect should be appropriate to the situation. Mood and affect are expressed verbally and nonverbally. Examples of abnormal findings include an unusual happiness in the presence of major illness, indifference, responses to imaginary people or objects, and unpredictable mood swings.

Speech and Language

Normal speech is understandable and moderately paced. The Diver medic should assess the quantity, rate, loudness, and fluency of the patient's speech patterns. Abnormal findings include aphasia (loss of speech), dysphonia (abnormal speaking voice), dysarthria (poorly articulated speech), and speech and language that changes with mood.

Thought and Perceptions

A healthy person's thoughts and perceptions are logical, relevant, organized, and coherent. Patients should have an insight into their illness or injury and should be able to demonstrate a level of judgment in making decisions or plans about their situation and their care. Although accurately assessing a person's thoughts and perceptions is difficult, the following usually are considered abnormal findings:

Abnormal thought processes

Flight of ideas

Incoherence

Confabulation

Abnormal thought content

- Obsessions
- Compulsions
- Delusions
- Feelings of unreality

Abnormal perceptions

Illusions

Hallucinations

Memory and Attention

Healthy persons normally are oriented to person, place, and time ("oriented times 3"). There are several other methods that can be used to assess a patient's memory and attention. These include asking the patient to count from 1 to 10 using only even or odd numbers (digit span), multiplying by sevens (serial sevens), and spelling simple words backward. The Diver medic also should assess the patient's remote memory (e.g., birthdays), recent memory (e.g., events of the day), and the patient's new learning ability. New learning ability can be evaluated by giving the patient new information (e.g., the year and model of the ambulance) and then later asking the patient to recall that information.

General Survey

After the patient's level of consciousness and mental status have been assessed, a general survey of the patient should be performed. In addition to the assessments described above, the patient should be evaluated for signs of distress, apparent state of health, skin colour and obvious lesions, height and build, sexual development, and weight. Vital signs also should be assessed during the general survey.

Signs of Distress

Obvious signs of distress include those that result from cardiorespiratory insufficiency, pain, and anxiety. Examples of these signs and symptoms are as follows:

Cardiorespiratory insufficiency

Laboured breathing

Wheezing

Cough

Pain

Wincing

Sweating

Protectiveness of a painful body part or area

Anxiety

Restlessness

Anxious expression

Fidgety movement

Cold, moist palms

Apparent State of Health

A patient's apparent state of health can be assessed by observation. The Diver medic should note the patient's general appearance as being acutely or chronically ill, frail, feeble, robust, or vigorous.

Skin Color and Obvious Lesions

Skin color can vary by body part and from person to person. A patient's normal skin color is of course dependent on race and can range in tone from pink or ivory to deep brown, yellow, or olive. Skin color is best assessed by evaluating skin that usually is, not exposed to the sun (e.g., the palms) or skin that has less pigmentation (e.g., lips and nail beds). Obvious skin lesions that car indicate illness or injury include rashes, bruises scars, and discoloration.

Vital Signs

Vital signs generally are considered to include pulse, blood pressure, respirations, skin condition, and pupil size and reactivity.

Pulse.

A normal resting pulse rate for an adult is usually between 60 and 100 beats per minute; it may be affected by the patient's age and physical condition. A child's pulse rate may be 80 to 100 beats per minute, for example, and a well-trained athlete's pulse rate may be 50 to 60 beats per minute. Factors such as pregnancy, anxiety, and fear also may produce a higher-than-normal pulse rate in healthy individuals.

Pulse rates may be obtained at the carotid artery in the neck or at any pulse site where the artery lies close to the skin surface. To evaluate the radial pulse, the pads of the Diver medic's index and middle fingers are placed at the distal end of the patient's wrist, just medial to the radial styloid. If pulsations are regular, they should be counted for 15 seconds and multiplied by four to determine the number of beats per minute. In addition to the number of times the heart beats per minute, the regularity and strength of the pulse should be assessed. For example, the pulse can be characterized as regular or irregular, weak or strong. Application of an ECG monitor also may be useful in evaluating cardiovascular status after initial assessment of the pulse.

Blood pressure.

The systolic blood pressure is the reading that identifies the amount of pressure exerted against the arterial walls when the heart contracts. Diastolic blood pressure is the amount of pressure exerted against the arterial walls during relaxation of the heart. For all age groups, normal systolic blood pressure is considered to be less than 140 mm Hg; normal diastolic pressure should be less than 90 mm Hg.

Blood pressure is best measured by auscultation. The blood pressure cuff is placed on the patient's arm with the lower end of the cuff positioned 1 to 2 inches (2 to 5 cm) above the antecubital space. The cuff is inflated to a point approximately 30 mm Hg above where the brachial pulse can no longer be palpated. The stethoscope is placed over the brachial artery, and the cuff is slowly deflated at a rate of 2 to 3 mm Hg per second. As the pressure falls, the Diver medic should observe the gauge and note where the first sound or pulsation is heard. This is the patient's systolic pressure. The point at which the sounds change in quality or become muffled is noted as the patient's diastolic pressure.

Blood pressure may be estimated by palpation when vascular sounds are difficult to hear with a stethoscope because of environmental noise, but this method is less accurate than auscultation and can only estimate systolic pressure. To estimate blood pressure by palpation, the Diver medic should locate the brachial or radial pulse and apply the blood pressure cuff as previously described. Finger contact is maintained at the pulse location as the cuff slowly deflates. When the pulse becomes palpable, the gauge reading denotes the systolic pressure. Like pulse rates, a patient's blood pressure may be unusually high because of fear or anxiety. Other factors, such as a patient's age and normal level of physical activity, may be responsible for unusual blood pressure readings.

Respirations.

The normal respiratory rate for adults is between 12 and 24 breaths per minute. The respiratory rate is obtained by watching the patient breathe, by feeling for chest movement, or by auscultating the patient's lungs. The Diver medic should count the patient's respirations for 30 seconds and multiply by two to determine breaths per minute. Rhythm and depth of respirations are assessed by visualization and auscultation of the thorax. Abnormal findings include shallow, rapid, noisy, or deep breathing; asymmetrical chest wall movement; accessory respiratory muscle involvement; or congested, unequal, or diminished breath sounds.

Skin.

Skin colour, temperature, and moisture provide additional information about the patient's status. As previously discussed, a patient's skin colour and the presence of bruises, lesions, or rashes may indicate serious illness or injury.

Skin temperature may be normal (warm), hot, or cold. Skin that is hot to the touch indicates a possible fever or heat-related illness or injury. Cold skin may indicate decreased tissue perfusion and cold related illness or injury. The dorsal surface of the hand is more sensitive than the palmar surface and should be used to estimate body temperature. Body temperature can be measured more accurately by applying plastic heat-sensitive tape to the patient's skin or by using standard mercury clinical thermometers, electronic thermometers, or tympanic membrane thermometers. Evaluations of body temperature may have specific applications in emergencies, such as febrile seizures and hyperthermic and hypothermic emergencies.

Many EMS services use tympanic membrane thermometers or electronic thermometers that obtain readings within seconds. With a standard thermometer, temperature readings are obtained by placing the thermometer under the conscious patient's tongue for 4 to 6 minutes, under the patient's armpit for 10 minutes, or in the patient's rectum for 5 to 8 minutes. (Rectal readings provide the most accurate assessment but may be impractical for prehospital use.) Normal body temperature is 37°C (98.6°F). Standard clinical thermometers record body temperatures from 34.4°C (94°F) to 40°C (106°F).

Skin moisture usually is classified as dry (normal) or wet (clammy or diaphoretic). Diaphoretic skin may indicate a hemodynamic deficit, such as hypovolemia, or another illness or injury that results in decreased tissue perfusion or increased sweat gland activity. Examples are cardiovascular and heat-related emergencies, respectively.

Pupils.

Examining the pupils for response to light may yield information on the neurological status of some patients. Normally, the pupils are equal and constrict when exposed to light. (The acronym PERRL indicates that the pupils are equal, round, and react to light.) When testing the pupils for light response, the Diver medic shines a penlight directly into one eye. The normal reaction is for the pupil exposed to the light to constrict with a consensual constriction of the opposite eye.

Anatomical regions

The remainder of this chapter will discuss physical examination techniques as they pertain to anatomical regions of the body.

Ears

The external ear and surrounding tissues should be inspected for signs of bruising, deformity, or discoloration. There should be no discharge from either ear canal. Pulling gently on the ear lobes (lobules) should not produce pain or discomfort. The Diver medic should palpate the skull and facial bones surrounding the ear and inspect the mastoid area for tenderness or discoloration. An alert, hearing patient who speaks the same language as the Diver medic should be able to respond to questions without excessive requests for repetition. Hearing-aid devices should be noted. An assessment of gross auditory acuity can be made by covering one ear at a time and asking the patient to repeat short test words spoken by the Diver medic in soft and loud tones.

Otoscopic Examination

An otoscope is used to evaluate the inner ear for discharge and foreign bodies and to assess the eardrum. The Diver medic performs an otoscopique exam using the following steps for each ear :

Select the appropriate size speculum.

Check the ear for foreign bodies before inserting the speculum.

Instruct the patient not to move during the examination to avoid injury to the canal and tympanic membrane. (Infants and young children may need to be restrained.)

Turn on the otoscope and insert the speculum into the ear canal, slightly down and forward. To ease insertion, pull the auricle up and backward in adults; back and downward in infants.

Identify cerumen and look for foreign bodies, lesions, or discharge.

Visualize and inspect the tympanic membrane for tears or breaks. A normal examination will reveal the following:

Cerumen will be dry (tan or light yellow) or moist (dark yellow or brown).

The ear canal should not be inflamed (a sign of infection).

The tympanic membrane should be translucent or pearly grey (pink or red indicates inflammation).

Chest

A thorough knowledge of the structure of the thoracic cage is required to perform an adequate respiratory and cardiac assessment. In addition to protecting the vital organs within the thorax, the ribs provide support for respiratory movements of the diaphragm and intercostals muscles. A loss of thoracic structural integrity (e.g., a flail segment) prevents or limits respiratory function.

The ribs of the thorax also are used as anatomical landmarks in locating specific areas for examination. The thorax can be evaluated by using imaginary lines to document physical examination findings.

Inspection

The chest wall should be inspected for symmetry on both the anterior and posterior surfaces. Although the thorax is not completely symmetrical, a visual inspection of one side should offer a reasonable comparison to the other. Chest wall diameter often is increased in patients with obstructive pulmonary disease, resulting in a barrel-shaped appearance of the thorax. The Diver medic should inspect the skin and nipples for cyanosis and pallor and should be alert to the presence of suture lines from chest wall surgery and skin pockets enclosing implanted pacemaker devices or implanted central venous lines. The patient's respiratory status should be evaluated by inspection, palpation, percussion, and auscultation. The pattern or rhythm of respirations and any use of accessory respiratory muscles (e.g., intercostal or supraclavicular retractions, or both) should be noted.

Palpation

The thorax should be palpated for pulsations, tenderness, bulges, depressions, crepitus, subcutaneous emphysema, and unusual movement and position. The examination begins with the Diver medic noting the position of the trachea, which should be midline and directly above the sternal notch. Starting with the patient's clavicles, the Diver medic firmly palpates both sides of the patient's chest wall simultaneously, front to back and right side to left side. The examination should proceed systematically, without pain or discomfort.

To evaluate the anterior chest wall for equal expansion during inspiration, the Diver medic places both thumbs along the patient's costal margin and the xiphoid process, with palms lying flat on the chest wall. Equal movement should be noted as the patient inhales and exhales. The posterior chest wall is evaluated for symmetrical respiratory movement by placing the thumbs along the spinous processes at the level of the tenth rib.

Percussion

Percussion should be performed in symmetrical locations from side to side to compare the percussion note. Resonance usually is heard over all areas of healthy lungs. Hyper resonance is associated with hyperinflation and may indicate pulmonary disease, pneurnothorax, or asthma. Dullness or flatness suggests the presence of fluid and/or pulmonary congestion. The level and movement of the diaphragm during breathing (diaphragmatic excursion) may be limited by disease (e.g., emphysema, tumour) or pain (e.g., rib fracture).

Auscultation

The thorax is best auscultated with the patient sitting upright (if possible) and breathing deeply and slowly through an open mouth during the examination. The Diver medic should be alert to the possibility of resulting hyperventilation and fatigue, which may occur in ill and older patients.

The Diver medic uses the diaphragm of the stethoscope to auscultate the high-pitched sounds of the patient's lungs by holding the stethoscope firmly on the patient's skin and listening carefully as the patient inhales and exhales. The chest auscultation should be systematic as well as thorough, allowing evaluation of both the anterior and the posterior lung fields.

BREATH SOUNDS

Air movement creates turbulence as it passes through the respiratory tree and produces breath sounds during inhalation and exhalation. During inhalation, air moves first into the trachea and major bronchi and then into progressively smaller airways to its final destination, the alveoli. During exhalation, the air flows from small airways to larger ones, which creates less turbulence. Therefore normal breath sounds generally are louder during inspiration.

NORMAL BREATH SOUNDS

Normal breath sounds are classified as vesicular, bronchovesicular, and bronchial. Vesicular breath sounds are heard over most of the lung fields and are the major normal breath sound. Lungs considered "clear" make normal vesicular breath sounds. These sounds are low pitched and soft and have a long inspiratory phase and a shorter expiratory phase.

Vesicular breath sounds are further classified as harsh or diminished. Harsh vesicular sounds may result from vigorous exercise in which ventilations are rapid and deep. They also occur in children who have thin and elastic chest walls in which breath sounds are more easily audible. Vesicular breath sounds may be diminished in older people, who have less ventilation volume, and in obese or very muscular persons, whose additional overlying tissue muffles the sound.

Bronchovesicular breath sounds are heard over the major bronchi and over the upper right posterior lung field. They are louder and harsher than vesicular breath sounds and are considered to be of medium pitch. Bronchovesicular breath sounds have equal inspiration and expiration phases and are heard throughout respiration.

Bronchial breath sounds are heard only over the trachea and are the highest in pitch. They are coarse, harsh, loud sounds with a short inspiratory phase and a long expiration. A bronchial sound heard anywhere but over the trachea is considered an abnormal breath sound.

ABNORMAL BREATH SOUNDS

Abnormal breath sounds are classified as absent, diminished, and incorrectly located bronchial sounds and adventitious breath sounds. Absent breath sounds may indicate total cessation of the breathing process (e.g., complete airway obstruction), or they may be absent only in a specific area. Causes of localized absent breath sounds include endotracheal tube misplacement, pneumothorax, and hemothorax.

Diminished breath sounds may result from any condition that lessens the airflow. Examples include endotracheal tube misplacement, pneumothorax, partial airway obstruction, and pulmonary disease. Although some airflow is present, diminished breath sounds usually indicate that some portion of the alveolar tissue is not being ventilated.

Bronchial breath sounds auscultated in the peripheral lung field indicate the presence of fluid or exudate in the alveoli, either of which may block airflow. Diseases that contribute to this condition are tumors, pneumonia, and pulmonary oedema.

ADVENTITIOUS BREATH SOUNDS

Adventitious breath sounds are abnormal sounds that are heard in addition to normal breath sounds. They may be divided into two categories: discontinuous and continuous. Adventitious breath sounds result from obstruction of either the large or small airways and are most commonly heard during inspiration. Adventitious breath sounds are classified as crackles (formerly known as rates), wheezes, and rhonchi.

Discontinuous breath sounds. Crackles are the high-pitched, discontinuous sounds (similar to the sound of hair being rubbed between the fingers) that usually are heard during the end of inspiration. They indicate disease of the small airways or alveoli, or both, and may be heard anywhere in the peripheral lung field. There is some debate about the etiology of crackles. Some experts believe that the alveoli become filled with fluid, mucus, or pus and tend to close on expiration. With inspiration, the air forces the alveoli open again, producing a "popping" sound. Others contend that the popping sound is produced by air movement through the fluid.

The most typical causes of crackles are pulmonary edema and pneumonia in its early stages. Because gravity draws fluid downward, they often start in the bases of the lungs. Crackles may be further classified as coarse crackles (wet, low-pitched sounds) and fine crackles (dry, high-pitched sounds). Crackles are discrete and sometimes difficult to hear and may be overridden by louder respiratory sounds. If the Diver medic suspects crackles when auscultating the chest, he or she should ask the patient to cough. A cough may clear secretions and make crackles more easily audible.

Continuous breath sounds. Wheezes (also known as sibilant wheezes) are high-pitched, "musical" noises that are usually louder during expiration. They are caused by high-velocity air travelling through narrowed airways and may occur because of asthma and other constrictive diseases as well as congestive heart failure. When wheezing occurs in a localized area, a foreign body obstruction, tumour, or mucus plug should be suspected. Wheezes are classified as mild, moderate, and severe and should be described as occurring on inspiration or expiration, or both.

Rhonchi (also known as sonorous wheezes) are continuous, low-pitched, rumbling sounds usually heard on expiration. Although rhonchi sound similar to wheezes, they do not involve the small airways. They are less discrete than crackles and are easily auscultated. Rhonchi are caused by the passage of air through an airway obstructed by thick secretions, muscular spasm, new tissue growth, or external pressure collapsing the airway lumen. They may result from any condition that increases secretions. Examples are pneumonia, drug overdose, and long-term postoperative recovery.

Stridor usually is an inspiratory, crowing-type sound that can be heard without the aid of a stethoscope. It indicates significant narrowing or obstruction of the larynx or trachea and may be caused by epiglottitis, viral croup, foreign body aspiration, or a combination of these factors. Stridor is heard best over the site of origin, usually the larynx or trachea. Stridor often indicates a life-threatening problem, especially in children, and its presence requires careful observation for ventilatory failure and hypoxia.

Pleural friction rub. Although it occurs outside the respiratory tree, a pleural friction rub also may be considered an adventitious breath sound. It is a low-pitched, dry, rubbing, or grating sound caused by the movement of inflamed pleural surfaces as they slide on one another during breathing. The friction rub may be auscultated on both inspiration and expiration and usually is loudest over the lower lateral anterior surface of the chest wall. Presence of a pleural friction rub may indicate pleurisy, viral infection, tuberculosis, or pulmonary embolism.

Heart

In the prehospital setting, the heart must be examined indirectly. However, information about the size and effectiveness of pumping action is obtained through a skilled assessment that includes palpation and auscultation.

Palpation

The apical impulse is the visible and palpable force produced by the contraction of the left ventricle. Palpating this impulse may be useful to compare the relationship of other pulses with the ventricular cycle. The hearts of some patients with cardiac irregularities, for example, do not always produce a peripheral pulse with every ventricular contraction. By palpating or auscultating the apical impulse and the carotid pulse simultaneously, the Diver medic can note these pulse deficits. Factors such as obesity, large breasts, and muscularity may make this landmark difficult to see or palpate.

Auscultation

Heart sounds may be auscultated for frequency (pitch), intensity (loudness), duration, and timing in the cardiac cycle. A thorough evaluation of heart sounds requires a high level of skill and experience, a quiet environment, and sufficient time to listen closely. Two basic heart sounds, however, may be assessed relatively quickly and improve understanding of the patient's condition. These are the basic heart sounds, S1 and S2, which are normal heart sounds that occur when the myocardium contracts. They are best heard toward the apex on the heart at the fifth intercostal space. For evaluation of heart sounds, the patient should be sitting up and leaning slightly forward supine, or in a left lateral recumbent position. These positions bring the heart closer to the left anterior chest wall. To listen for S1, the Diver medic should instruct the patient to breathe normally and hold the breath in expiration To listen for S2, the patient should breathe normally again and hold the breath in inspiration.

Heart sounds may be muffled or diminished by, obesity or obstructive lung disease and by the presence of fluid in the pericardial sac surrounding the heart muscle. This usually is the result of penetrating or severe blunt chest trauma, cardiac tamponade, or cardiac rupture and is considered a true emergency. Other causes of muffled or diminishes heart sounds include infectious uremic pericarditis and malignancy.

Inflammation of the pericardial sac may produce a rubbing sound audible with a stethoscope. This is a pericardial friction rub, which may result from infectious pericarditis, myocardial infarction, uremia trauma, and autoimmune pericarditis. These rubs have a scratching, grating, or squeaking quality an tend to be louder on inspiration. They can be differentiated from pleural friction rubs by their continued presence when the patient holds the breath.

Extra Sounds

Extra sounds that can sometimes be heard during auscultation or felt by palpation include heart murmurs, bruits, and thrills. Heart murmurs are prolonged extra sounds that are caused by a disruption in the flow of blood into, through, or out of the heart. Most murmurs are caused by valvular defects. Some heart murmurs are very serious, while others (e.g., some that occur in children and adolescents) are benign and have no apparent cause. Heart murmurs can be detected during auscultation of the heart.

A bruit is an abnormal sound or murmur that may be heard while the carotid artery or another organ or gland is being auscultated, and may indicate local obstruction. Bruits usually are low pitched and relatively hard to hear. To assess blood flow in the carotid artery, the Diver medic should place the bell of the stethoscope over the carotid artery at the medial end of the clavicle, and ask the patient to hold his or her breath.

Thrills are similar to bruits, but are described as fine vibrations or tremors that may indicate blood flow obstruction. They may be palpable over the site of an aneurysm or on the precordium. Like murmurs and bruits, thrills may be serious or benign.

Abdomen

The abdomen is divided by two imaginary lines that separate the abdominal region into four quadrants: upper right, lower right, upper left, and lower left. These quadrants and their contents.

Inspection

The Diver Medic should visually inspect the abdomen for signs of cyanosis, pallor, jaundice, bruising, discoloration, swelling (ascites), masses, and aortic pulsations. Surgical scars and implanted devices such as automatic implanted cardioverter defibrillators (AICDs) also should be noted. The abdomen should be evenly round and symmetrical. Symmetrical distension of the abdomen may result from obesity, enlarged organs, fluid, or gas. Asymmetrical distension may result from hernias, tumour, bowel obstruction, or enlarged abdominal organs. A flat abdomen is common in athletic adults, and convex abdomens are common in children and in adults with poor exercise habits. The umbilicus should be free of swelling, bulges, and signs of: inflammation. The normal umbilicus usually is inverted, or it may protrude slightly.

Abdominal movement during respiration should be smooth and even. As a rule, males have more abdominal involvement than females during respiration, so limited abdominal movement in the symptomatic male may indicate an abdominal pathologic condition. Visible pulsations in the upper abdomen may be normal in thin adults, but marked pulsation may indicate an abdominal aortic aneurysm.

Auscultation.

Noting the presence or absence of bowel sounds to assess motility and to discover vascular sounds has limited value in the prehospital setting because it does not affect or determine the approach to patient care. In addition, the time required for thorough bowel sound assessment (about 5 minutes per quadrant) far exceeds the justifiable scene time for most patients. If auscultation is to be performed, however, it should always precede palpation, since the latter maneuvers may alter the intensity of bowel sounds.

To auscultate bowel sounds, the Diver medic holds the diaphragm of the stethoscope on the abdomen with light pressure. If bowel sounds are present, they usually are heard as rumblings or gurgles that occur irregularly, ranging in frequency from 5 to 35 per minute. Auscultation should be done in all four quadrants, and a minimum of 5 minutes per quadrant is required to determine that normal bowel sounds are absent. Increased bowel sounds may indicate gastroenteritis or intestinal obstruction. Decreased or absent bowel sounds may indicate peritonitis (inflammation of the lining of the abdominal cavity) or ileus (inactive peristaltic activity resulting from one of several causes).

Percussion and Palpation.

Percussion and palpation of the abdomen may be useful to detect the presence of fluid, air, and solid masses. The Diver medic should use a systematic approach, moving either from side to side or in a clockwise direction, noting any rigidity, tenderness, or abnormal skin temperature or colour. The patient's face should be observed for signs of pain or discomfort. If the patient is complaining of abdominal pain, the painful quadrant should be examined last so that the patient will not unnecessarily tighten or "guard" the abdominal area. The abdominal assessment should begin with a light palpation, using an even pressing motion. As previously stated, the Diver medic's hands should be warm, and sharp and quick jabs should be avoided. Palpation may be done simultaneously with percussion.

Percussion should begin by evaluating all four quadrants of the abdomen for a general assessment of tympany and dullness. (Tympany is the major sound that should be noted during percussion because of the normal presence of air in the stomach and intestines. Dullness should be heard over organs and solid masses.) When one is percussing the abdomen, it is best to proceed from an area of tympany to an area of dullness, because the change in sound is easier to detect. Individual assessments of the liver and spleen (described in the following paragraphs) may be done when the abdomen is examined if indicated by patient complaint or mechanism of injury.

PERCUSSION AND PALPATION OF THE LIVER.

The liver is percussed by beginning just above the umbilicus in the right midclavicular line in an area of tympany. Percussion should continue in an upward direction until the change from tympany to dullness occurs. This change usually occurs slightly below the costal margin and indicates the lower border of the liver. To determine the upper border of the liver, the percussion should begin in the same midclavicular line at the midsternal level, proceeding downward until the tympany from the lung area changes to dullness (usually between the fifth and seventh intercostal spaces). Liver size is related to age and sex. It will usually be proportionately larger in adults than in children and larger in males than in females.

For palpation of the liver, the patient should be supine, comfortable, and have a relaxed abdomen. The examination should be performed from the patient's right side and begins by placing the left hand under the patient in the area of the eleventh and twelfth ribs. The right hand should be placed on the abdomen, with the fingers pointing toward the patient's head and extended, resting just below the edge of the costal margin. The conscious patient should be instructed to breathe deeply through the mouth. During exhalation, the hand under the patient is pressed upward, and the right hand is gently pushed in and up. If the liver is felt, it should be firm and nontender. (A healthy liver usually cannot be palpated unless the patient is thin.).

PERCUSSION AND PALPATION OF THE SPLEEN.

For percussion of the spleen, the patient must be lying supine or in a right lateral recumbent position. Percussion should begin at the area of lung tympany, just posterior to the midaxillary line on the left side. When one is percussing downward, a change from tympany to dullness should be heard between the sixth and tenth ribs. Large areas of dullness suggest an enlarged spleen. Stomach contents and air-filled or feces-filled intestines make splenic assessment by percussion difficult since these and other factors may affect percussion tones of dullness and tympany.

Palpation is a more useful assessment technique for evaluating the spleen. The patient should be lying supine with the Diver medic positioned at the patient's left side. The left hand is placed under the patient, supporting the lower left rib cage. The right hand is placed just below the patient's lower left costal margin. The area should be gently palpated by lifting up the left hand, and pressing down with the right. (a normal spleen usually cannot be palpated in an adult. A palpable spleen is probably enlarged three time its normal size.)

Extremities.

When examining the upper and lower extremities, Diver medics should pay attention to function as well as structure. The patient's general appearance, body proportions, and ease of movement are important observations. In particular, the Diver medic should note any limitation in the range of motion or an unusual increase in the mobility of a joint. Abnormal findings include the following:

Signs of inflammation.

Swelling.

Tenderness.

Increased heat.

Redness.

Decreased function.

Asymmetry.

Crepitus.

Deformities.

Decreased muscular strength.

Atrophy.

Examining Upper and Lower Extremities.

A systematic assessment of the upper and lower extremities includes an evaluation of the skin and tissue overlying the muscles, cartilage, and bones; and joints for soft tissue injury, discoloration, swelling, and masses. The upper and lower extremities should be reasonably symmetrical in both structure and muscularity. The circulatory status of each extremity should be assessed during the examination by determining skin color, temperature, sensation, and the presence of distal pulses. Bones, joints, and surrounding tissues of the extremities should be assessed for structural integrity and continuity. Muscle tone should be firm and nontender. Joints are assessed for function by moving each joint through its full range of motion. A normal range of motion occurs without pain, deformity, limitation, or instability.

HANDS AND WRISTS.

The Diver medic should inspect both hands and wrists for contour and positional alignment. Palpate the wrists, hands, and joints of each finger for tenderness, swelling, or deformity. To determine range of motion, request the patient to flex and extend the wrists, make a fist, and touch the thumb to each fingertip. All movements should be performed without pain or discomfort.

ELBOWS.

The diver medic should inspect and palpate the elbows in both the flexed and extended positions. To determine the elbow's range of motion, the Diver medic should ask the patient to rotate the hands from palm up to palm down. The grooves between the epicondyle and olecranon should be inspected by palpation. Pain and tenderness should not be present when the examiner presses on the lateral and medial epicondyle.

SHOULDERS AND RELATED STRUCTURES

The shoulders should be inspected and palpated for symmetry and integrity of the clavicles, scapulae, and humeri. Pain, tenderness, or asymmetric contour may indicate a fracture or dislocation. The patient should be able to shrug shoulders and raise and extend both arms without pain or discomfort. The following regions should be palpated, noting any tenderness or swelling:

Sternoclavicular joint.

Acromioclavicular joint.

Subacromial area.

Bicipital groove.

Ankles and Feet.

The patient's feet and ankles should be inspected for contour, position, and size. Tenderness, swelling, and deformity are abnormal findings on palpation. The toes should be straight and aligned with each other. Range of motion can be determined by requesting the patient to bend the toes, point the toes, and rotate the feet both inward and outward from the ankle. These movements should be possible without pain or discomfort. All surfaces of the ankles and feet should be inspected for deformities, nodules, swelling, calluses, corns, and skin integrity.

PELVIS, HIPS, AND KNEES.

The structural integrity of the pelvis should be verified. To palpate the iliac crest and the symphysis pubis, the Diver medic places both hands on each anterior iliac crest, pressing downward and outward (Fig. 13-28). To determine stability, the Diver medic places the heel of the hand on the symphysis pubis and presses downward. Deformity and point tenderness of the pelvis may be signs of fracture, masking major structural and vascular injury.

The hips should be inspected and palpated for instability, tenderness, and crepitus. The supine or unconscious patient can be examined by assessing the structural integrity of the iliac crest. A mobile patient should be able to walk without discomfort.

A supine patient should be able to raise the legs and knees and rotate the legs inward and outward.

The knees should be inspected and palpated for swelling and tenderness. The patella should be smooth, firm, nontender, and midline in position. The patient should be able to bend and straighten each knee without pain.

Nervous System.

Detail of an appropriate neurological examination varies greatly and depends on the origin of the patient's complaint (e.g., peripheral nervous system vs. central nervous system problems). The examination may be performed separately, but more often the evaluation is completed during other assessments. A neurological examination may be organized into five categories:

• Mental status and speech.

• Cranial nerves.

• Motor system.

• Sensory system.

• Reflexes.

Mental Status and Speech.

As previously discussed, a healthy patient should be oriented to person, time, and place. Patients should also be able to organize thoughts and converse freely (provided there are no hearing or speech impediments). Abnormal findings include unconsciousness, confusion, slurred speech, aphasia, dysphonia, and dysarthria.

Cranial Nerves.

The 12 cranial nerves can be categorized as sensory, somatomotor and proprioceptive, and parasympathetic. The following methods can be used to assess each of the cranial nerves:

Cranial Nerve I Olfactory: Test sense of smell with spirits of ammonia.

Cranial Nerve II Optic: Test for visual acuity (previously described).

Cranial Nerve II and III Optic and Oculomotor: Inspect the size and shape of the pupils; test the pupil response to light.

Cranial Nerve Ill, IV, VI Oculomotor, Trochlear, Abducens: Test extraocular movements by asking the patient to look up and down, to the left and right, and diagonally up and down to the left and right (the six cardinal directions of gaze).

Cranial Nerve V Trigeminal: Test motor movement by asking the patient to clench the teeth while you palpate the temporal and masseter muscles. Test sensation by touching the forehead, cheeks, and jaw on each side.

Cranial Nerve VII Facial: Inspect the face at rest and during conversation, noting symmetry, tics, or abnormal movements. Ask the patient to raise the eyebrows, frown, show both upper and lower teeth, smile, and puff out both cheeks. Strength of the facial muscles can be assessed by asking the patient to close eyes tightly so they cannot be opened, and gently attempt to raise the eyelids. Observe for weakness or asymmetry.

Cranial Nerve VIII Acoustic: Assess hearing acuity (previously described).

Cranial Nerve IX and X Glossopharyngeal and Vagus: Assess the patient's ability to swallow with ease; to produce saliva; and to produce normal voice sounds. Instruct the patient to hold the breath, and assess for normal slowing of the heart rate. Testing for the gag reflex also will test the cranial nerves.

Cranial Nerve XI Spinal Accessory: Ask the patient to raise and lower the shoulders, and to turn the head.

Cranial Nerve XIIHypoglossal: Ask the patient to stick out the tongue and to move it in several directions.

Motor System.

An evaluation of a patient's motor system includes observing the patient during movement and while at rest. Abnormal involuntary movements should be evaluated for quality, rate, rhythm, and amplitude. Other body movement assessments include posture, level of activity, fatigue, and emotion.

MUSCLE STRENGTH.

Muscle strength should be bilaterally symmetrical, and the patient should be able to provide reasonable resistance to opposition. One method to evaluate muscle strength in the upper extremities is to instruct the patient to extend the elbow and to pull it toward the chest while using opposing resistance. Muscle strength in the lower extremities is evaluated by requesting the patient to push the soles of the feet against the Diver medic's palms. Next, the patient is directed to pull the toes toward the head while the Diver medic provides opposing resistance. Both of these actions should be easily performed by the patient without evident fatigue. Other methods that can be used to evaluate muscle strength and agility include testing for flexion, extension, and abduction of the upper and lower extremities.

COORDINATION.

To evaluate a patient's coordination, the Diver medic should assess the patient's ability to perform rapid alternating movements. These include point-to-point movements, gait, and stance.

One point-to-point movement that the patient can easily perform is to touch the finger to the nose, alternating hands. Another test is to instruct the patient to touch each heel to the opposite shin. Both movements should be performed numerous times and quickly to assess coordination, which should be smooth, rapid, and accurate.

Gait can be evaluated in several ways. A healthy patient should be able to perform each of the following tasks without discomfort or losing balance:

- Walk heel to toe.
- Walk on the toes.
- Walk on the heels.
- Hop in place.
- Do a shallow knee bend.
- Rise from a sitting position without assistance.

Stance and balance can be evaluated by using the Romberg test and the Pronator Drift test. To perform the Romberg test, ask the patient to stand erect with the feet together and arms at the sides. The eyes should initially be open and then closed. Although slight swaying is normal, a loss of balance is abnormal (a positive Romberg sign). A patient also should be able to stand in this position with one foot raised for 5 seconds without losing balance.

The Pronator Drift test (also known as an arm drift test) is performed by having the patient close the eyes and hold both arms out from the body. A normal test will reveal that both arms move the same or both arms do not move at all. Abnormal findings include one arm that does not move in concert with the other or one arm that drifts down compared with the other.

Sensory System.

The sensory pathways of the nervous system conduct sensations of pain, temperature, position, vibration, and touch. A healthy patient is expected to be responsive to each of these stimuli. Common assessments of the sensory system include evaluating the patient's response to pain and light touch. Each of the responses should be considered in relation to dermatomes.

In conscious patients, a sensory examination should be performed with light touch on each hand and each foot. If the patient cannot feel light touch or is unconscious, sensation may be evaluated by gently pricking the hands and soles of the feet with a sharp object that will not penetrate the skin (e.g., a paper clip or cotton swab). The sensory examination should proceed from head to toe, comparing symmetrical areas on each side of the body as well as distal and proximal areas of the body. A lack of sensory response may indicate spinal cord damage.

LESSON 4_01 BLEEDING

Hemorrhage occurs when there is a disruption, or "leak", in the vascular system. Sources of hemorrhage can be external or internal.

Whenever you are going to be exposed to blood or other potentially infectious body fluids, wear sterile latex rubber gloves from your first-aid kit. If you are allergic to latex, use other nonpermeable gloves (such as nonlatex synthetic).

While it is occasionally visually distressing, bleeding can be one of the easiest problems to manage, because the treatment options are so straightforward. The severity of the injury determines the rate of blood loss and what measures you must take to control the bleeding. Evaluate the following considerations:

Where is the bleeding? It is important to consider and identify internal bleeding as well as external bleeding. Considerable blood loss can be associated with blunt (nonpenetrating) abdominal injury (liver or spleen), as well as long bone or pelvic fracture (2 quarts or 2 liters of blood can rapidly accumulate in the thigh following a broken femur). Examine the entire victim!

Is the bleeding from an artery or from a vein? Because arterial blood is under higher pressure, blood loss tends to be more rapid from a severed artery than from a vein. Arterial bleeding can be recognized by its spurting nature and rapid outflow. All blood exposed to air, in the absence of unusual drug intoxications, turns red fairly quickly, so you cannot rely upon color to indicate origin.

External bleeding

Bleeding (also known as hemorrhage) is classified by the type of blood vessel that is damaged : artery, vein or capillary. Arterial bleeding can be very dramatic, but copious venous bleeding is potentially more serious.

ARTERIAL BLEEDING

Richly oxygenated blood is bright red and, under pressure from the heart, spurts from a wound in time with the heartbeat. A severed main artery may jet blood several feet high, and rapidly reduce the volume of circulating blood.

VENOUS BLEEDING

Venous blood, having given up its oxygen, is dark red. It is under less pressure than arterial blood, but as vein walls are capable of great distention, blood can "pool" within them. Blood from a severed major vein may gush profusely.

CAPILLARY BLEEDING

This type of bleeding, or oozing, occurs at the site of all wounds. Capillary bleeding may at first be brisk, but blood loss is usually slight. A blunt blow may rupture capillaries under the skin, causing bleeding into the tissues (bruise).

Internal hemorrhage

Internal hemorrhage can result from blunt or penetrating trauma and acute or chronic medical illnesses. Internal bleeding that can cause hemodynamic instability usually occurs in one of four body cavities : the chest, abdomen, pelvis or retroperitoneum. Intracranial hemorrhages also can cause grave hemodynamic instability. Internal

If bleeding is internal, such as from a bleeding ulcer, broken bone, injured spleen or liver, leaking abdominal aneurysm, or lung cancer, the victim may suffer from shock. Symptoms of internal (undetected) bleeding are the same as those of external bleeding, except that you don't see the blood. They include rapid heartbeat, shortness of breath, general weakness, thirst, dizziness or fainting when arising from a supine position, pale skin color (particularly in the fingernail beds and conjunctivae), and cool, clammy skin. Other signs include increasing pain and firmness of the abdomen after an injury, vomiting blood or "coffee grounds" (blood darkened by stomach acid), blood in the urine or feces, or large bruises over the flank or abdomen. Because it is difficult to predict the rate of internal blood loss and because the only effective treatment for many causes of severe internal bleeding is surgery, medical help should be sought immediately

Treatment for Bleeding

First, remove all clothing covering the wound so that you can see precisely where the bleeding is coming from. Almost all external bleeding stops with firm, direct pressure. This should be applied directly to the wound with the heel of your hand, using the cleanest and most available thick (four or five thicknesses of a 4 inch by 4 inch — or 10 centimeter by 10 centimeter — sterile gauze pad, for instance) bandage or cloth compress. Maintain pressure for a minimum of 10 minutes, to allow severed vessels to close by spasm (an artery contains small amounts of muscle tissue in its walls) and to allow early blood clot formation. Peeking at the wound under the compress interrupts the process and prolongs active bleeding. The application of cold packs or ice packs over the compress (not under it) may hasten the process by initiating spasm and closure of disrupted blood vessels. It is also useful to have the victim lie down, and to elevate the bleeding part above the level of his heart. A scalp wound tends to bleed freely, and may require prolonged pressure or wound closure for control.

If direct pressure to the wound does not stop the bleeding, you must make certain that you are applying the pressure in the correct spot. Check quickly to see that you are pressing precisely over the bleeding point. If you are a fraction of an inch off, you can miss the best compression spot for a torn blood vessel; in this case, simply piling on more bandages may not solve the problem. Once you have repositioned your pressure, wait again for 5 to 10 minutes. If the pressure appears to be working, once the bleeding has substantially subsided, you can apply a pressure dressing. Do this by covering the wound with a thick wad of sterile gauze pads or the cleanest dressing available, and wrapping the area firmly with a rolled gauze or elastic bandage. Do not apply the dressing so tightly that circulation beyond it is compromised (as indicated by blue fingertips or toes, or by numbness and tingling). Watch the dressing closely for blood soaking and dripping, which indicate continuous bleeding.

Some important things to be aware of with a serious wound are:

1. A victim who has lost 25% to 30% of his blood volume may suffer from shock.

2. Prolonged, uncontrollable bleeding is rare unless a major blood vessel or more than one vessel is disrupted; the victim is taking an anticoagulant (blood thinner) medication; or the victim suffers from hemophilia. In such a case, heroic intervention may be lifesaving. The application of extreme compression to "pressure points," such as the radial, brachial, or femoral arteries, is both difficult and of considerable risk (since the purpose is to cut off all circulation).

A tourniquet is indicated only in a life-threatening situation and is best applied by an experienced person. Only in the case of torrential bleeding is a tourniquet more advantageous than continuous pressure. The decision to apply a tourniquet is one in which a limb is sacrificed to save a life.

A tourniquet should be applied to the limb between the bleeding site and the heart, as close to the injury as is effective, and tightened just to the point where the bleeding can be controlled with direct pressure over the wound.

To construct a tourniquet, use a 2- to 4-inch (5- to 10-centimeter) bandage — not something that will cut through the skin. Wrap the bandage around the limb several times, then tie half or an entire square knot, leaving loose ends long enough to tie another knot. Place a stick or stiff rod over the knot, then tie it in place with the loose ends. Twist the stick until the bandage is tight enough to stop the bleeding, then secure it.

If possible, the tourniquet or a pressure-point occlusion should be released briefly every 10 to 15 minutes to see if it is still necessary. Always keep a tourniquet in plain view, so that it doesn't get left in place longer than necessary just because someone didn't know or forgot it was there.

3. If the victim has suffered a large wound through which internal organs (such as loops of bowel) or bones are protruding, do not attempt to push these back inside the body or under the skin unless they slide back in without your assistance. Cover extruded internal organs or bones with continually moistened bandages (pads of gauze or cloth) held in place without excess pressure. Seek immediate medical attention.

4. If the victim has suffered a severe cut in his neck, take special care to not disturb the wound, because such disturbance might remove a blood clot that is controlling the bleeding from a large blood vessel. Apply a firm pressure dressing (don't choke the victim with the bandage) and seek immediate medical attention. Continually assess the airway, because an expanding blood clot within the neck can compress the throat and windpipe. If the victim begins to have raspy breathing or a changed voice, evacuation is maximally urgent.

5. Bleeding can be quite brisk from a ruptured or torn varicose (dilated) vein in the leg. This can usually be managed with direct pressure, while elevating the leg. Follow this with a pressure dressing.

6. If a foreign object (such as a knife, tree limb, or arrow) becomes deeply embedded (impaled) in the body, do not attempt to remove it, because the internal portion may be occluding a blood vessel that will hemorrhage without this "plug." Any attempt at removal may create more damage than already exists, which includes increasing the bleeding. This is particularly true with a hunting (broadhead) arrow. Instead, pad and bandage the wound around the object, which should be fixed in place with tape if possible. The external portion of the object may be cut to a shorter length (cut off the shaft of the arrow a few inches above the skin, for example), if necessary to facilitate splinting and transport of the victim.

7. A gunshot wound may cause severe internal damage that is not readily visible from the surface wound. Any victim who has suffered a gunshot wound should be brought to immediate medical attention, no matter how minor the external appearance. Always disarm the victim. A head-injured or otherwise confused victim carrying a loaded weapon could accidentally create an additional victim. If you don't know how to handle a gun, move the weapon at least several feet away and point it in the direction where accidental discharge will do the least harm.

8. After the bleeding has stopped, immobilize the injury. Check all dressings regularly to be certain that swelling has not made them too tight.

LESSON 4_02 BANDAGING

Applying dressings and bandages is an important part of good first-aid practice. Wounds usually require a dressing, and almost all injuries will benefit from the support that bandages can give.

Using first-aid materials

The materials that you need to equip a useful first-aid kit, and how to use them, are shown in this chapter. The dressing or bandage that you choose, and the technique for applying it, will depend upon the injury and materials that are available to you. Always use sterile first-aid equipment if it is available. However, if it is not, you can improvise using clean, everyday articles.

The following pages demonstrate the techniques required to apply each type of dressing and bandage; more detailed information about when to use each one is given on the pages dealing with specific injuries. If you wish to increase your proficiency in bandaging, it is well worth attending an approved first-aid course.

Dressing are used to:

Help control bleeding.

Cover a wound and protect it, thereby reducing the risk of infection.

Bandages are used to:

Maintain direct pressure over a dressing to control bleeding.

Hold dressings, splints, and compresses in place.

Limit swelling.

Provide support to an injured limb or joint.

Restrict movement.

First Aid Material

The materials necessary for first-aid are usually kept together in a first-aid kit or some other suitable container. First-aid kits should be kept in the workplace, at sports and leisure facilities, in your home and car.

The contents of a kit for a workplace or leisure centre must conform to legal requirements; they should also be clearly marked and readily accessible. The contents of this standard kit should form the basis of your first-aid kit at home, although you may wish to add to it.

Any first-aid kit must be kept in a dry atmosphere, and checked and replenished regularly, so that the items you need are always ready to use.

Basic materials for a first-aid kit

Easily identifiable watertight box; 20 adhesive dressings (plasters) in assorted sizes; six medium sterile dressings; two large sterile dressings; two extra-large sterile dressings; two sterile eye pads; six triangular bandages; six safety pins; disposable gloves.

Useful additions

Two crepe roller bandages; scissors; tweezers; cotton wool; non-alcoholic wound cleansing wipes; adhesive tape; notepad, pencil, and tags; plastic face shield; for outdoor activities: blanket, survival bag, torch, and whistle.

Dressing

Dressings cover a wound, prevent infection from entering it, and help the blood-clotting process. Although they may stick to a wound, the benefits outweigh any discomfort caused on removal.

Use a pre-packed, sterile dressing where possible. If none is available, any clean, non-fluffy material can be used to improvise a dressing.

General rules for applying dressings

The dressing pad should always extend well beyond the wound's edges.

Place dressings directly on a wound.

Do not slide them on from the side, and replace any that slip out of place.

If blood seeps through a dressing, do not remove it; instead, apply another dressing over the top.

If there is only one sterile dressing, use this to cover the wound, and use other clean materials as topdressings.

Sterile dressing

Sterile dressings consist of a dressing pad attached to a roller bandage. The dressing pad is a piece of gauze or lint backed by a layer of cotton wool padding. Sterile dressings are sold singly in various sizes, and are sealed in protective wrappings. If the seal on a sterile dressing is broken, the dressing is no longer sterile.

Gauze dressing

If a sterile dressing is not available, use a gauze pad. Made from layers of gauze, it forms a soft covering for wounds. Cover the gauze with cotton wool to absorb blood or discharge. Secure the dressing with adhesive tape or a roller bandage if pressure is needed. Do not fully encircle a limb or digit with tape as it can impede circulation. If the casualty is allergic to adhesive tape, use a roller bandage.

Adhesive dressings

These dressings, or plasters, are useful for small wounds. They consist of a gauze or cellulose pad with an adhesive backing. Plasters come in various sizes (some are specially shaped for fingertips, heels, and elbows), often wrapped singly in sterile packs. Check the casualty is not allergic to adhesive dressings before use. Food handlers must apply waterproof plasters, usually blue, to wounds on their hands.

Cold compresses

Cooling an injury such as a bruise or sprain can reduce swelling and pain, although it will not alter the severity of the underlying injury. You can use an ice pack or cold compress, or place the injured part under cold running water or in a basin of cold water. A pack of frozen vegetables can also be used, but wrap it in a cloth before applying it to the skin.

Bandages

Bandages have a number of purpose: they are used to hold dressings in position over wounds, to control bleeding, to support and immobilise injuries, and to reduce swelling. There are three main types of bandage:

roller bandages, which secure dressings and can give support to injured limbs;

tubular bandages, which can secure dressings on fingers or toes or support injured joints;

triangular bandages, which are usually made of cloth; they are used as slings or large dressings, to secure dressings, and to immobilise limbs.

In an emergency, you may have to improvise bandages from everyday items.

General rules for bandaging

Before applying bandages:

Reassure the casualty and explain clearly what you are going to do

Make the casualty comfortable, in a suitable position, sitting or lying.

Keep the injured part supported. The casualty or an assistant may do this.

Always work in front of the casualty, and from the injured side where possible.

When applying bandages:

If the casualty is lying down, pass the bandages under the body's natural hollows at the ankles, knees, waist, and neck. Then slide the bandages into position by easing them back and forth under the body To bandage the head or upper torso, pull a bandage through the hollow under the neck, and slide into place.

Apply bandages firmly, but not so tightly as to impede circulation to the extremity.

Leave fingers and toes on a bandaged limb exposed, if possible, so that you can check the circulation afterwards.

Use reef knots to tie bandages. Ensure that the knots do not cause discomfort and do not tie the knot over a bony area. Tuck loose ends under a knot if possible.

Regularly check the circulation to the extremity of a bandaged limb (see opposite) Loosen the bandages if necessary.

When bandaging to immobilise a limb

Place some soft, bulky padding, such as towels, folded clothing, or cotton wool, between an arm and the body, or between the legs so that the bandaging does not displace any broken bones.

Bandage around the limb at intervals, avoiding the injury as much as possible

Tie the knots on the uninjured side towards the upper part of the body If both sides are injured, tie knots in the middle of the body or where there is least chance of causing further damage.

After applying bandages

Check the circulation in a bandaged limb every ten minutes.

Checking the circulation

You must check the circulation in a hand or foot immediately after bandaging a limb or using a sling, and again every ten minutes until medical aid arrives.

Rechecking the circulation is vital because limbs swell following an injury, and a bandage can quickly become too tight and impede the circulation. The symptoms will change, as first the veins in the limb, and then the arteries supplying the limb, become impeded.

Recognition of impaired circulation

Initially, there may be:

A swollen and congested limb.

Blue skin with prominent veins.

A feeling of painful distension.

Later, there may be:

Pale, waxy skin and cold numbness.

Tingling, followed by deep pain.

Inability to move fingers or toes.

Roller bandages

These are made of cotton, gauze, or linen, and are applied in spiral turns. There are three principal types:

open-weave bandages, which are used to hold light dressings in place; because of their loose weave, they allow good ventilation, but cannot be used to exert pressure on the wound or to give support to joints;

conforming bandages, which mould to the body shape, are used to secure dressings and lightly support injuries;

crepe bandages, which are used to give firm support to joints.

Applying roller bandage

Follow these general rules when you are applying a roller bandage.

When the bandage is partly unrolled, the roll is called the "head", and the unrolled part, the "tail". Keep the head of the bandage uppermost when bandaging.

Position yourself towards the front of the casualty at the injured side.

While you are working, support the injured part in the position in which it will remain after bandaging.

Check the circulation beyond a bandage, especially when using conforming and crepe bandages; these mould to the shape of the limb, and ma become tighter if the limb swells.

Elbow and knee bandage

Roller bandages can be used on elbows and knees to hold dressings in place or to support soft tissue injuries, such as strains or sprains. They are not effective for this purpose if applied with the standard spiralling turns, so use the method shown below for elbows and knees. Always make sure that you bandage sufficiently far on either side of the injured joint to exert an even pressure.

Hand and foot bandage

A roller bandage may be used to hold dressings in place on the hand or foot, or to provide support to wrists or ankle that have been sprained or strained. Support bandaging should extend well beyond the joint to provide pressure over the injured area. The method shown below for bandaging a hand can be used on a foot, substituting the big toe as the thumb and leaving the heel unbandaged.

Tubular gauze

This is a tubular bandage made from a roll of seamless gauze, which is used to support joints such as the elbow or ankle. A small tubular gauze can be applied to a finger or toe with a special applicator, supplied with each roll. A tubular gauze is useful for holding light dressings in place, but it cannot exert enough pressure to control the bleeding from a wound.

Triangular bandages

These bandages, sometimes sold in sterile packs, can also be made by cutting or folding a square metre of sturdy fabric (such as linen or calico) diagonally in half. They can be used:

folded into broad-fold bandages to immobilise and support limbs and secure splints and bulky dressings;

folded into narrow-fold bandages, to immobilise feet and ankles, and hold dressings in place;

straight from a pack and folded into a pad to form a sterile improvised dressing pad;

open, as slings to support an injured limb, or to hold a hand, foot, or scalp dressing in position.

Reef knots

When tying a bandage, always use a reef knot. It lies flat so is more comfortable for the casualty; it is secure and will not slip, but is easy to untie. Avoid tying the knot around or over the injury itself as this may cause discomfort.

Scalp bandage

An open triangular bandage may be used to hold a dressing in position on the top of a casualty's head, although it cannot provide enough pressure to control profuse bleeding. A dressing on a bleeding scalp wound should be held in position with a roller bandage. If possible, sit the casualty down because this makes it easier to apply the scalp bandage.

Slings

Slings are used to support the arm of a casualty who is sitting or is able to walk. There are two types of sling:

arm sling, which supports the arm with the forearm horizontal or slightly raised, used for an injured upper arm, wrist, or forearm, or a simple rib fracture;

elevation sling, which supports the upper limb with the hand in a well raised position. It is used for some fractures, to help control bleeding from wounds in the forearm, to reduce swelling in burn injuries, and for complicated rib fractures.

Improvised slings

You can improvise a sling with a square of cloth. Make sure it is sturdy and large enough to support the arm. You can also improvise slings from items of clothing, or adjust the casualty's clothes to support an injured arm.

LESSON 4_03 4_04 SHOCK

Clinical shock is due to an inadequate blood flow to the peripheral tissues, usually giving rise to hypotension and reduced urinary output, and may be due to a variety of causes.

When shock occurs the clinical signs to be monitored are:

• Pulse volume, rhythm, and rate

• Blood pressure

• Respiratory rate

• Skin appearance

• Level of consciousness

Hypovolemic shock

This is due to an inadequate intravascular volume usually caused by haemorrhage. There are three phases.

Signs

Compensation phase (caused by release of adrenaline)

• Tachycardia

• Pallor

• Sweating.

Plateau phase

• Tachycardia of 120-130 beats per minute

• Pallor

• Restlessness.

Decompensation phase

• Sudden fall in pulse rate

• Sudden fall in blood pressure. Note Any single reading may appear within the normal range; this phase may only be detected with serial readings.

IMMEDIATE TREATMENT

Once the decompensation phase is reached, treatment is difficult due to the occurrence of vasoconstriction.

- Lay the patient supine with the legs raised.
- Give an intravenous infusion of one litre of normal saline and one litre of Haemaccel.

•	Do not give intramuscular analgesia as it will not be absorbed at the time; the time and the amount of absorption is unpredictable.

Emotional shock

This is typical of `shock' as known to the layman. It is caused by fear, fright, etc.

IMMEDIATE TREATMENT

- Give support
- Lie the patient flat with raised legs
- Loosen the neckwear.

Anaphylactic shock

Symptoms

Flushing Generalized itching and urticaria Palpitations Husky voice and rhinitis Respiratory distress Occasionally abdominal pain, vomiting, and diarrhoea.

Signs

Collapse with a weak pulse and low blood pressure Stridor, wheeze, dyspnoea, and cyanosis Urticarial rash Swelling of the mouth or face Sometimes diarrhoea and vomiting.

Differential diagnosis

IMMEDIATE TREATMENT

Lay the patient supine.

Ensure that there is a clear airway.

Give injection of 0.5 ml adrenaline 1 : 1000 either intramuscularly, subcutaneously, or slowly intravenously. If necessary this may be repeated every 5 min, but do not give more than 2 ml in all.

Give hydrocortisone 100-200 mg intravenously. Set up an intravenous infusion of normal saline. Give an intravenous injection of chlorpheniramine 10 mg followed by 4 mg tablets by mouth three times daily, remembering that this can take 4 h or so to become effective.

For wasp and bee stings

Remove the sting

Apply ice cubes

Apply topical hydrocortisone cream I %a

Cardiogenic shock

This is induced by inadequate cardiac function.

Causes

Acute left ventricular failure

Caused by conditions which reduce cardiac output by ventricular dilation or hypertrophy, resulting in reduced cardiac output in spite of adequate ventricular filling. Urgent treatment is necessary in order to save life.

CAUSES

- Rheumatic valve disease.
- Ischaemic heart disease (including silent myocardial infarction).
- Hypertension.

SYMPTOMS

- Sudden acute breathlessness.
- Fatigue and sometimes cough with haemoptysis.
- Attacks often at night (cardiac asthma).
- Some relief on sitting or standing (orthopnoea).

SIGNS

- Often added sounds at the bases due to pulmonary oedema.
- Tachycardia.
- Cardiac enlargement.
- Ankle or sacral oedema if right ventricular failure is also present.
- Triple rhythm may be found.
- Pulsus alternans.

DIFFERENTIAL DIAGNOSIS

Other causes of acute breathlessness especially acute bronchial asthma.

IMMEDIATE TREATMENT

- Reassure and sit the patient upright.
- Administer oxygen if available (100% if there is no preexisting lung disease).

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Cardiac tamponade

General Signs of cardiogenic shock

- Hypotension (80-90 mmHg from the onset).
- Rarely tachycardia, unless this is the cause of the shock.

- Signs of cardiac tamponade, i.e. fall in blood pressure, rising jugular venous pressure, a small quiet heart.

IMMEDIATE TREATMENT

- Apply resuscitation (p 486).
- Administer oxygen.
- Set up a slow intravenous infusion of dextrose 5%.
- Give intravenous analgesia i.e. diamorphine 5 mg.
- If it is present, treat left ventricular failure.
- Correct any arrhythmia .

Refer to hospital?

Yes, arrange urgent admission preferably using a Cardiac Ambulance if available.

Shock due to vasodilation

Causes

Vasodilation as the cause of shock may be suspected in patients with

- Cerebral trauma or haemorrhage (neurogenic shock)
- Poisoning
- Liver failure
- Bacterial infection (septic shock, see below).

This may be complicated by hypovolaemia or myocardial dysfunction.

IMMEDIATE TREATMENT

Give general supportive treatment while finding the underlying cause.

Refer to hospital?

Yes, for urgent admission.

Septic shock

This is due to toxins from bacterial infection.

Clinical shock is due to an inadequate blood flow to the peripheral tissues, usually giving rise to hypotension and reduced urinary output, and may be due to a variety of causes.

When shock occurs the clinical signs to be monitored are:

- Pulse volume, rhythm, and rate

• Blood pressure

• Respiratory rate

• Skin appearance

• Level of consciousness

Hypovolaemic shock

This is due to an inadequate intravascular volume usually caused by haemorrhage. There are three phases.

Signs

Compensation phase (caused by release of adrenaline)

• Tachycardia

• Pallor

• Sweating.

Plateau phase

• Tachycardia of 120-130 beats per minute

• Pallor

• Restlessness.

Decompensation phase

• Sudden fall in pulse rate

• Sudden fall in blood pressure. Note Any single reading may appear within the normal range; this phase may only be detected with serial readings.

LESSON 4_05 FRACTURES, SPRAINS AND MUSCLE TRAUMA

This chapter covers only some of the more complicated injuries. The medic should already be trained in the treatment of simple common injuries and the splinting of fractures. This chapter covers general principles first then discusses some injuries often seen in working men.

NOTE: A **sprain** is an injury of the tissues supporting a joint (ligaments); a **strain** is an injury to some part of a muscle-tendon unit. In real life the distinction is often artificial and the two words are frequently interchanged.

General principles

These principles can be followed for most acute musculoskeletal injuries, which typically feel worse after 4-12 hours due to stiffness and swelling and a bit worse still for another 36-48 hours. Always warn the patient he may feel worse in the morning, as he will probably stiffen up overnight.

The first four principles are the standard first aid treatment of the acute injury and are often summed up by the memory device "RICE"-Rest, Ice, Compression, Elevation

REST

This is self-explanatory; an injured part often must be rested by being taken out of use and/or placed in a position of comfort. This may be done with a sling, crutch, or by lying in bed. Patients typically protect their injuries by assuming the position of maximum comfort and this can often be maintained with bandages, straps, tape, padding or elastic wraps. Since the trunk and back support the body weight, the only possible form of rest for them is usually by lying in bed. The period of total rest should be brief, seldom more than 48 hours, since exercise or movement should be started as soon as possible (see below).

ICE

There is general agreement that an ice pack or cold compress applied to the acute injury reduces inflammation, retards swelling, and decreases pain. This in turn is important in allowing early protected motion of the injured area (see below). Ice can be left on for an hour or so immediately alter the injury, but after that it is often more practical to apply it for 30 minutes several times a day. Ice should be used for the first 48 hours and can be continued after that as long as there is benefit.

COMPRESSION

Wrapping the injured area with an elastic bandage often brings comfort and reduces swelling. The wrap should be snug but not so tight as to cause more pain or actually restrict circulation. If some swelling continues under the wrap, it will have to be loosened from time to time.

ELEVATION

Propping the injury up so it is higher than the trunk helps reduce swelling by the effect of gravity on the venous and lymph systems.

HEAT

Opinions vary about the proper use of heat or even whether to use it at all (the patient himself is often the best judge of what helps the injury). Most agree that in the fresh injury, where swelling and inflammation from damaged tissue are important, heat will increase this and should be avoided. After about 48 hours, many authorities try heat or alternate heat and cold. Where heat is most useful is in getting the patient started in situations where tightness and spasm are preventing motion and exercise (see next section). Use a light bulb, hot towel, hot shower or bath. Hot packs should bc comfortably hot only, as the patient can get used to a high skin temperature and burn himself.

PAIN-FREE MOTION

In the fresh injury, early motion and exercise is extremely important in shortening healing time and promoting proper strength of the healed tissue. As soon as pain permits even slight movement (usually at least by the second or third day) the injured part should be exercised in a way that does not overstress damaged tissue. Begin with gentle back-and-forth movements, setting the limits where **significant** pain is encountered.

Emphasize to the patient that pain determines the range of movement; it is not a test of bravery. Emphasize also that a small amount of pain does no harm and must be tolerated to achieve the benefits of exercise. Start small and allow the patient to work into the exercise at his own pace; give encouragement. As healing progresses, a wider range of motion is possible. Pain-free motion is best done frequently but for short periods (5 minutes every hour). It works best after applying ice for 10-20 minutes in the fresh injury; heat may work better for mobilizing the older injury.

Passive motion

The injured part is moved by another person, by the patients opposite hand, or by using gravity (see "shoulder" below). Usually passive motion is done first.

Active motion

After improvement occurs, the part is exercised using the muscles that control the damaged area. As before, the range of motion is guided by pain. Tell the patient, "Let pain bc your guide", but do not allow pain to stop him from exercising. Assure him that light activity will not add to the damage and actually promotes stronger healing.

PAIN-FREE MASSAGE

Most useful for muscular strains but may also help sprained joints. This may be done by itself or after applying heat. Use only fingertip pressure, moving back and forth along the length of the muscle. Increase the pressure until slight pain is just felt, then continue with slightly less pressure. The overall effect should be improvement. Do not continue if the pain is made worse but try again the next day.

MEDICATIONS

These help permit general body activity, promote adequate sleep, and assist exercise and massage. Improved rest reduces fatigue, which tends to increase stiffness and pain. Pain killers should not be used to allow harmful activity.

Specific areas

NECK AND UPPER BACK

Spasms and strains — A very common problem, both spontaneous ("crick") and due to falls, bumping the head, or even simply turning suddenly. The pain is usually in various areas of the trapezius muscle (back of the neck, tops of the shoulders, and between the shoulder blades). The patient may have symptoms suggesting a cervical disk (see below), but they are usually milder and improve quickly with treatment. For mild cases, follow the general principles above. Worse cases may require a few days in bed, as getting the weight of the head off the neck is an important factor in treatment.

Cervical disk — The symptoms may follow an injury, occur spontaneously, or after a minor event (coughing). The classic symptoms are neck pain with discomfort in one arm (seldom both). The neck and arm pain are usually made worse by certain neck movements, especially looking up and turning the head towards the painful side and also by downward pressure on the top of the head. The pain in the arm is usually a deep, intense ache and may have a burning or tingling quality. It often extends to the hand and certain fingers and usually occurs in a patch or strip down the arm. There may be weakness of the bicep, tricep, or grip. Routine care may help considerably, but severe pain usually requires constant rest in bed.

CHEST WALL — Chest wall pain is often the cause of concern because of fear of a possible heart problem. The most common pain patterns are: along the spine in back, near the edges of the breast bone (sternum), and around the chest in a belt-like fashion. A most reliable point is that chest wall pain is caused or aggravated by movement of the shoulders or upper body (twisting, reaching) or by deep breathing. Often there are areas which are tender to touch or where the pain can be reproduced by pressing on the chest (front-to-bock or side-to-side). Local heat and pain killers are usually enough.

LOWER BACK

Strain — This is a very common injury, usually due to lifting or straining but often from simply bending or from nothing at all. It often only feels sore at first, then worse after 4-8 hours or the next morning after muscle spasm and stiffness set in. The pain is located in the lower back mainly, but may extend upward to the shoulder blades and downward to the tailbone and upper buttocks. Follow the general principles. Mild cases can do light work, avoiding lifting and bending. Worse cases may require 2-3 days in bed with gradual resumption of full activity over 1-3 weeks.

Lumbar disk — The classic symptoms are low bock pain and "sciatica" (pain in the thigh and lower leg). The back pain is worse with sitting, straining and bearing down (e.g. bowel movements), coughing, or bending. Sciatica is a deep, intense ache in the buttock, thigh, knee or lower leg. Often there is burning, tingling or numbness in a strip down the lateral thigh, lower leg, in the foot or big toe. Lifting the patients straight leg while he lies on his bock will cause sharp pain to shoot down the leg. Routine care may help but severe cases will require rest in bed. If possible, allow rest for 1-2 days prior to transport.

SHOULDER

Strain-Treat as in "general principles". After the acute pain subsides, begin the **pendulum exercise.** Have the patient lean over, arm hanging down loosely, and swing the arm in circles by moving the upper body (not by actively moving the arm). Repeat several times a day to prevent stiffness, making small circles to start.

Dislocation-This is easy to recognize due to the "stair step" appearance of the shoulder. It is easiest to replace the arm if this is done soon after the accident. Give a large dose of pain killer or sedative. Pass a bed sheet under the arm on the dislocated side, then diagonally across the chest and back. Have another person hold the sheet for counter pull. Remove a shoe and place your heel in the armpit under the dislocated arm. Grasp the wrist of the dislocated arm and exert a firm, steady pull by leaning back, pulling the arm away from the body at a 45° angle. Do not yank or jerk. With a steady, hard pull (may require two people), the arm will slip back into place. (This technique for reducing a dislocated shoulder is called the "method of Hippocrates" and has been used for almost 2,500 years.) Bind the arm with a sling and swath. Allow no active use of the arm for 10-14 days, but begin pendulum exercise the next day and apply ice frequently for the first few days.

- **ALTERNATE METHOD:** Lie the patient face down, arm hanging down off the edge of a table. Tape sandbags or suitable weights to the wrist, starting with 15 pounds. Go up to 25-30 pounds, adding 5 pounds every 5-10 minutes until the arm slips into place.

NOTE: Always check the radial pulse and sensation in the hand and **fingers before and after** attempting to replace a dislocated shoulder.

Acromioclavicular (AC) separation-This is the result of torn ligaments which normally hold the outer end of the collarbone to the point of the shoulder (acromion process of the scapula). The end of the collarbone is raised up and will frequently move downward with pressure. It is usually easy to recognize by glancing at the opposite shoulder. Sling the arm in the position of comfort. The patient will probably need to be replaced, as the pain usually prevents work. Strains of the AC joint are much more common than separations, and usually heal in 10-14 days.

KNEE

Sprain — Usually occurs on the inner side of the knee and is tender there to touch. There may be slight swelling. The pain is increased by holding the knee nearly straight and pushing the ankle outward **gently** (thus putting stress on the injured ligament). If the knee actually opens up on the inner side there is a complete tear of the ligament. Slight looseness is usually normal, so check the opposite knee for comparison. If there is no tear, wrap the knee with sheet cotton or several layers of gauze for padding, then wrap the leg with an elastic bandage from the base of the toes to a hands-width above the knee. For mild pain, allow ordinary walking but no climbing or heavy lifting; for severe pain, use crutches until the pain allows walking. During crutch time, the knee should be put through active range of motion frequently and the thigh muscles should be clenched and relaxed often.

Internal damage (cartilage) — This usually occurs with a fall or accident where the knee is twisted with the foot held in place. The pain may not be severe at first. Usually there is obvious fluid in the knee joint. There may be locking or catching as the knee is moved back and forth and the knee may give way suddenly while walking. These same symptoms may occur without provocation in a knee that was previously injured. Treat as the level of discomfort requires and restrict activities appropriately. Transport for physician evaluation.

Bursitis (water on the knee) — With a blow to the knee, a fluid filled sac develops under the skin over the kneecap. It disappears in a few weeks and is harmless. Pain killers and heat are usually adequate treatment. The same injury occurs over the tip of the elbow (olecranon bursitis).

ANKLE

Probably the most commonly injured joint. The sprained ankle usually results from an inward turning (inversion) which sprains the ligaments in front of and below the lateral malleolus. There is tenderness in these areas, usually followed quickly by swelling and sometimes discoloration. Before swelling occurs, there is no obvious deformity. General treatment is according to the principles outlined above.

If the patient can bear weight on the ankle, he should be encouraged to do so, perhaps with a cane or crutch for assistance. The normal hinge-litre ankle motion with walking does not harm the sprained ligaments and helps them heal properly. Many commercial ankle splints are available which permit walking but protect the ankle from sidewise motion.

If weight bearing is impossible, give the patient crutches and instruct in the "touch gait": the foot is placed on the floor and a complete walking motion is carried out, though body weight is on the crutch rather than the foot. As the ankle heals, more weight is gradually placed on the foot. When crutches are not needed, the ankle should be splinted as above.

LESSON 4_06 ELECTRIC SHOCK

According to recent statistical data we can evaluate in France the number of deaths due to electric shock at 180 per year, concerning for 2/3 home accidents, and for 1/3 work accident and other outdoors accidents.

Accident involving apparent death state are called "electrocution", other manifestations are called electric shocks.

Aetiological notions

It is usual to say that "amperes kill and volts burn". In fact, other factors explain these accidents and their several manifestations.

Intensity causes immediate severe clinical signs. It depends on the voltage of the current, generally known, and the resistances according to the relation I = U/R (U=voltage in volts; R= resistances in ohms; I=intensity in Amperes). Resistances to the electric current can vary in large proportions depending on the path they take (body and cutaneous resistances can vary), clothes (serial resistances), humidity (low resistances), quality of the contact…explaining that for the same voltage, the effects of the current can be variable. A 1 milliampere intensity produces a simple jolt; the muscular contraction appears near about 10 milliamperes; an 80 milliampere current can create a cardiac arrest.

The voltage which vary from 110 to 250 000 volts or more, is the second important point, its action beeing due to the Joule effect releasing heat and causing burns;

The frequency of the current creates different polarisation effects and the dangerous level is reached when alternative current is four time lower than direct current;

The contact duration, the passage through duration, the path through the body are also essential elements.

Clinical manifestations

They are numerous and quite different according to the type of current : low voltage currents (50 to 380 volts) create an immediate vital risk because of the cardiac and respiratory disruptions ; high voltage cause further serious and deep burns.

Cardiovascular effects

Ventricular fibrillation : especially due to the low intensity current (less than 4 amperes) with a path crossing the heart (from arm to arm; or from head or arm to leg). In case of direct heart contact (catheter, innercavity stimulation probe), very low intensity current (2 to 10 micro-amperes) caused by defective apparatus (leak current) which can set off a ventricular fibrillation;

Other cardiac consequences : excitability troubles (extra-systole), conduction troubles, temporary repolarisation troubles can be seen in the ECG several days after a serious electric shock. Arterial spasms and peripheral thrombosis have also been described.

Muscular contractions

Muscular contractions are due only to alternative current and the casualty is sticked to the contact point or more rarely projected away causing trauma (high voltage). Thoracic and diaphragmatic muscles tetanisation can involve difficulty and even complete respiratory arrest.

Neurological effects

A diffuse brain suffering syndrome with loss of consciousness is often due to severe electric shocks. It may be an hypoxic suffering due to a cardiac arrest, but the electric shock may also have direct effects on the central nervous system, causing cellular or circulatory troubles, with a consecutive brain oedema, and causing variable consciousness level troubles, neurovegetative troubles, respiratory disorders (temporary loss of breath) possibly lasting 24 hours, convulsions or neurological deficient syndromes. Their evolution is unforeseen. Sensory complications (cataract, deafness) have also been described.

Burns

Because of their depth, high voltage current can produce serious burns, reaching muscle tissues, vessels and nerves (whose electric resistance is low). They can simulate a “crush syndrome” with compressive phenomena due to sub-aponevrotic oedema, rhabdomyolyse and acute kidney failure. Anyway, these burns are responsible for important functional and aesthetic after effects.

Treatments

Every casualty who shows consciousness troubles, even temporary, or who was injured by a high voltage current should proceed to the nearest hospital.

What is to be done on the accident site:

The removal must be executed as quickly as possible since the current passage duration will condition the clinical gravity. The removal is dangerous if the rescuers are improperly isolated and possibly causing electrocutions in chain. Of course, the fall of the shocked casualty must be prevented;

Immediate care must be that of the CPR: proper positioning, opening the airway, check breathing, asses for circulation, start CPR;

The Advanced Care Life Support should be applied as soon as possible

Transportation by a special team will ensure the use of instrumental oxygen ventilation, the use of adapted drugs, the precise diagnosis and early defibrillation.

Lightning injuries

They are electrocutions due to atmospheric electricity which can hit man directly (direct hit or within 30 meters radius by earth conduction) or indirectly transmitted by a conductor (electric wires) as far as 1000 meters from the lightning impact.

Clinical manifestations, even when numerous are led by neurological signs: amnesia, lack of orientation, or in more serious cases, different levels of coma or temporary neurological stroke.

Sequels are neurologic (prolonged coma by cerebral injuries) and often psychic (hysteria, dementia).

In return, cardiac damages are very limited (ECG repolarisation disorders) and burns usually cutaneous and shallow.

LESSON 4_07 METHOD OF CARING FOR A CASUALTY ON SITE AND DURING TRANSPORTATION

This section of the guide is concerned with the care and treatment of bed patients until they recover or are sent to hospital for professional attention.

Good nursing is vital to the ease and speed of recovery from any condition. Attention to detail and comfort may make the lot of the sick or injured person much more bearable. Morale is also a vital factor in any illness. Cheerful, helpful, and intelligent nursing can do much to encourage the patient to take a positive attitude towards his illness or injury; the reverse is also true.

A sick person needs to have confidence in his attendants, who accordingly should understand his requirements. Stewards or those most keen to undertake the task are not necessarily the most suitable choice. The person to look after the patient should be selected with care, and the master or a senior officer should keep a check on his performance.

Sick-quarters

Wherever possible, a patient sufficiently ill to require nursing should be put in the ship's hospital or in a cabin away from others. In this way he will benefit from quiet, and the risk of spreading any unsuspected infection will be minimized.

Superfluous fittings and all pictures and carpets should be removed from the sick-quarters. This will lessen the accumulation of dust and facilitate cleaning. The deck should be washed daily and scrubbed twice a week. Fittings should be dusted daily with a wet cloth to clean them and then polished with a dry duster.

Adequate ventilation of the sick-quarters is of great importance and it is equally important that changes of temperature, and also draughts, should be avoided as much as possible. The ideal temperature for the sick-room is between 16 °C and 19 °C. If possible, direct sunlight should be admitted to the cabin. If the weather is warm and the portholes will admit fresh air they should be left open.

In hot weather there is a great tendency to have the patient lie in a position exposed to a cooling draught. This must not be allowed because of the risk of causing chills. Equally, if the sickquarters are ventilated by a system of forced draught, the current of air from the outlet must not be allowed to play directly on the patient; it should be directed onto an adjacent bulkhead from which it will be deflected as a gentle current of air.

Arrival of the patient

It may be necessary to assist the patient to undress and get into bed. An unconscious or helpless patient will have to be undressed. Take off boots or shoes first, then socks, trousers, jacket, and shirt in that order.

In the case of severe leg injuries, you may have to remove the trousers by cutting down the seam of the injured leg first. In the case of arm injuries, remove the sound arm from its shirt sleeve first, then slip the shirt over the head, and lastly withdraw the injured arm carefully from its sleeve.

In cold climates the patient should always wear pyjamas. With helpless or unconscious patients the pyjama trousers should be omitted. The common tendency for the sick person to wish to add one or two sweaters should be resisted. In the tropics a cotton singlet and cotton shorts are better than pyjamas.

Blankets are unnecessary in the tropics but the patient should have some covering-either a sheet spread over him, or a sheet folded once lengthwise and wrapped round his middle.

If your patient has a chest condition accompanied by cough and spitting, he should be provided with a receptacle, either a sputum pot or an improvised jar or tin. The receptacle provided should be fitted with a cover or alternatively be covered with a piece of lint so as to distinguish it from a drinking receptacle. If the sputum pot is not of the disposable variety add a little disinfectant. It should be thoroughly cleaned out twice daily with boiling water and a disinfectant.

Other duties may make it impossible for the attendant to give uninterrupted attention to the patient, and a urine bottle should therefore be left handy for the patient on a chair, stool, or locker, and covered with a cloth.

Food, plates, cups, knives, forks, and spoons should be removed from the sick-quarters immediately after a meal, and in no circumstances should they be left there unless the patient is infectious. In that case they should be washed up in the cabin in a basin or bucket and then be stacked neatly away and covered with a cloth.

The patient should be protected from long and tiring visits from well-meaning shipmates. Visits to patients who are ill and running a temperature should be restricted to 15 minutes.

The following check-list will make it easier to remember all important points in nursing a patient on board ship.

Check-list

1. Ensure that the patient is comfortable in bed.
2. Check temperature, pulse, and respiration twice daily (morning and evening), or more often if not in the normal range. A fourhourly check is usual in any serious illness. Record results.
3. In appropriate cases test a specimen of urine.
4. Keep a written record of the illness.
5. Arrange for soft drinks to be easily available unless fluids are to be restricted.
6. Specify normal diet or any dietary restrictions.
7. Ensure that the person knows to ask for a bottle or a bedpan as needed-- some patients do not ask unless told to.
8. Check and record each day whether the patient has emptied his bowels or not.
9. Check fluid intake and loss by questioning the patient about drinking and passing urine. In certain illnesses an intake-loss fluid chart must be kept .
10. Check that the patient is eating and record appetite.
11. Remake the bed at least twice a day, or more often if this is necessary for the patients comfort. Look out for crumbs and creases, both of which can be uncomfortable.

12. Try to prevent boredom by providing suitable reading and hobby material. A radio will also help to provide interest for the patient.
13. A means of summoning other people, such as a bell, telephone, or intercom should be available if the patient cannot call out and be heard or if he is not so seriously ill as to require somebody to be with him at all times.
14. Fit bunkboards at all times for seriously ill patients, and at night or in heavy weather for others. Release retaining catches of swinging beds when the ship is rolling.

Vital signs

After the patients arrival in the sick-quarters, it will be necessary to note his vital signs. These indicate how effectively the body is carrying out the essential activities of living. They include:

1. Temperature;
2. Pulse;
3. Respiration;
4. Blood pressure;
5. Level of consciousness.

The body temperature

The temperature, pulse rate, and respiration should be recorded. You should make use of temperature charts or, if charts are not available, write down your findings, indicating the hour at which they were noted. Readings should be taken twice a day and always at the same hours, say, 7 h and 19 h (7a.m. and 7p.m.) and more frequently if the severity of the symptoms warrants it.

It will rarely be necessary to record the temperature more frequently than every four hours. The only exceptions to this rule are in cases of severe head injury, acute abdominal conditions, and heat-stroke, when more frequent temperature recordings are required.

The body temperature is measured using a clinical thermometer, except in hypothermie when a low-reading thermometer must be used. Place the thermometer in the patient’s mouth, under the tongue. The thermometer should remain in the patient's mouth (lips closed, no speaking) for at least one minute. After one minute, read the thermometer, then replace it in the patients mouth for a further minute. Check the reading and if it is the same as before, record the temperature on the chart. If it is different, repeat the process. Then disinfect the thermometer.

Because of the toxicity of mercury if the thermometer is broken, prefer the use of electronic thermometer with digital reading.

Sometimes it will be necessary to take the temperature per rectum, for instance in hypothermia. A thermometer used for taking a rectal temperature has a short, blunt bip to prevent injury to the rectum. First lubricate the thermometer with petroleum jelly. Then, with the patient lying on his side, push the thermometer gently into the rectum for a distance of 5 cm and leave it there for two minutes before reading it. Then disinfect the thermometer.

People who are unconscious, restless, or possibly drunk should not have mouth temperatures taken in case they chew the thermometer. Their temperature should be taken by placing the thermometer in the armpit and holding the arm against the side of the body for five minutes before the thermometer is read.

The normal body temperature (oral) is about 37 ° Celsius (centigrade); temperatures outside the range 36.3-37.2 °C are abnormal. Temperature taken in the armpit (or groin) is 1/2 °C lower, and in the rectum 1/2 °C higher. Body temperature is slightly lower in the morning and slightly higher at the end of the day. In those enjoying good health, variations in temperature are slight.

Body temperature is low in conditions that cause fluid loss (dehydration) such as severe bleeding and some severe illnesses of a non-infectious kind.

Body temperature is raised, and fever is said to be present, in infectious conditions and in a few disorders that affect the heat-regulating mechanism in the brain.

In feverish illnesses, the body temperature rises and then falls to normal. At first the patient may feel cold and shivery. Then he looks and feels hot, the skin is red, dry, and warm, and he becomes thirsty. He may suffer from headache and may be very restless. The temperature may still continue to rise. Finally the temperature falls and the patient may sweat profusely, becoming wet through. When this happens, he may need a change of clothing and may feel cold if left in the wet clothing or bedding.

During the cold stage, the patient should have one or two warm blankets put round him to keep him warm, but too many blankets may help to increase his temperature. As he reaches the hot stage, he should be given cool drinks.

If the temperature rises above 40 °C, sponging or even a cool bath may be required to prevent further rise in temperature. In the sweating stage, the clothing and bedding should be changed as necessary.

The pulse rate

The pulse rate is the number of heartbeats per minute. The pulse is felt at the wrist, or the heart rate is counted by listening to the heartbeat over the nipple on the left side of the chest. The pulse rate varies according to age, sex, and activity. It is increased by exercise and excitement; it is decreased by sleep and, to a lesser extent, by relaxation.

Pulse rates of 120 and above can be counted more easily by listening over the heart.

Normal pulse rate (number of heartbeats per minute)

Age 2-5 years about 100

Age 5-10 years about90

Adults, male 65-80

Adults, female 75-85

The pulse rate will usually rise along with the temperature, about 10 beats per minute for every 0.5 °C over 38 °C. In heart disease, a high pulse rate may be found with a normal temperature.

Note and record also whether the pulse beat is regular or irregular, i.e., whether there are the same number of beats in each 15 seconds and whether the strength of each beat is about the same.

If the rhythm is very irregular, count the pulse at the wrist and also by listening over the heart. The rates may be different because weak heartbeats will be heard, but the resulting pulse wave may not be strong enough to be felt at the wrist. Count for a full minute in each case, and record both results.

To take the pulse rate at the wrist, the procedure is as follows:

1. The patient's forearm and hand should be relaxed. Place your fingers over the radial artery, on the thumb side of the patient’s wrist.
2. Move your fingers until the pulse beat is located and exert enough pressure to make the pulse distinct, but not blotted out.
3. When the pulse is felt plainly, count the beats for one minute. Record the result.

The respiration rate

The respiration rate will often give you a clue to the diagnosis of the case.

The rate is the number of times per minute that the patient breathes in. It is ascertained by watching the patient and counting his inspirations. The person making the count should do so without the patients knowledge by continuing to hold his wrist as if taking the pulse. If the patient is conscious of what you are doing, the rate is liable to be irregular. A good plan is to take the respiration rate immediately after taking the pulse.

The respiration rate varies according to age, sex, and activity. It is increased by exercise, excitement, and emotion; it is decreased by sleep and rest.

Normal respiration rate (number of breaths per minute)

Age 2-5 years	24-28
5 years - adult	progressively less
Adult, male	16-18
Adult, female	18-20

Always count respirations for a full minute, noting any discomfort in breathing in or breathing out.

The pulse rate will usually rise about four beats per minute for every rise of one respiration per minute. This 4:1 ratio will be altered in the case of chest diseases such as pneumonia which can cause a great increase in the respiration rate.

Blood pressure

Blood pressure readings are obtained using a sphygmomanometer and a stethoscope to measure the force exerted by the blood in an artery in the arm. This

procedure is one requiring accuracy and skill, which have to be acquired through practice.

Blood pressure varies in the healthy person as a result of many factors. Emotional and physical activity have an effect on the blood pressure. During periods of physical rest and freedom from emotional excitement, the pressure will be lowered. Age in itself is a factor in elevating blood pressure.

An injury or internal bleeding can result in a great loss of blood, which causes lowered blood pressure. Shock is marked by a dangerous drop in pressure.

Blood pressure is usually expressed in millimetres of mercury. Two pressures are recorded: the systolic pressure, as the heart beats or contracts and the diastolic pressure, as the heart rests. In the blood pressure recording 120/80, the systolic pressure is 120 mm Hg and the diastolic pressure is 80 mm Hg. These are within the normal range. A slight variation from these values is insignificant.

When blood pressure is being taken, the patient should lie or sit, and the arm that is to be used should be supported. Measurements may be made in either arm. In taking blood pressure, this procedure should be followed:

1. Place the cuff around the patients arm, above the elbow. Check to see that the valve on the bulb is fully closed (turned clockwise).
2. Before inflating the cuff with air, find the arterial pulse on the inner side of the bend of the elbow.
3. Keep fingers on this pulse and inflate the cuff by pumping on the rubber bulb until the pulse disappears.
4. Place the earpieces of the stethoscope in your ears (the earpieces should be directed upwards) and position the disc of the stethoscope over the space where the pulse was felt.
5. Hold the disc of the stethoscope snugly in position over the pulse with one hand, while pumping the cuff with the other.
6. Pump the cuff until the mercury on the scale of the mercury apparatus, or the needle on the gauge of the aneroid apparatus, is about 30 points above the systolic pressure that was obtained previously, i.e., when the arterial pulse was felt to disappear.
7. Loosen the valve slightly and permit the pressure to drop slowly while listening carefully for the sound of the pulse. Soon a definite beat will be heard, but it will be quite faint. If this beat is missed or if there is a question as to the pressure when it started, tighten the valve again, pump once more, and listen for the sound. The number at which the first sound is heard is the systolic pressure. This number should be recorded.
8. Continue to deflate the cuff slowly until the sound disappears. The reading at which the last sound is heard is the diastolic pressure.
9. Open the valve completely and allow the cuff to deflate.

Difficulty in obtaining the blood pressure reading may be due to the valve being opened too much, causing the pressure to drop too rapidly, or to the attendant having expected a louder sound through the stethoscope.

Levels of consciousness

Consciousness is controlled by the brain and the involuntary nervous system. There are four levels of consciousness: alertness, restlessness, stupor, and coma.

The alert patient is well aware of what is going on and reacts appropriately to factors in the environment. Facilities to supply his body needs will be requested, such as a urinal or bedpan, medication for pain, or a drink of water.

The restless patient is extremely sensitive to factors in the environment and exaggerates them.

Such a patient may scream with moderate pain. He wants constant attention, moves about in bed continuously, and thrashes from side to side.

The stuporous patient lies quietly in bed, seems to be sleeping, and requests nothing. Even when awakened, he quickly returns to a sleeplike state that makes feeding difficult. The patient may be incontinent, exhibiting involuntary loss of urine or faeces.

The degree of stupor is determined by the stimuli required to awaken the patient. If he can be awakened by a voice, the level of consciousness would be described as light stupor. If he can be awakened only by pressure, e.g., by light tapping on the side of the face, the level would be described as deep stupor.

Glasgow Coma Scale

Eye Opening	**E**
spontaneous	4
to speech	3
to pain	2
no response	1
Best Motor Response	**M**
To Verbal Command:	
obeys	6
To Painful Stimulus:	
localizes pain	5
flexion-withdrawal	4
flexion-abnormal	3
extension	2
no response	1
Best Verbal Response	**V**
oriented and converses	5
disoriented and converses	4
inappropriate words	3
incomprehensible sounds	2
no response	1

E + M + V = 3 to 15

- 90% less than or equal to 8 are in coma
- Greater than or equal to 9 not in coma
- 8 is the critical score
- Less than or equal to 8 at 6 hours - 50% die
- 9-11 = moderate severity
- Greater than or equal to 12 = minor injury

Coma is defined as: (1) not opening eyes, (2) not obeying commands, and (3) not uttering understandable words

The patient in a coma lies quietly in bed, appears to be sleeping, and cannot be awakened. The patient will not ask for a drink or urinal, he cannot swallow, and may be incontinent or retain urine. Strong sensations or calling by name will not awaken the patient.

What levels of consciousness mean

The alert patient is one whose brain is functioning adequately.

The restless patient's brain is extremely active in its attempt to meet the body's needs. Restlessness is often observed in the following patients:

- those frightened, worried, or in pain;
- those haemorrhaging; the restlessness results because the brain is receiving a reduced or inadequate blood supply;
- those with a head injury or brain tumour, if the increased pressure on the brain is cutting off the blood supply to a part of the brain;
- those who have suffered a heart attack; the weakened heart cannot pump enough blood to the brain;
- those in shock, when blood pressure is so low that there is insufficient force to pump blood to the brain.

Restlessness may be an early sign of these conditions.

TRANSPORTATION OFFSHORE

The helicopter is now the normal means of transport to and from offshore installations both for routine crew changes as well as for the injured and sick.

The noise and vibration in most helicopters may cause stress and fatigue on a long journey and some form of ear protection must be worn. This is particularly important for a day trip when the journey to and from the offshore installation is made in one day. Ear protectors will preserve efficiency following a helicopter journey and protect the hearing of those who travel frequently by helicopter.

Transporting casualties by helicopter

Helicopter transport enables a sick or injured man to be taken from the offshore structure straight to the hospital onshore. A casualty can be plucked or winched from the sea, the deck of a ship or an offshore structure. Or if the helicopter can land on the helideck of the offshore structure the casualty can be carefully placed inside it.

The casualty must be in a stable condition before the journey begins. The journey may take several hours, so he will require continuing attention during the journey. For this reason most oil companies train a group of offshore personnel to provide an escort service for casualties.

Assessing transportation priorities

In most oil and gas field developments a certain number of helicopters are constantly available for transporting medical emergencies. If it is necessary to transport more casualties than can be done with the helicopter facilities immediately available it is necessary to decide which casualties to evacuate first. Paradoxically, it is not always appropriate to evacuate the more seriously ill casualties first.

For example, following a fire there may be a number of seriously burned casualties who have been treated as recommended. Suppose there are six burned patients awaiting evacuation.

They have burns involving the following percentage areas of body surface: 9, 31, 40, 45, 80, 85 respectively. If the helicopter can only take three patients the problem is to decide who should be sent ashore first. It should be the three patients whose burned surface is 31, 40 and 45 per cent, because they are at risk of dying if they do not receive medical attention urgently but have a good chance of survival if they receive hospital attention. The casualties with burned surfaces of 80 and 85 per cent will probably die whether they receive medical attention or not. While the casualty whose burn amounts to 9 per cent of his body surface needs medical attention, but his condition will not get worse if he has to wait for the next helicopter.

Consider another scenario, this time in the Arabian summer. Following an accident, a number of minor injuries are caused which require hospital attention. One casualty also has a badly crushed chest and is in shock, and another is suffering from severe heat stroke. A medical team arrives in a helicopter and a second helicopter is expected to arrive within the hour. On this occasion it is the patients with minor injuries who should go on the first helicopter, while the medical team resuscitate the two seriously injured casualties. These two can then be accompanied by the medical team in the second helicopter in a stable condition. Under these circumstances the seriously injured men are more likely to withstand the journey.

Preparing for evacuation

If the casualty has to be evacuated the following actions can be taken while waiting for the helicopter:

1. Escort It may be better if the rig medic does not escort the patient ashore, because the remaining personnel on the rig would be left with no medical assistance. Therefore a suitable escort should be chosen, preferably someone with basic life support training.

2. Monitoring of the patient should continue while waiting for transport and during the journey. The escort should be instructed on what to do and the problems which might arise.

3. An account of the incident should be written down, if it has not been done before, with times of the various events noted. This should be sent ashore with the casualty.

4. No food or drink should be given to the casualty because he may have to have an anaesthetic during later treatment. Exceptions to this general rule of no fluids are burns victims and casualties in hot climates who may be at risk of dehydration.

5. Additional evidence which might be of value to the hospital team, such as a bottle or chemical specimen if there is suspected poisoning, should be sent ashore with the patient. Or if he has vomited, any contaminated clothing or vomit should also be sent with him.

These procedures are vital to the continuing management of the patient. Seeing them being performed he will also feel more confident and reassured while waiting for the helicopter to arrive.

Monitoring the casualty in flight

We have already stressed the importance of monitoring a casualty continuously during the journey. With the escort's notes and verbal account of the trip the hospital doctor receiving the casualty can begin treatment at once without spending an unnecessary amount of time determining the patient’s condition.

Monitoring the casualty can be very difficult in a helicopter with all the noise and vibration. There have been occasions when casualties have been plucked from the sea and it has been hard to distinguish between life and death in the noisy environment of the helicopter. In certain cases special equipment can be used to measure vital signs visually, where auditory means are more usual - determining the presence of a heartbeat or measuring blood pressure, for instance. Standard monitoring equipment which functions well in a helicopter is also available - for example, some types of electrocardiogram (ECG) for measuring heart activity.

During the journey the attendant must make sure that the casualty is breathing and his heart is beating. Any bleeding should be kept under control and fractures and wounds should be kept immobilized. It is also important to monitor changes in the patient's condition in case it deteriorates and he needs more treatment. For example, when escorting a casualty who has been poisoned his breathing may stop. If artificial respiration can be given before the heart stops, he will have a good chance of survival. Or, a splint immobilizing a fracture may become too tight and hinder the circulation if there is further swelling at the fracture site. It will then need to be loosened.

Communication

Before the helicopter reaches the offshore casualty the doctor on board may have to contact the first aider or medic on the offshore structure. The person escorting the casualty back to shore may also have to contact the medical centre or hospital onshore. For example, if the casualty is getting worse, special facilities may be needed at the heliport to deal with him.

This communication is not easy because radio equipment does not allow free discussion and reception may be poor. Therefore short, relevant messages about the casualty's condition should be used. Communicating in this way may need practice, which should be obtained before an emergency arises.

LESSON 5_01 DIVING PHYSICS

Basic Physics

Air

Atmospheric Pressure

A layer of air, which we call the atmosphere, surrounds the earth. Air is a mixture of gases and, like all matter, has mass. A mass exerts a force on those things, which lie beneath it and at sea level the atmosphere presses down with aa force of approximately 1 kilogram force for every square centimetre of the earth's surface.

Atmospheric pressure = 1 kgf/cm^2 (approx.)

In diving, it is customary to use the simple measure of ' 1 bar' to describe the earth's atmospheric pressure at sea level. This is an approximate figure.

Atmospheric pressure = 1 bar or 1 kgf/cm^2 (approx.)

Atmospheric pressure varies slightly with changes in weather and decreases with altitude, until it reaches zero at the extreme outer limits of the atmosphere. At about 5 500 metres above sea level, for example, the atmospheric pressure is about 0.5 bar.
Our bodies do not suffer in any way from this pressure, which is applied, to every square centimetre of their surface we are born to it!

Gauge and Absolute Pressure

When pressure is to be measured it is normal practice to relate it to atmospheric pressure. Thus a simple gauge would read zero when in fact the atmospheric pressure is 1 bar. A diving cylinder pressure gauge might read 200 bar, but this really means 200 bar above the normal atmospheric pressure of 1 bar. Such a reading is known as 'gauge pressure'. If the gauge were calibrated to true zero as found in space or in a vacuum, it would read 201 bar - the extra bar being atmospheric pressure. Such a gauge reading is termed “absolute pressure”.

Absolute pressure = gauge pressure + atmospheric pressure

In diving physics, if is normal to work in terms of absolute pressure.

Composition of Air

The air which makes up the atmosphere, and which we breathe, comprises:

nitrogen (N_2) 79 per cent (say, 80 per cent or 4/5)

oxygen (O_2) 21 per cent (say, 20 per cent or 1/5)

There are traces of carbon dioxide (CO_2) and other gases, but these occur in such small quantities that they can be safely ignored.

The body uses oxygen in its metabolism. Nitrogen is an inert gas, which serves no useful purpose in the body. However, as it constitutes almost four-fifths of the air we breathe, it is present in all body tissues and under certain conditions has noticeable effects on the diver.

Compressibility

All gases, including air, are compressible, having neither shape nor volume. On the other hand, liquids have a definite volume and mass and may be regarded as incompressible at the pressures we are considering.

Air Density

Air becomes denser (thicker) at depth and a diver using breathing apparatus encounters a slight increase in breathing effort when deep. Modern regulators are designed to minimize the effects of increased air density, but it can be a problem if a diver is expecting to undertake hard work at depth.

Nitrox

Some divers also use a gas called Enriched Air Nitrox (EANx) generally referred to as nitrox. This gas, as air, contains nitrogen and oxygen, however the amount of nitrogen is reduced and the oxygen increased. For example, Nitrox 36 would contain 36% oxygen and 64% nitrogen. The number written after the word nitrox always refers to the amount of oxygen in the gas.

Water

Water Density

Water is a very dense medium compared with air. Sea water is slightly more dense than fresh water. Because of water's great density, its resistance to body movement is considerable. Movements should be slow and deliberate, and the diver should swim through the water so as to present the minimum frontal area and resistance.

Hydrostatic Pressure

Being a dense medium, water exerts a noticeable pressure upon anything immersed in it. Water pressure increases rapidly with depth and a cubic metre of water (1000 litres) has a mass of 1000 kg or 1 tonne. Some fairly simple arithmetic will reveal that, if our cubic metre is divided up into 1 metre-high columns, each of 1 square centimetre crosssection, the mass of water in each centimetre column is 0.1 kg. If each 1 centimetre-square column were extended to 10 metres in height, the mass of water would be 1 kg and the pressure exerted by it would be 1 kg force per square centimetre (1 kg/cm^2)

It has already been explained that atmospheric pressure presses down with a force of 1 kg for every square centimetre of the earth's surface. So at 10 metres beneath the surface, the water pressure or hydrostatic pressure is equivalent to the atmospheric pressure at the surface. At 10 metres the water exerts the same force as 1 bar gauge pressure or 2 bar absolute, and for every further descent of 10 metres beneath the surface the hydrostatic pressure increases by another bar. Thus at 30 metres the absolute pressure is 4 bar at 50 metres 6 bar and so on.

In air and water - especially in water - pressure has the property of acting in all directions. Thus, 30 metres down, a body is subjected evenly to 4 bar absolute pressure over its whole surface and from all directions. For example, the pressure in an underwater cave at 30 metres is still 4 bar, the pressure being transmitted horizontally through the water. (Pascal's Principles)

Since the human body consists largely of fluids, an increase in the hydrostatic pressure does not result in a decrease in volume. Problems occur, however, in body airspaces when a diver descends and is subjected to increasing water pressure.

It is necessary to study the behaviour of airspaces underwater, whether they are within the diver's body or part of his equipment, and to see how they behave as pressure changes.

Gases under Pressure

Pressure/Volume changes

Since gases are compressible, the space (volume) they occupy will be reduced if the pressure is increased and enlarged when the pressure is decreased. If changes in pressure are the result of descent or ascent while diving, the air pressure within an airspace will always seek to remain equal to ambient pressure. The volume will change while the pressure remains equal to ambient pressure.

Thus, an inverted open-ended container full of air at the surface, where the pressure is 1 bar absolute, will appear half full of air at a depth of 10 metres, where the total pressure is 2 bar absolute, and only one-quarter full at 30 metres, where the total pressure is 4 bar absolute.

During ascent, the air will expand in volume as the ambient pressure falls and, on reaching the surface, it will have expanded to fill the container once again. Note that the greatest pressure and volume changes occur between the surface and 10 metres. On descent to 10 metres, pressure doubles and volume is halved. For every further 10 metres thereafter, the pressure and volume changes are smaller. On ascent, the reverse applies.

If the container were filled with air at depth, the air would expand on ascent and the surplus would escape from the inverted mouth of the container. If a closed but flexible air container were used rather than an open inverted one, it would start off full at the surface, but it would progressively collapse as it was taken deeper underwater.

If it were filled with air at depth, sealed and returned to the surface, volume would increase as pressure fell. It would expand to the limits of the material and then rupture, as the internal pressure tried to remain equal to ambient water pressure. This pressure/volume relationship is Boyle's Law a relationship first recorded by the physicist of that name. In diving, it is a fundamental physical relationship, which cannot be ignored. Divers encounter the effects during training and diving, whether snorkelling or using scuba. Any compressible airspace, whether in the diver's body or equipment, will change its volume in proportion to pressure during descent and ascent; and if pressures in the body's rigid airspaces are not kept equal to ambient pressure, injury or damage of some sort will occur.

Partial Pressure

It has been explained that air comprises approximately 80 per cent nitrogen and that atmospheric pressure is 1 bar. It is correct to assume, therefore, that nitrogen is responsible for 80 per cent of atmospheric pressure and oxygen for the remaining 20 per cent. In a mixture of gases the total pressure is equal to the sum of partial pressures which each gas would have if it alone occupied the available space. The physicist Dalton discovered this state of affairs, and Dalton's Law of Partial Pressure was established to describe it.

It is normal to use the prefix 'pp' to indicate partial pressure, thus:

PpN_2 = 80 per cent of 1 bar = 0,8 bar

PpO_2 = 20 per cent of 1 bar = 0,2 bar

Total pressure of air = 1 bar

Partial pressure increases in direct proportion to absolute pressure. For example, at 30 metres (4 bar absolute) the pp nitrogen is 3.2 bar and the pp oxygen is 0.8 bar.

The significance of partial pressure in diving concerns the toxic effects, which various gases can have on the body at elevated pressures. Even oxygen, essential for life can have adverse effects if breathed at a partial pressure in excess of 2 bar absolute.

One hundred per cent oxygen breathed at depths in excess of 10 metres (2 bar absolute) can lead to oxygen poisoning. When breathing air, the pp oxygen can reach 2 bar absolute at a depth of 90 metres (10 bar absolute). Carbon monoxide (CO) is a contaminant sometimes found in air. It is highly toxic. At atmospheric level the body can safely withstand 10 parts per million (p.pm.) of CO, but if the same air were breathed at 50 metres (6 bar absolute) the effect on the body would be the same as breathing 60 p.p.m. at the surface - a dangerous level of poisoning.

Solubility of Gases

Wherever there is an interface between gases and a liquid, gas will dissolve in the liquid. The amount which dissolves, is dependent on various factors, the main one being the partial pressure of the gas. As pressure increases so more gas will dissolve. When pressure falls, the situation is reversed and gas will be released from the liquid, appearing as bubbles. Henry's Law of gas solubility governs this relationship.

Everyday examples of gas dissolved in a liquid and the effects of its sudden release can be found in aerated drinks. Bottled or canned drinks have carbon dioxide dissolved in them. If the drink is opened rapidly the release of gas can be violent enough to cause aerated liquid to rush from the container.

The significance of this gas law to the diver is that it explains two important functions: first, the uptake of oxygen by the blood and the release of carbon dioxide from it - an exchange which happens virtually instantly and continuously; second, the absorption/release of nitrogen by/from the blood and tissues on descent/ascent, when the

ambient pressure of air in the lungs is increasing/decreasing. Descent is not the problem - it is on ascent that absorbed nitrogen can cause trouble to the diver especially if its rate of release from body tissues is rapid. Nitrogen bubbles can actually form in certain tissues, giving rise to the various problems of decompression illness.

Effects of Temperature

While temperature underwater may be considered relatively constant, air temperature can vary considerably throughout the course of a day. If a gas is heated, it will either increase its volume or its pressure will increase if the volume is constrained. This relationship is known as Charles' Law.

Charged diving cylinders should not be left in the hot sun, where their pressure will steadily increase until it possibly exceeds the safe working pressure of the cylinder. Inflatable boats should be slightly deflated if they are to be left in strong sunshine.

Buoyancy

Any object immersed in water will receive an upthrust equal to the weight of water it displaces (i.e. whose volume it occupies). This is the basis of Archimedes' Principle.

If the weight of the immersed object is less than the weight of water it displaces, it will float (positive buoyancy). If the weight is greater it will sink (negative buoyancy). An object whose weight is the same - or is capable of being adjusted until it is the same - will neither float nor sink. It will have neutral buoyancy.

Since the body contains a lot of water, the weight of the average unclad human body almost exactly matches the weight of water it displaces when immersed. Slight differences can usually be accommodated by varying the depth of breathing - exhale, reduce lung volume, displace less, sink, and vice versa. By varying the volume of the body, its buoyancy will also vary.

A diver is able to vary his volume (by adjusting his depth of breathing or the equipment he uses) and therefore the amount of water displaced, so that it matches his own total weight leaving him in a state of neutral buoyancy (weightlessness) while underwater.

Air is an easily packaged and very buoyant gas, and is regularly used to adjust or achieve buoyancy underwater.

Vision/Light

Magnification

A diver's mask allows the eyes to operate in their normal medium of air. Without an airspace, eyes cannot focus and vision will be blurred. Light rays, passing from water into air, are bent causing objects to appear about 33 per cent larger and 25 per cent closer to the viewer. Until the diver gets used to a slightly magnified outlook on the underwater world, the beginner may find this a little confusing.

Light/Absorption

Light is both absorbed and scattered by water. Daylight is made up of different colours, each of which is absorbed at a different depth. Since each colour is part of the total light entering the water, as depth increases, less light remains to penetrate. Reds are the first to go, with only blue light reaching great depths. Colour can be restored by use of artificial light.

Light Scattering/Diffusion

Light will also be blocked and scattered by particles suspended in the water, which prevent it penetrating to great depths.

Sound

In air and at normal temperatures, sound travels at approximately 350 metres/second. Underwater, it travels much faster - approximately 1400 metres/second. The human ear is confused by the high speed of sound underwater and cannot accurately focus on the source of the sound, which becomes all enveloping. The underwater world is far from silent. A diver can clearly hear not only the sound of his buddy's exhaust bubbles, but also the throb of a distant ship's propellers, the swirl of wave-washed shingle or the sound of prawns as they feed!

Sound can be a useful means of attracting attention underwater, but the diver being signalled will have to look up and around to locate the sound source. Sounds made above the water's surface will not penetrate into the water and vice versa.

Conduction

Water has a colossal capacity to conduct heat away from the body - some twenty-five times more effectively than air. An unclad diver in waters of less that 21 ° C will lose heat faster than his body can generate it, and will become chilled. In extreme cases, hypothermia can follow. Diving suits are necessary to maintain body temperature in all waters other than in the high tropics.

Body Airspaces

The Ear

In addition to being the organ of hearing, the ear is also concerned with the senses of balance and position. The visible outer ear consists of the ear and the external auditory canal, which is closed off at its inner end by the eardrum. The outer ear is open to air and its purpose is to collect sound waves and direct them to the eardrum, which will vibrate as a result.

The middle ear is a rigid air-filled space, mostly surrounded by the bone of the skull. The eardrum forms an outer wall and the airspace is connected to the rear of the throat by the Eustachian tube. The centre of the middle ear is a series of bones, which transmit vibrations from the eardrum to the inner ear.

The inner ear is filled with fluid and is embedded in the bone of the skull. Vibrations picked up at the eardrum and transmitted to the inner ear are converted into nerve impulses that are sent to the brain and perceived as sounds.

The semicircular canals are considered to be part of the inner ear but play no part in hearing. They are of major importance for a sense of balance and position and their function can be upset by certain conditions affecting the middle ear.

The Sinuses

Sinuses are rigid filled airspaces within the bone of the skull and are mostly connected to the upper nasal passages. The largest are the frontal sinuses in the bone over the eyes, and the maxillary sinuses in the cheekbones. There are other smaller sinuses elsewhere within the skull. Sinuses appear to serve no useful purpose other than to reduce the total weight of the skull.

The Rspiratory Airways

The entire network of respiratory airways, from the mouth and the nose to the bronchi and the bronchioles within the lungs, may be considered to behave as a rigid airspace.

The Lungs

There are two separate lung sacs within the chest cage. They are airspaces containing millions of flexible alveoli through which gas exchange takes place with the blood. The lungs are regarded as flexible airspaces and will reduce in volume in order to maintain ambient air pressure within the lungs and airways. The part played by the lungs in respiration is explained on p. 80.

Stomach and Gut

Air may be ingested into the stomach and the normal digestive process generates gases in the gut. Any air/gas pockets, which exist, will behave as flexible airspaces.

The Effects of Pressure

If not already familiar with pressure/volume relationships, the reader is advised to gain an understanding of that subject before considering the effects of pressure on body airspaces. The latter will not be clear without an appreciation of the former.

The Effects of Pressure on Body Airspaces

Any compressible airspace in the diver's body will change its volume in proportion to ambient pressure during descent and ascent; and if pressure within the body's rigid airspace is not kept equal to ambient pressure, injury or damage of some sort will occur. During descent, when pressure increases and volume reduces, the problems that arise are the result of compression. On accent, when pressure falls and volume increases, problems are caused through expansion.

Compression Problems

Ears and Sinuses

The ears are very sensitive to changes in pressure and will be affected within 2 metres of leaving the surface. Increasing external water pressure will depress the eardrum inwards in an effort to reduce the volume of the near-rigid middle-ear cavity. Pain is felt, increasing as pressure increases. If the imbalance of pressure is not relieved, the eardrum will rupture, allowing cold water to enter the middle-ear cavity where it will upset the organs of balance and hearing. Vertigo is likely to follow rapidly. Deafness and risk of middle-ear infection are longer-term risks.

The effects of pressure on the ears can be avoided by allowing air from the nasal passages to pass through the Eustachian tubes into the middle-ear cavity, where it balances external pressure. For reasons, which are explained shortly, the pressure in the respiratory airways will always be effectively equivalent to ambient pressure. In their normal state the Eustachian tubes are closed, but by swallowing or by closing the nostrils and blowing into the nose, they can be opened and air admitted to the middle-ear cavity.

The process of blowing against closed nostrils to force air up the Eustachian tubes is known as the “Valsalva manoeuvre” or, more commonly amongst divers, 'ear clearing'. A diver's face mask must include the nose and will usually have pockets built into it which allow the nose to be pinched so that the ear-clearing action can be made. The ears should then be cleared regularly during descent before any discomfort is felt.

If a normal healthy person finds it difficult to clear their ears, it is a good idea to ascend a little to relieve the discomfort and then try ear clearing once again.

External ear plugs which seal the outer-ear passage may appear to prevent compression of the eardrum but can damage it in another way. Increasing air pressure within the middle-ear cavity will push the eardrum outward and, in some cases, it can rupture. However, the tissues surrounding the outer-ear passage are likely to bleed and fill the space with blood, thereby relieving the pressure but nevertheless rendering the diver unfit to dive. This condition is known as 'reversed ear'. Sometimes a very tight-fitting diving suit hood can block off the outer-ear passages. Air or water at ambient pressure must be encouraged to enter the hood and outer-ear passages.

Sinuses

Like the middle-ear cavity, the sinus spaces are connected to the respiratory airway by fine passages. If the air passages within the sinuses do not balance automatically, they will almost certainly do so as a result of ear-clearing efforts.

If the connecting passages are blocked for any reason, an imbalance of pressure will cause acute pain.

If the pressure is not relieved by equalizing or by reducing the ambient pressure, the linings of the sinus cavity will bleed, flooding the cavity to balance the pressure. A slight nosebleed during or after a dive is a common sign of a mild sinus blockage.

Diving with a Cold or Nasal Infection

A cold, heavy catarrh or hay fever will cause inflammation and swelling of the tissues making up the nasal tract, Eustachian tubes, sinus cavities and airways and the secretion of mucus, all of which lead to blockages of the airways and inability to clear ears and sinuses.

DO NOT DIVE WITH NASAL INFECTION OR CONGESTION.

Ears and sinuses are unlikely to clear; eardrums may be damaged and infection may be forced into the ear and sinus cavities.

Decongestant medication should only be used under medical guidance. Seek medical advice if you suffer persistent difficulty with ears and sinuses.

Lungs and Respiratory Airways

Being flexible, the lungs of a breath-holding diver will reduce in volume on descent, while the air pressure within them, and also within the rigid respiratory airways which are directly connected to the lungs, will maintain a pressure equal to ambient.

The breath-holding diver will also lose buoyancy as he descends because of the reduction in lung volume.

The reduction in lung volume is in direct proportion to the increasing ambient pressure, and if a breathholding diver commences a descent with full lungs (total lung volume = 6 litres), at 4 bar absolute pressure the total lung capacity will be compressed to 1.5 litres - a figure equal to residual volume in normal full exhalation. In practice, it appears that the lungs can withstand further compression, but the limits have not been quantified. The fact that the world record for breathholding diving stands in excess of 150 metres (more than 15 bar absolute) says much for the versatility of the human body. This type of diving is ill-advised for sport divers and the BSAC strongly recommends against any attempts at depth or endurance records.

A slightly different form of lung squeeze, but with similar theoretical results, can occur when a diver attempts to breathe surface air through a long snorkel tube. The air pressure within the lungs remains equal to atmospheric pressure, while the outside of the chest is exposed to water pressure. At as little as 0.5 metre depth (1.05 bar absolute), pressure on the outside of the chest is sufficient to inhibit the muscular action of inhalation. A further increase in depth will expose the diver to the risk of lung squeeze.

The diver using scuba breathes normally throughout the dive and therefore maintains normal lung volumes (and normal buoyancy). There is no risk of compression injury unless the diver breathes out hard to commence a descent and fails to resume normal breathing within a few metres. Under these circumstances there is a possibility of thoracic squeeze. It is easily avoided by resuming normal breathing once the descent has begun.

It should be remembered that the diver's mask represents an extension of the nasal airways and the airspace between will be compressed on descent. This could lead to the condition of 'mask squeeze', which can damage the delicate tissues of the eyes and the eye sockets. Mask squeeze can be prevented by deliberate efforts to exhale a small amount of air through the nose into the mask during descent. This will return the lower pressure mask space to ambient pressure.

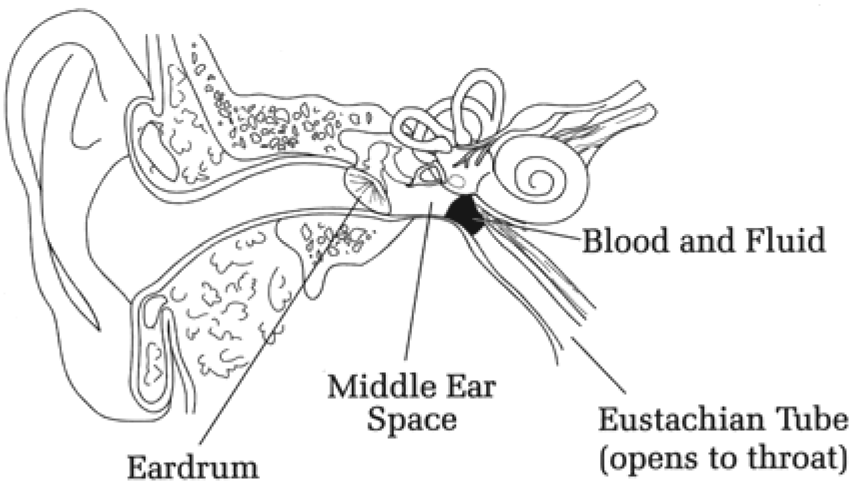
There is a remote chance that air under pressure will enter minute cavities within dental fillings and this can lead to pain on ascent. It is a very rare condition, which can be put right with fresh dental filling.

LESSON 5_02 SQUEEZE, EAR & DENTAL PROBLEMS

There are a variety of injuries associated with diving. These injuries make up a group referred to as barotrauma or trauma to the soft tissues of the body as caused by pressure. Most of these injuries are not life-threatening. Examples include: sinus squeeze, ear squeeze, reverse ear squeeze and tooth squeeze. "Squeeze" injuries can cause mild to severe pain and may damage the related soft tissue structures. If pain persists after the dive or blood presents after an ear or sinus squeeze, the patient should be evaluated to ensure proper treatment of the injury and prophylactic treatment of infection

WHAT IS THE CAUSE OF MIDDLE-EAR SQUEEZE AND HOW CAN IT BE PREVENTED?

Squeeze on the middle ear is prevented by making sure inhaled compressed air travels from the back of the nose (nasopharynx) into the middle ear spaces. The only route of passage into the middle ear is through a tiny, compressible canal called the eustachian tube (after its discoverer, the Italian Bartolommeo Eustachi, 1524-74). Anatomically, this is a soft and flexible canal that functions as a one-way flutter valve; it easily opens up when pressure in the middle ear is higher than in the nasopharynx, but tends to close shut when pressure in the nasopharynx is higher than in the middle ear. As a result, gas flow is passive from the middle ear to the nasopharynx on ascent (you don't have to think about it), but "active" on descent (you have to make it happen).



Middle ear squeeze. The external ear canal leads to the flexible tympanic membrane or eardrum, which is exposed to the ambient pressure. Behind the ear drum is the middle ear air space, which will be compressed at depth unless pressure is equalized, via the eustachian tube, with inhaled air. If the eustachian tube is blocked as may happen without equalization after descending just a few feet fresh air cannot enter the middle ear space and the ear drum will bulge inward, causing pain. If the diver descends too quickly without equalization, the tympanic membrane can rupture. If the diver continues to descend slowly without equalization, blood and fluid from surrounding tissue will be forced into the middle ear space.

Thus the diver has to consciously work to keep the eustachian tube open on descent, or else it will close and prevent compressed air from reaching the middle ear. This is done by one of several maneuvers, including blowing against a closed mouth and nose, swallowing, yawning, or the Valsalva or Frenzel maneuvers. (The Valsalva is a forced exhalation with nose pinched, lips closed against mouthpiece, glottis open. The Frenzel is accomplished with nose pinched and lips closed against the mouthpiece; the back of tongue is thrust against soft palate, gently pushing air through the eustachian tubes.)

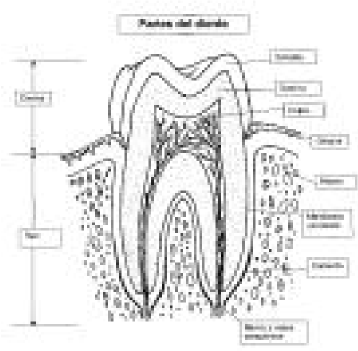
Whichever method is used, it must be done frequently on descent because at some point no maneuver will work; this is the situation when the pressure keeping the tube shut is too great. If the pressure gradient across the tube (nasopharynx to middle ear) exceeds 90 mm Hg - a gradient reached at only about 4 feet depth - none of the maneuvers will open the eustachian tube and the diver *must* ascend to relieve the pressure. Scuba divers are universally taught to prevent middle ear squeeze by forcing air through the eustachian tubes *before* symptoms occur, just before or at the beginning of descent and then every few feet. "Equalize early and often" is the universal advice.

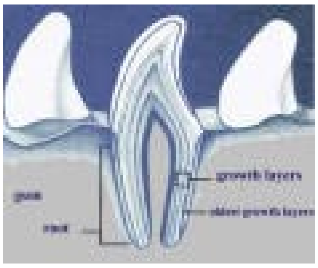
WHAT IS THE TREATMENT OF MIDDLE EAR SQUEEZE?

Treatment of middle ear squeeze depends on its severity. Mild cases often to respond to decongestants. Antibiotics may be indicated if there is tympanic membrane rupture, but such a problem should be referred to an otolaryngologist. In all cases diving should be avoided until the ear has returned to normal.

Dental SQUEEZE

Increasing pressure during descent into the water can cause entrapped gas in the interior of a tooth or in the structures surrounding a tooth to contract. In an extreme case, this can cause a tooth to crack or implode. Conversely, air under a filling or within a cavity or abscess can expand on ascent, causing a minor (and painful) “explosion.” To minimize the risk of a tooth squeeze, do not enter the water for at least 24 hours after dental treatment.

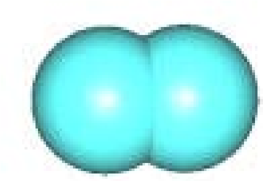




LESSON 5_03 GAS POISONING (OXYGEN, CARBON DIOXIDE, CARBON MONOXIDE, NITROGEN) , OTHER GAS CONTAMINANTS

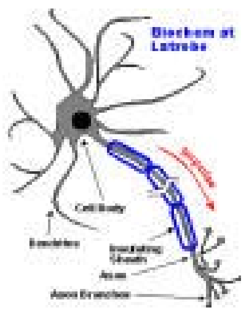
Oxygen toxicity

Oxygen is poisonous at high doses. The amount of damage depends on both the partial pressure (PpO2) and the time exposed; thus, a high, brief exposure may equal a low, long exposure. All tissues in the body are affected, but in diving interest centers around the central nervous system (CNS) and lungs. Very high exposures may cause permanent tissue damage or death but, at the levels encountered in diving, effects are usually reversible.



CENTRAL NERVOUS SYSTEM (CNS)

CNS problems are unlikely in air diving, as narcosis limits depth to levels that do not harm the nervous system. Problems can occur during Sur-DO_2 (Surface décompression on oxygen) procedures, bends treatment, in-water oxygen, or due to improper mix in gas diving.



CAUSE

This is not known precisely. High oxygen affects neurotransmitter function in the brain, causes a build-up of certain chemicals (Radical Oxygen Species or ROS), and alters nerve-to-nerve impulses.

SYMPTOMS

Numerous symptoms are possible, thus suspicion is always justified at oxygen levels which may cause trouble. The most common symptoms are facial twitching, vertigo, convulsion, and nausea, but many others may occur.

Twitching — typically involves the lips, but can be any part of the face or body. This is not a reliable warning for seizures.

Vertigo — the diver may say he feels faint, dizzy, or light-headed.

Convulsion — usually a sudden, unexpected gran mal seizure, identical to epilepsy. There may be only jerking or twitching of one part of the body with the diver remaining conscious.

Nausea — there may be sudden vomiting without actual nausea, retching, indigestion or stomach discomfort.

Behavior — sleepiness, depression, feeling happy or "high", sudden fear or feeling of danger, or restlessness and fidgeting.

Visual — tunnel vision, dim or blurred vision, flashes of light or patterns in the air.

Respiratory — A choking sensation, panting, grunting, hiccups, or spasms of the diaphragm may be seen.

Hearing-bells, music, knocking, ringing or humming.

Unpleasant taste or smell.

TREATMENT

First, reduce the PpO2. If the diver is wearing a mask, remove it for 15 minutes, then resume decompression or treatment at the point of interruption. Usually it will not happen again, but the diver must be watched. If the diver convulses, follow the same protective procedures as with an epileptic. Unlike an epileptic seizure, hypoxia doesn't occur in oxygen convulsions.

VARIABILITY

The unpredictability of CNS oxygen toxicity is legendary, and the amount of variability is considerable. For this reason, precise statements about safety are not possible. At best, oxygen tolerance tests may only identify the most sensitive individuals. Passing the test does not mean a diver will never experience an "O_2 hit".

Variation between people-some people have great tolerance to oxygen, some very little.

Individual variability-the dose of oxygen required to produce a reaction in a given person can vary as much as eight times. Factors such as emotion, fatigue, illness, and especially hangover may also affect sensitivity to oxygen.

Environment-sensitivity is greater at work than at rest, greater in water than in a chamber.

LIMITS

Safe limits vary mainly according to rest versus exertion.

In-water, working-problems seldom occur with a PpO_2 below about 1.6-1.8, even with strenuous exertion. For an exposure of 25-35 minutes, a PpO_2 of 2.0-2.1 is probably safe (220 feet on air - PpO_2 of 1.6).

Resting, dry chamber-Because help is usually available, oxygen can be used more liberally during decompression or accident treatment. Oxygen limits of 2.8 ATA for two hours or 3.0 ATA for one hour are almost always safe. Pure oxygen at 60 feet gives a PpO_2 of 2.8; for deeper treatment, a PpO_2 of 1.5-2.5 is usually chosen. Even at a high PpO_2, symptoms are usually not seen in less than 30 minutes. Therefore, breathing air or chamber atmosphere every 20-25 minutes will usually prevent problems, even if normal limits are exceeded.

LUNG

At a high PpO_2, CNS symptoms occur fairly quickly. Therefore, lung problems occur at oxygen levels that are safe for the CNS and they require more time to develop.

CAUSE

There is congestion and fluid build-up, damage to the lung capillaries, and chemical changes allowing the air sacs to collapse. Marked changes can lead to permanent lung damage.

SYMPTOMS

Begin as mild tickling or irritation in the trachea and bronchi, usually with a slight cough. They then progress to a severe, constant burning in the chest, aggravated by breathing, with an uncontrollable cough. Eventually shortness of breath is noticed, even at rest.

TREATMENT

Reduce the PpO2 by moving to shallower depth, changing the gas mix, giving longer air breaks, or stopping oxygen completely for 624 hours. Mild symptoms clear quickly, worse ones over 2-6 hours depending on the reduction in PpO2. The problem is totally reversible at the levels usually seen in diving, though sensitive tests of lung function may be abnormal for days or even weeks.

Severe accident cases may require levels of oxygen which result in temporary lung damage. This is acceptable if the alternative is permanent damage to brain or spinal cord, or a fatality. Permanent lung damage is unlikely. The following table gives hours of oxygen exposure which might cause tolerable, temporary lung damage, arbitrarily chosen as 10-20% (average sensitivity to oxygen):

<table>
<tr><th colspan="3">Lung Damage</th></tr>
<tr><th>PpO2 in atmospheres</th><th>10%</th><th>20%</th></tr>
<tr><td>2.0</td><td>9 hrs.</td><td>15 hrs.</td></tr>
<tr><td>1.5</td><td>13 hrs.</td><td>20 hrs.</td></tr>
<tr><td>1.0</td><td>23 hrs.</td><td rowspan="3">(doesn't reach 20%)</td></tr>
<tr><td>0.8</td><td>2 days</td></tr>
<tr><td>0.45</td><td>no limit, no damage</td></tr>
</table>

Note that long holds ("soaks") are possible on air if an accident victim is being treated by saturation decompression, without risking unacceptable lung damage. Soaks are often desirable for the following reasons:

- Allow sleep overnight.
- Allow topside and in-chamber personnel to recompose and regroup in a stressful accident situation.
- Allow time for medical consultation, more equipment or gas supplies, moving the chamber, or the arrival of a doctor or other specialised help.
- Allow the victim to stabilise where decompression may be aggravating the injury.

Brief holds (few hours) are often possible on air at 165-200 feet, with holds of at least 8-12 hours in the 100-150 feet range. Once the victim is nursed up to the 60-80 foot range, soak time is essentially unlimited. Precise limits deeper than 80 feet are not possible, as the victim's oxygen exposure from recent dives or decompression must be considered. The times above are conservative, assuming the victim starts with "clean" lungs. If early signs of lung damage appear during a soak, saturation decompression is resumed.

THE UNIT PULMONARY TOXICITY DOSE (UPTD)

The UPTD concept is a method for estimating total oxygen dose, the possibility that lung damage may be occurring, and the approximate degree of damage. It bas certain theoretical and practical limitations. Overall, it is a conservative method whose built-in errors work in the direction of safety for the victim.

Definition — The Unit Pulmonary Toxicity Dose — one UPTD — is the effect on the lung of breathing oxygen at 1.0 ATA for one minute. The rate of accumulation increases, however, so that doubling the PpO2 more than doubles the UPTD's (oxygen at 1.0 ATA = 1 UPTD per minute; 2.0 ATA = 2.5 UPTD/min). The following table gives values in UPTD per hour for various levels of oxygen:

Unit Pulmonary Toxicity Dose (UTPD)											
PpO2	**0.8**	**1.0**	**1.2**	**1.4**	**1.6**	**1.8**	**2.0**	**2.2**	**2.4**	**2.6**	**2.8**
UTPD per/hr.	**39**	**60**	**79**	**98**	**116**	**133**	**150**	**166**	**182**	**199**	**214**

Limitations of the system-Ignoring theoretical and mathematical arguments, the practical limitations of the UPTD system must be kept in mind for it to be put to best use.

a) The system attempts to describe biological function with mathematics, which can never be more than a close approximation. This is simply the nature of mathematics versus physiology.

b) The system cannot allow for variations in sensitivity between people. In estimating lung damage, the method calculates a theoretical dose which will produce a given amount of lung damage in an "average" person.

c) It is not possible to allow for oxygen exposure prior to treatment (i.e. , during the dive and decompression) without tedious calculations. Realistically, the effect of this pre-treatment exposure can only be estimated.

d) The major limitation is that the method does not allow for recovery between oxygen doses when the victim is breathing air or chamber atmosphere, or as the chamber is brought to a shallower depth. Thus, the calculated UPTD's can only get larger, yet in real life oxygen can be given almost indefinitely if doses are spaced properly.

Practical suggestions:

a) Field experience suggests total UPTD is most reliable for high exposures received in 24 hours or less. For doses accumulated over more than 24 hours, there is probably a reasonable margin of safety at any given dose.

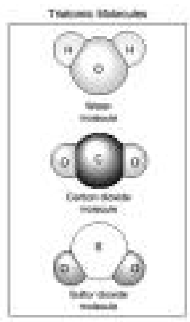
b) Total UPTD's in the range of 1400-1450 will cause a 10% loss of lung function in about half the general population; a dose around 2200 will cause 20%. Therefore, in a life-threatening case requiring lots of oxygen, a total UPTD of about 2000 in the first day or so should be acceptable. The degree of lung damage should be tolerable and the lung will probably recover.

c) The medic should not be seduced by the apparent precision of these numbers and should see them for what they are: useful guidelines for estimating the effect of high oxygen exposure. The numbers cannot be used to prove that a victim's lungs are injured, or safe. They will suggest where the zone of lung toxicity may be reached. The alert medic will then use this information in repeatedly evaluating his victim, looking for early symptoms of lung toxicity.

The following chart gives total UPTD for the major US Navy Tables plus the Lambertsen Table :

Table/UPTD	
Treatment Table	Total UPTD
USN 5	333
USN 6	645
USN 6, extended at 60'	718
USN 6, extended at 30'	787
USN 6, extended at 60' & 30'	860
USN 6A	690
USN 6A, extended at 60'	763
USN 6A, extended at 30'	833
USN 6A, extended at 60' & 30'	906
**Lambertsen/SOSI7A	1813
**Lambertsen/SOSI7A, 50-50 nitrox used	2061
**Total time of 36 hours from 165 feet to surface.	

Carbon Dioxide (C02) Intoxication.



Carbon dioxide intoxication (hypercapnia) may occur with or without a deficiency of oxygen. Inadequate ventilation of open-circuit UBAS, controlled or skip-breathing, excessive breathing resistance, or excessive dead space in equipment (e.g., failure of mushroom valves in SCUBA mouthpiece) can cause build-up of carbon dioxide. In some closed-circuit and semiclosed-circuit underwater breathing apparatus, failure or expenditure of the carbon dioxide absorbent material will allow carbon dioxide to build up in the breathing gas. In cases where the oxygen partial pressure is above 0.5 atm, the shortness of breath usually associated with carbon dioxide intoxication may not be as severe as it would be at lower oxygen partial pressures. In these cases, especially when breathing hard because of physical exertion, the diver may have no warning of hypercapnia and may become confused and even slightly euphoric before losing consciousness.

Injury from hypercapnia is usually due to secondary effects such as drowning or other injury due to decreased mental function or unconsciousness. The high inspired C02 in and of itself does not usually cause permanent injury. Because the first sign of hypercapnia may be unconsciousness and it may not be readily apparent whether the cause is hypoxia or hypercapnia, rule out hypoxia first. First correct any hypoxia, then take action to correct the hypercapnia.

To treat carbon dioxide intoxication, lower the inspired carbon dioxide level by (1) increasing helmet ventilation, (2) decreasing the level of exertion, (3) shifting to an alternate breathing apparatus, and/or (4) aborting the dive if defective equipment is the cause. Divers surfacing unconscious should be treated as if they had arterial gas embolism.

Treatment of hypercapnia in specific operational environments is presented in Volume 2, US Navy Diving Manual.

Shortness of Breath (Dyspnea)

The increased density of the breathing gas at depth, combined with physical exertion, may lead to shortness of breath that may become severe and cause panic in some divers.

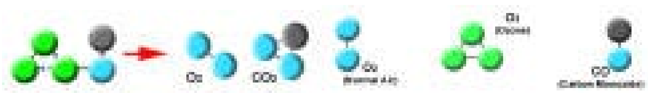
Dyspnea is usually associated with carbon dioxide build-up in the body, but may occur without it. When dyspnea occurs, the diver must rest until the shortness of breath subsides. This may take several minutes. If dyspnea does not subside with rest, or if it returns with even slight exertion, it may be due to carbon dioxide build-up. In open-circuit UBAS (i.e., MK 12), ventilation rates should be checked to make sure they are adequate; the helmet should be ventilated if necessary. Adequate ventilation rates are at least four acfm for moderate work and six acfm for very hard work. Ventilation should not drop below one acfm, even at rest.

In demand systems, excessive dead space from a damaged oral-nasal may be the cause. In closed or semi-closed UBAS, the C02 absorbent canister may be spent. If these causes are likely, the dive must be aborted to correct them.

Hyperventilation

Hyperventilation may result from rapid breathing due to malfunction in breathing apparatus or, occasionally, apprehension. It results in an excessive lowering of carbon dioxide levels in blood. This, in turn, may lead to a biochemical imbalance which gives rise to dizziness and twitching or tingling of the extremities which may be mistaken for convulsions. Usually, this twitching is also accompanied by some degree of spasm of the small muscles of the hands and feet which allows a sure diagnosis to be made. Treatment is to slow down the breathing rate by direction and reassurance which allows the condition to correct itself.

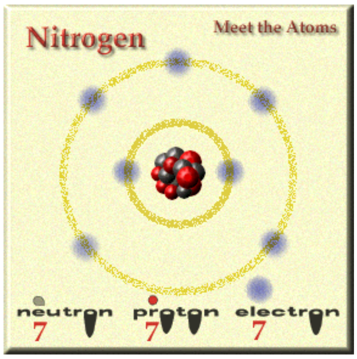
Carbon Monoxide (CO) Poisoning.



Carbon monoxide poisoning from contamination of divers' air supply by exhaust gas fumes is rare. It will be treated the same way as low oxygen content of breathing gas. Divers suffering early symptoms of carbon monoxide (CO) toxicity (headache, nausea, vomiting) can be treated with 100-percent oxygen at the surface. Divers with neurological symptoms or who surface unconscious must be treated as if they had arterial gas embolism, since diagnosing CO toxicity requires laboratory tests that are time consuming and not readily available in the field. The associated high oxygen tension during the recompression treatment will also treat CO toxicity. In cases of suspected CO toxicity, the suspect breathing gas source should be isolated and gas samples forwarded for analysis as soon as possible.

Nitrogen Narcosis

Introduction



One hundred and fifty years ago it was first observed that men exposed to hyperbaric air behaved as if intoxicated by alcohol. Since then it has become clear that this condition, which is called “nitrogen narcosis”, will occur in anyone exposed to a raised partial pressure of nitrogen.

As soon as he leaves the surface and descends, a diver is exposed to an increasing partial pressure of nitrogen. At the same time the effects of nitrogen narcosis begin. At shallow depths the effects are mild, but as he descends, the effects increase, altering his awareness of events and of his own behaviour.

The danger from nitrogen narcosis lies mainly in the effect it has on the diver's awareness. Like a drunk who refuses to believe he has had too much to drink, a diver with nitrogen narcosis may not accept that there is anything the matter with him.

The.analogy between alcohol and nitrogen narcosis is very pertinent. Alcohol, if taken in very large amounts, can prove fatal purely because it poisons the brain cells and the person who takes it passes into a coma, stops breathing and dies. Most deaths from alcohol occur when people have much less alcohol than this in their blood. At these lower levels of blood alcohol, people make irrational decisions about their ability. They may decide that they can safely drive home when they are really incapable and have an accident in the attempt. Nitrogen narcosis may prove fatal in its own right, but this is very rare. It has, for example, happened to divers who have attempted to set new depth records (at about 100 metres). Much more frequently, nitrogen narcosis causes the death of divers at shallower depths and in indirect ways.

Nitrogen narcosis may cause divers to misread their gauges or to make inaccurate calculations of depths or times. There have been cases in which divers could not decide in which direction to go to reach the surface. Hallucinations and bizarre beliefs and behaviour may occur. Any of these can result in the diver drowning.

Nitrogen narcosis is a significant danger to the diver because it increases the risk of an accident and, at the same time, decreases his ability to cope with the emergency.

Nitrogen narcosis differs from alcohol intoxication in a number of ways. Unlike alcohol, which takes time to be absorbed from the stomach into the blood, during a dive the partial pressure of nitrogen in the blood changes quickly with depth. The effects of nitrogen narcosis occur as the partial pressure of nitrogen changes, with little delay.

Symptoms

Narcosis symptoms
loss of judgment
loss of skills
false sense of well-being or euphoria
lack of concern for safety
does things that are unsafe or dangerous
acts stupid
laughs inappropriately
tingling or numbness noted in lips gums and legs
hallucinations or exhibiting bizarre behaviour
loss of consciousness

The table opposite shows the main symptoms experienced by a diver with nitrogen narcosis. These findings were obtained from observations made during compression in a chamber under dry conditions. Underwater, the effects of nitrogen narcosis are apparent at shallower depths.

There is individual variation in susceptibility to nitrogen narcosis. In addition, the same individual may be susceptible to the effects of nitrogen narcosis on some occasions more than on others. There is no doubt that, ii measurements are made, everyone shows some evidence of nitrogen narcosis at quite shallow depths.

Some divers claim that they never get nitrogen narcosis, even on dives beyond 30 metres. These divers are either not telling the truth or they do not remember that they were affected. If tests are performed on any diver at 30 metres or deeper, it is possible to demonstrate some slowing of thought and impairment of concentration.

It is extremely common for divers who have had nitrogen narcosis to be unable to recall the fact after surfacing. The mental problems that they had or the odd acts they performed at depth are forgotten. This type of amnesia is rather like getting so drunk that the next day you cannot remember what happened.

At shallow depth, nitrogen narcosis causes mild impairment of concentration and the ability to reason, some delay in response to stimuli and mild euphoria. As the diver goes deeper he makes more serious errors of judgement and at the same time becomes overconfident. Confusion and hallucinations follow, leading to unconsciousness and death.

Underwater, the diver would probably have lost his demand valve and drowned long before unconsciousness occurred.

If the diver reaches depths in excess of 60 metres, the effects of nitrogen narcosis will be added to those of oxygen toxicity. In addition, at great depths the increased density of air will make the work of breathing more difficult. The risk of the diver inadequately ventilating his lungs and developing hypercapnia will also occur. Hypercapnia has been demonstrated to increase the severity of nitrogen narcosis.

There are a number of other factors, which increase an individual's susceptibility to nitrogen narcosis. Sedative drugs, particularly alcohol, fatigue, heavy exertion, ill health, apprehension, poor visibility and cold all increase the severity of nitrogen narcosis.

The effects of nitrogen narcosis increase progressively with depth, but do not increase over time at the same depth.

Repeated exposure to depth allows some degree of tolerance to develop. How this occurs is unclear. It may be that repeated exposure enables some divers to function with a high level of nitrogen narcosis in the way chronic alcoholics can function with blood alcohol levels which would put most people to sleep.

Effects on the Body

Since the first observations of men breathing hyperbaric air, scientists have been investigating the causes of nitrogen narcosis. This condition, which has been termed 'the narks' and 'rapture of the deep', has also been given a variety of other names by scientists. Some call it 'inert gas narcosis' others 'air intoxication' and yet others 'depth intoxication'.

The reason for the different names used by scientists to describe this condition is that none of the experts has yet produced an adequate explanation of its cause. There are a number of theories, but none adequately explains everything observed in divers suffering from nitrogen narcosis.

There is, however, general agreement that in people breathing air at a raised ambient pressure the presence of nitrogen is important for the development of the condition.

It is known that the effects of nitrogen narcosis are similar to the effects of some anaesthetic agents used during surgery (e.g. nitrous oxide or 'laughing gas'). The effects are also similar to those of sedative drugs such as alcohol. These agents and nitrogen all have one thing in common. They are more soluble in fats than they are in water.

Nerve cells contain a lot of special fats. These fats are important in enabling nerves to conduct electrical impulses. Anything that dissolves in the fats of nerve cells will reduce the speed at which these cells conduct nerve impulses. Eventually the cells will stop conducting impulses altogether.

One particular group of nerve cells in the brain appears particularly sensitive to nitrogen and other narcotic agents. They are in the reticular centre, which is really the brain's telephone exchange. The reticular centre receives messages from one part of the brain and transmits them to other parts to act upon. If the reticular centre is not working properly, all brain function becomes disrupted and eventually, the subject becomes unconscious or narcotized.

If a second agent is dissolved in the fat of nerve cells, it will increase the effect that the other exerts. In some cases, the combination will exert a greater effect than would be expected from adding together the effects produced by each agent alone. This is what happens with alcohol and a raised partial pressure of nitrogen. A small amount of alcohol in the body can make the effects of nitrogen narcosis much worse.

The body in metabolism does not use nitrogen. It is said to be metabolically inert. Other metabolically inert gases also produce narcosis, but the depth at which the symptoms occur varies. The gases with smaller molecules (e.g, helium) do not produce narcosis until at considerable depths.

The reason gases with bigger molecular weights produce narcosis at shallower depths is not entirely clear. It may partly be because the bigger the molecular weight of a gas, the denser it is and the more likely it is to cause under-ventilation of the lungs and hypercapnia. This certainly increases the severity of narcosis.

With increasing depth, the partial pressures of other gases also alter. At great depths, deeper than 60 metres, for a diver breathing air the effects of nitrogen narcosis and oxygen toxicity will be additive and produce even more severe problems.

Prevention and Treatment

Any diver breathing air underwater will be subject to the effects of nitrogen narcosis. There is no way of eliminating these effects, unless a gas mixture is used which has less of a narcotic effect than the nitrogen in air has.

Professional deep divers use gas mixtures such as helium plus oxygen to prevent nitrogen narcosis. These gas mixtures and the equipment required for their use are expensive.

The main limits imposed by breathing air underwater are those of depth and time. The effects of nitrogen narcosis become significant at depths greater than 30 metres and are of great importance below 50 metres.

It is impossible to lay down precise limits of acceptable depth. This must depend on the objective of the dive and the experience of the divers in the prevailing conditions. The term “limit” itself implies that at a particular depth things are safe, while at a metre deeper they are unsafe. Clearly, danger increases progressively with depth and safe cutoffs are never precise.

Few experts would disagree with the statement that at depths approaching 60 metres the risk of sudden unconsciousness and death make these depths inappropriate for air-breathing divers.

The risks of nitrogen narcosis are considerably reduced if suitably experienced divers only perform dives below 40 metres with specific objectives in mind, after adequate work-up dives.

The effects of nitrogen narcosis can also be reduced if divers ensure that they leave a sufficient time after taking alcohol or sedative drugs for these to be eliminated from the body.

Should a diver experience symptoms suggestive of nitrogen narcosis he should immediately ascend to a shallower depth. The symptoms will improve almost immediately. If a diver behaves in an unusual manner and fails to respond to the signal to ascend, his buddy should assist him upwards. Care must be taken, because in severe cases people with nitrogen narcosis might behave violently, although this is not usual.

Poisoning by Inhalation (other gas contaminants)

Accidental or intentional inhalation of poisons can lead to a life-threatening emergency. The type and location of injury caused by toxic inhalation depend on the specific actions and behaviors of the chemical involved .

Physical Properties

The concentration of a chemical in the air and the duration of exposure help determine the severity of inhalation injury. At low concentrations and with brief exposure, the chemical may be removed from the air before reaching the tracheobronchial tree, whereas large concentrations or prolonged exposure are more likely to cause contact with the lungs and damage to lung tissue. As a rule, increasing the concentration of the chemical or the duration of exposure increases the dose received.

Solubility also influences inhalation injury. For example, soluble chemicals such as chlorine and anhydrous ammonia can be converted to hydrochloric acid and ammonium hydroxide, respectively, when they contact moisture in the respiratory tract mucus, producing injury in the nasopharynx and conducting airways. In contrast, insoluble chemicals such as phosgene and nitrogen dioxide may have little impact on the upper airways but can produce severe damage to the alveoli and respiratory bronchioles.

Chemicals may be inhaled as gases and vapors, mists, fumes, or particles. Gases and vapors mix with air and distribute themselves freely throughout the lung and its airways. Mists are liquid droplets dispersed in air. Their toxic effects depend on droplet size (the larger the size, the greater the exposure). Fumes contain fine particles of dust dispersed in air. Large particles are likely to be trapped in the nasopharynx and conducting airways, whereas small particles (1 to 5 microns) are more likely to penetrate the lower airways.

Chemical Properties

The ability of a chemical to interact with other chemicals and body tissue is called its reactivity. As a rule, highly reactive chemicals cause more severe and rapid injury than less-reactive chemicals. Four potential properties of chemicals that determine reactivity are the following:

1. Chemical pH: The likelihood for severe injury from alkaloid or acid exposure increases as the pH approaches its extremes: a pH of less than 2 for acidic substances and greater than 11.5 for alkaline substances.
2. Direct-acting potential of chemicals: Direct-acting chemicals are capable of producing injury without first being transformed or changed. An example is hydrofluoric acid,

which causes severe corrosive burns on contact with mucous membranes of the upper airways.

3. Indirect-acting potential of chemicals: Indirectacting chemicals must be transformed before they can produce injury. An example is phosgene, a gas that may cause acidic burns of the alveolar membranes after conversion to hydrogen chloride (a process that may take up to several hours).
4. Allergic potential of chemicals: Some reactive chemicals bind with proteins to form structures that stimulate allergic reactions. For example, formaldehyde can cause severe asthmatic and anaphylactic reactions after even a small exposure. In general, the allergic potential of a chemical is related to its reactivity.

Classifications

Toxic gases can be classified in three categories: simple asphyxiants, chemical asphyxiants, and irritants/ corrosives. Simple asphyxiants (methane, propane, and inert gases) cause toxicity by displacing or lowering ambient oxygen concentration. Chemical asphyxiants (carbon monoxide and cyanide) possess intrinsic systemic toxicity manifested after absorption into the circulation. Irritants/corrosives (chlorine and ammonia) cause cellular destruction and inflammation as they come into contact with moisture. Table 34-1 provides an overview of toxic gases and their clinical manifestations.

General Management

The general principles of managing patients who have inhaled poisons are the same as for any other hazardous materials incident (see Chapter 51). These include the following:

1. Scene safety
2. Personal protective measures (protective clothing and appropriate respiratory protective apparatus)

Rapid removal of the patient from the poison environment

Surface decontamination

5. Adequate airway, ventilatory, and circulatory support
6. Initial assessment and physical examination
7. Irrigation of the eyes (as needed)
8. IV line with a saline solution
9. Regular monitoring of vital signs and cardiac rhythm by ECG
10. Rapid transport to an appropriate medical facility

Management of Specific Inhaled Poisons

The specific inhaled poisons discussed in this section include cyanide, ammonia and hydrocarbons. Carbon monoxide poisoning is described in the specific chapter of the diving medical course.

Cyanide

Cyanide refers to any of a number of highly toxic substances that contain the cyanogen chemical group. Because of its toxicity, cyanide has few applications. The agent sometimes is used in industry in electroplating, ore extraction, and fumigation of buildings and as a fertilizer. It has been used in gas chambers as a means of execution. Cyanide is one of the products of combustion from burning nylon and polyurethane and is therefore a potential hazard in fire environments.

Cyanide poisoning may result from the inhalation of cyanide gas; ingestion of cyanide salts, nitriles, or cyanogenic glycosides (e.g., amygdalin, a substance found in the seeds of cherries, apples, pears, and apricots, and the principal constituent of laetrile); or the infusion of nitroprusside (Nitropress). Cyanide also can be absorbed across the skin. Regardless of the route of entry, cyanide is a rapidly acting poison that combines and reacts with ferric ions (Fe^3) of the respiratory enzyme cytochrome oxidase to inhibit cellular oxygenation. The cytotoxic hypoxia produces a rapid progression of symptoms from dyspnea to paralysis, unconsciousness, and death. Large doses usually are fatal within minutes from respiratory arrest.

After ensuring personal safety, emergency care for a patient with cyanide poisoning begins with securing a patent airway and providing adequate ventilatory support with high-concentration oxygen. Oxygen competitively displaces cyanide from cytochrome oxidase and enhances the efficacy of drug administration. After these measures, the principal treatment of cyanide poisoning is to convert (oxidize) ferrous ions in hemoglobin (Fe^2) to ferric ions (Fe^3), forming methemoglobin, hemoglobin with ferrous ion in the oxidized (Fe^3) state. Cyanide, which has a greater affinity for iron in the ferric state, is released from the cytochrome oxidase and combines with methemoglobin, thus allowing cytochrome oxidase to resume its function in normal cellular respiration. Cyanide antidotes, such as those found in the Pasadena cyanide antidote kit (formerly the Lily Cyanide Poison Kit), are thought to be effective because they induce methemoglobin (Box 34-10).

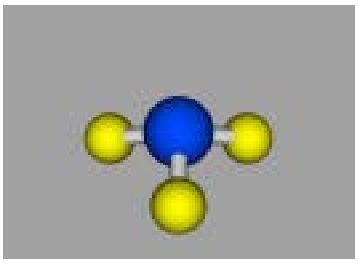
Methemoglobin cannot transport oxygen and must therefore be reconverted to hemoglobin by sodium thiosulfate. This is accomplished in a three-step process, which includes administration of (1) amyl nitrite by inhalation (converting about 5% of hemoglobin to methemoglobin); (2) sodium nitrite (300 mg IV), which results in methemoglobinemia approaching 25% to 30%; and (3) sodium thiosulfate (12.5 mg IV).

Prehospital care for patients with cyanide poisoning is as follows:

1. Don personal protective equipment as needed to prevent rescuer contamination.
2. Remove the patient from the cyanide source. Rapid decontamination and removal of any contaminated clothing is essential.
3. Ensure a patent airway and provide adequate ventilatory support.
4. Administer high-concentration oxygen.
5. If using the Pasadena cyanide antidote kit, consult with medical direction or a poison control center and follow the instructions provided by the manufacturer.
6. If an antidote kit is not available, a pearl of amyl nitrite should be crushed and held under the patient's nose for 15 of every 30 seconds, followed by continuation of supplemental oxygen. If the patient's respirations are being assisted, place the crushed pearl under the intake valve of a bag-valve device.

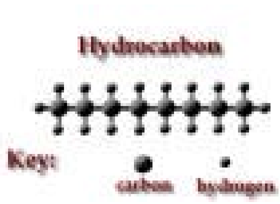
7. Initiate IV fluid therapy with a volume-expanding solution.
8. Monitor cardiac rhythm by ECG.
9. Rapidly transport the patient for physician evaluation.

Ammonia Inhalation



Ammonia is a toxic irritant that causes local pulmonary complications after inhalation. Exposure to ammonia vapours results in inflammation, irritation, and in severe cases, erosion of the mucosal tissue of all respiratory structures as the ammonia vapour combines with water, producing a highly caustic alkaline compound. Patients usually develop coughing, choking, congestion, burning and tightness in the chest, and a feeling of suffocation. These respiratory symptoms often are accompanied by burning of the eyes and lacrimation. In severe cases, bronchospasm and pulmonary oedema may ensue. In addition to the general management principles, emergency care may include positive-pressure ventilation and the administration of diuretics and bronchodilators.

Hydrocarbon Inhalation



The hydrocarbons that pose the greatest risk for injury have a low viscosity, a high volatility, and a high surface tension or adhesion of molecules along a surface. These characteristics combine to allow hydrocarbons to enter the pulmonary tree, causing aspiration pneumonitis and the potential for systemic effects such as CNS depression and liver, kidney, or bone marrow toxicity.

Most hydrocarbon inhalations result from "recreational use" of halogenated hydrocarbons such as carbon tetrachloride and methylene chloride or aromatic hydrocarbons such as benzene and toluene. These agents may produce a state of inebriation or euphoria through "sniffing" or "huffing" (placing the solvent on a rag and inhaling the vapors through a plastic bag). The onset of these effects usually is rapid (occurring within seconds) and may be followed by CNS depression, respiratory failure, or cardiac dysrhythmias. Other signs and symptoms of hydrocarbon inhalation include the following:

- Burning sensation on swallowing
- Nausea and vomiting
- Abdominal cramps
- Weakness
- Anesthesia
- Hallucinations
- Changes in color perception
- Blindness
- Seizures
- Coma

Emergency care for hydrocarbon inhalation generally is supportive and includes airway, ventilatory, and circulatory support; IV fluid therapy; vital sign and ECG monitoring; and transport for physician evaluation.

LESSON 5_04 NEAR DROWNING, SECONDARY DROWNING, VOMITING UW, PULMONARY OEDEMA

Near-drowning

Causes and Prevention. A swimmer can fall victim to drowning because of overexertion, panic, inability to cope with rough water, exhaustion, or the effects of cold water or heat loss. These same factors can affect a diver, but if the diver is properly equipped, trained, and monitored by a partner or tender, drowning should be a remote possibility. Drowning in a hard hat diving rig (MK 12) is rare. It can happen if the helmet is not properly secured and comes off, or if the diver is trapped in a head down position with a water leak in the helmet. Normally, as long as the diver is in an upright position and has a supply of air, water can be kept out of the helmet no matter what the condition of the suit.

Divers wearing lightweight or SCUBA gear can drown if they lose or ditch their mask or mouth piece, run out of air, or inhale even small quantities of water. This could be the direct result of failure of the air supply, or panic in a hazardous situation. The SCUBA diver, because of direct exposure to the environment, can be affected by the same conditions that may cause a swimmer to drown.

The prevention of drowning is best ensured by the establishment of and thorough training in safe diving practices coupled with the careful selection of diving personnel. A trained diver should not easily fall victim to drowning. However, overconfidence can give a feeling of false security that might lead a diver to take dangerous risks.

Treatment. The treatment of near-drowning falls into two phases: (1) restore breathing and heart beat, and (2) call for assistance from qualified medical personnel. Regardless of the severity of a near-drowning case, hospitalise all victims as quickly as possible. Pulmonary oedema (accumulation of fluids in the lungs), pneumonia, and other complications may occur many hours after the incident. Therefore, proper medical observation is essential. Subsequent to resuscitation, while awaiting transportation to medical facilities, keep the patient warm and rested. Give 100-percent oxygen by mask if any symptoms persist.

Rescue Breathing. Initial treatment of the near drowning victim consists of rescue breathing using the mouth-to-mouth or mouth-to-nose technique. Rescue breathing should be started as soon as possible, even before the victim is moved out of the water.

If neck injury is suspected, however, the victim's neck should be supported in a neutral position (without flexion or extension), and the victim should be floated supine onto a horizontal back support before being removed from the water. If the victim must be turned, the head, neck, chest, and body should be aligned, supported, and turned as a unit to the horizontal supine position. If artificial respiration is required, maximal head-tilt should not be used. Rescue breathing should be provided with the head maintained in a neutral position, i.e., jawthrust without head-tilt, or chin-lift without head-tilt, should be used.

Foreign Matter in the Airway. The need for clearing the lower airway of aspirated water has not been proved scientifically, although there are anecdotal reports of clinical response to a Heimlich Manoeuvre. At most, only a modest amount of water is aspirated by the majority of both freshwater and seawater drowning victims, and freshwater is rapidly absorbed from the lungs into the circulation. Furthermore, 10 to 12 percent of victims do not aspirate at all due to laryngospasm or breath-holding. An attempt to remove water from the breathing passages by any means other than suction is usually unnecessary and dangerous because it could eject gastric contents and cause aspiration.

Because the risk-benefit ratio of a Heimlich Manoeuvre in this setting is unknown, the only time it should be used is when the rescuer suspects that foreign matter is obstructing the airway or if the victim does not respond appropriately to mouth-to-mouth ventilation. Then, if necessary, CPR should be reinstituted after the Heimlich Manoeuvre has been applied. The Heimlich Manoeuvre is performed on the near-drowning victim in the same way as for the treatment of foreign-body airway obstruction (unconscious supine) except that in near-drowning, the victim's head should be turned sideways.

Chest Compressions. In-water chest compressions are probably ineffective so the individual should be removed from the water as fast as possible.

On removal from the water, the victim must be assessed immediately for adequacy of circulation. The pulse may be difficult to detect in a near drowning victim because of peripheral vasoconstriction and a low cardiac output. If a pulse cannot be felt, CPR should be started at once.

Definitive Advanced Life-Support Care. There should be no delay in moving the victim of near drowning to a life-support unit where advanced life support is provided. Every near-drowning victim, even one who requires only minimal resuscitation and regains consciousness at the scene, should be transferred to a medical facility for follow-up care. It is imperative that life-support measures be continued en route and that oxygen be administered if it is available in the transport vehicle.

Successful resuscitation with full neurological recovery has occurred in near-drowning victims with prolonged submersion in cold water. An absolute time limit beyond which resuscitation is not indicated has not been established. Since it is often difficult for rescuers to obtain an accurate time of submersion, attempts at resuscitation should be initiated by rescuers at the scene unless there is obvious physical evidence of death (such as severe trauma or putrefaction). The victim should be transported with continued CPR to an advanced life-support facility where a physician can decide whether to continue resuscitation.

Secondary drowning

Loss of conscientiousness may carry on a secondary drowning:

Head injury

Stroke, fainting, heart attack, shock

Hypoxia, hyperoxia, poisoning (including alcohol) and drug intoxication

Low blood sugar

Epilepsy, thermal stress (hypothermia, hyperthermia)

Vomiting underwater

Consequences of Vomiting underwater and Effects of Pulmonary Aspiration

The severity of pulmonary aspiration depends on the pH of the aspirated material, the volume of the aspirate, and if particulate matter (e.g., food) and bacterial contamination are present in the aspirate. It generally is accepted that when the pH level of an aspirate is 2.5 or less, a severe pulmonary response occurs. When the pH is below 1.5, the patient usually dies. The mortality among patients who aspirate material grossly contaminated (as occurs in bowel obstruction) approaches 100%.

The toxic effects on the lungs of gastric acid (with a pH of less than 2.5) can be equated with those of chemical burns. These are severe injuries that produce pulmonary changes such as destruction of surfactant-producing alveolar cells, alveolar collapse and destruction, and destruction of pulmonary capillaries. The permeability of the capillaries increases with massive flooding of the alveoli and bronchi with fluid. The resulting pulmonary edema creates areas of hypoventilation, shunting, and severe hypoxemia. The massive fluid shift from the intravascular compartment to the lungs also may produce hypovolemia severe enough to require volume replacement.

Note:

The risk of pulmonary aspiration can be minimized by continuously monitoring the patients mental status, properly positioning the patient to allow for drainage of secretions, limiting ventilation pressures to avoid gastric distention, and using suction devices and esophageal or endotrocheal (ET) intubation. Airway protection should be provided if the risk of aspiration exists or promptly after an occurrence of aspiration.

Pulmonary Pathophysiology Secondary to Near Drowning (Pulmonary oedema)

Respiratory failure and ischemic neurological injury from hypoxia and acidosis are the life-threatening complications of submersion. Hypoxia can result from the following factors:

- Fluid in the alveoli and interstitial spaces
- Loss of surfactant
- Contaminant particles in the alveoli and tracheobronchial tree
- Damage to the alveolar-capillary membrane and vascular endothelium

Poor perfusion and hypoxemia lead to metabolic acidosis in most patients. In those who survive the incident, acute respiratory failure (including adult respiratory distress syndrome [ARDS]) may follow, with a reduction in compliance and an increase in ventilation-perfusion mismatching and intrapulmonary shunting. The onset of symptoms can be delayed for as long as 24 hours after the submersion.

In addition to having pulmonary effects, near drowning can affect other body systems. For example, cardiovascular derangements can occur secondary to hypoxia and acidosis, resulting in dysrhythmias and decreased cardiac output. CNS dysfunction and neuronal damage commonly are caused by cerebral edema and anoxia. The paramedic also must be suspicious of concurrent spinal injury in near-drowning victims. Renal dysfunction is unusual but can progress to acute renal failure as a result of hypoxic injury or hemoglobinuria, leading to acute tubular necrosis.

Factors that Affect Clinical Outcome

The following four factors can affect clinical out come after a submersion incident:

1. Temperature of the water: Submersion in cold water can have beneficial and deleterious effects on survival. The rapid development of hypothermia can serve a protective function, particularly regarding brain viability in patients with prolonged submersion. The survival of a child submerged for 66 minutes in a creek with a water temperature of 37° F (5° C) is the longest documented submersion with good neurological outcome.' The exact mechanism of this phenomenon is not understood; in the past it was attributed to a "mammalian diving reflex" found in seals and lower mammals. Hypothermia, which may be organ protective, also contributes to neurological recovery after prolonged submersion, probably by decreasing the metabolic needs of the brain. The relative contributions of these two mechanisms are not clear. The adverse effects of coldwater submersion include severe ventricular dysrhythmias.

2. Duration of submersion: The longer the duration of submersion, the less likely the patient is to survive. When rescue operations have been in progress for more than 30 minutes, victims re trieved from warm water in summer months or in warm southern waters usually are considered nonviable. Because cold-water submersion for up to 60 minutes has been associated with neurological recovery, most patients rescued from cold-water drowning should receive resuscitative life-support measures. Resuscitation is indicated unless there is physical evidence of death (e.g., putrefaction, dependent lividity, and rigor mortis).,

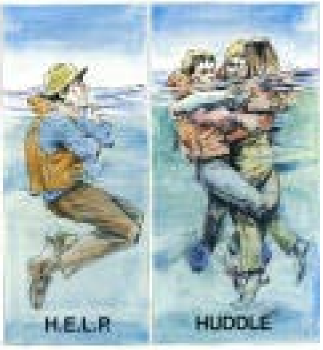
3. Cleanliness of the water. Contaminants in water have an irritant effect on the pulmonary system, leading to bronchospasm and an increased tendency toward poor gas exchange. They also can cause a secondary pulmonary infection with delayed severe respiratory compromise.

Age of the victim. The younger the patient or victim, the better the chance for survival.

LESSON 5_05 HYPOTHERMIA AND HYPERTHERMIA

Hypothermia

GENERAL MEASURES



General rule: A victim who is cooled gradually usually can be warmed gradually**.**

Passive rewarming — The victim's own metabolism rewarms him from the inside. Stop heat loss by shielding the victim from the wind; change to warm, dry garments; and wrap him with blankets or a sleeping bag. This is usually sufficient in awake patients. Internal heat production will gradually rewarm the patient if heat loss is stopped. More aggressive treatment will sometimes cause unexpected complications.

Active rewarming — The victim is warmed from the outside. This will speed recovery but should not be excessively rapid.

Awake victim — use muscular exercise, give hot liquids by mouth, place in a hot bath or shower. Continue until the patient shows perspiration.

Unconscious victim — place hot water bottles at the groin, underarms and neck. Cover the victim with several blankets. If the equipment is available, give hot saline as an enema or by irrigation through a nasogastric tube (should not be too hot to hold in the mouth). When the victim is able to swallow, give hot liquids by mouth. Keep in bed until ready for transport or clearly, alert and stable.

Diver in chamber — in a hypothermic diver with a decompression obligation remaining, remove the chamber floor plates and fill the bilge with hot water (bath hot). If he is in his suit, fill the suit through the neck, cuffs and ankles.

"Dead" victim

A victim who dies from hypothermia is not dead until he is warm and dead. Many victims who appeared dead have made complete recoveries with skillful care.

If the victim has no pulse and is not breathing, start CPR immediately.

Apply hot water bottles and give hot saline irrigations by a naso gastric tube, as above. Continue warming and CPR until a deep rectal temperature is at least 99° F (36° C), 5 minutes after any previous enema. If the patient still exhibits no vital signs (pupils are nonreactive, no heartbeat or breathing) he is probably dead. If possible, the order to stop CPR should come from the Master of the vessel, supervising physician or other appropriate authority.

Other problems

Low blood sugar (hypoglycemia) is often seen and will tend to become worse as the victim rewarms and recovers. As the body metabolism increases with warming and particularly with shivering, blood sugar falls even lower. Add sugar to oral liquids or use dextrose-containing IV fluids.

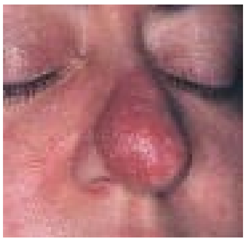
Victims often need fluids due to dehydration and fluid shifts out of the circulation. However, pulmonary edema is also seen and excessive fluids may make lung congestion worse. The best guide is to watch urine output closely (aim for about 1-2 ounces per hour) and withhold fluids if the victim develops respiratory distress (in which case, give oxygen).

Recovered victims often develop pneumonia. It is reasonable to give antibiotics for 3-5 days, then stop if there is no sign of chest trouble.

Specific Problems

The treatment of cold injury to the face or extremities should not delay general rewarming if the victim is hypothermic.

Chilblain



This is a cold injury to the skin, but the skin is not frozen. It usually involves exposed skin on the face, ears, and extremities.

The skin is red, itching and burning, and may be swollen or blistered. Heat may cause pain.

Elevate the affected part and allow to warm gradually at room temperature. Do not rub or massage or apply heat or cold. The patient may require pain killers.

Frostbite

There is damage to the skin due to freezing. Like thermal burns, frostbite may be divided into categories by severity:

First degree-skin is red and swollen, perhaps superficially ("frost nip").

Second degree-deeper freezing with blisters or peeling skin.

Third degree-full thickness freezing with skin death. It may involve deeper tissues.

The skin may be numb, tingling or itching. It may be white or pale, inelastic, and there may be areas of gangrene.

Treatment

- Rewarm the part. If the frostbite is superficial, treat by covering with a warm hand or changing to a dry, warm garment.
- If available, immerse the part in warm (not bot) water (about 105° F, 40° C) for about 30 minutes. Do not allow any pressure against the sides or bottom of the container.
- Protect the injured part. The damaged skin is very sensitive to even minor trauma. Allow no pressure, rubbing or friction, no dressings or bandages.
- Place the victim at rest, elevate the injured part, padding carefully with pillows, etc. Leave uncovered.
- If there is clear evidence of dead tissue, start antibiotics and soak in warm soapy water daily, rinsing gently.

Hyperthermia

PREVENTION

Almost all heat accidents are preventable.

Allow new personnel time to adjust to the heat, 4-5 days at least.

Furnish plenty of water and encourage personnel to drink more than actual thirst requires (especially divers in decompression).

Require hats and shade working areas.

Work at a moderate pace, as heat reduces the available energy for work.

TREATMENT

The principles are to stop heat production, restore fluid volume, and cool the patient.

In the **usual case**, the patient is conscious but may be faint, dizzy, nauseated or have muscle cramps. The skin is sweaty.

Stop work and have the patient rest in the shade. As he rests, he will cool gradually and may not need any other treatment, since he is no longer producing much heat by working.

Cool the patient by removing clothing, fanning, and applying ice packs or cool compresses to the face, neck, underarms and groin,

If not nauseated, give any ordinary fluid by mouth, starting slowly. If the patient is nauseated, hypotensive, or faints upon sitting or standing, give 500-1000 cc. of any IV fluid over 30-40 minutes. If IV fluids are not available, let the patient rest and cool down for 20-30 minutes, lying down, then place ice chips in the mouth or give small sips of liquid, increasing the intake as tolerated.

Have the patient rest for 8-24 hours. He may be sensitive to heat for a time.

In the **severe case**, the patient is unconscious or delirious, may convulse, the skin is very bot and dry. Heat bas damaged the temperature and blood pressure centers in the brain. This heat stroke is a medical emergency with a high mortality rate.

Cool the patient as fast as possible. Apply ice to the neck, arm pits and groin, soak the victim in ice water, or bathe with alcohol. Continue until a deep rectal temperature is about 102° F or until the victim feels like someone with ordinary fever. Then stop active cooling and place the patient in a cool area.

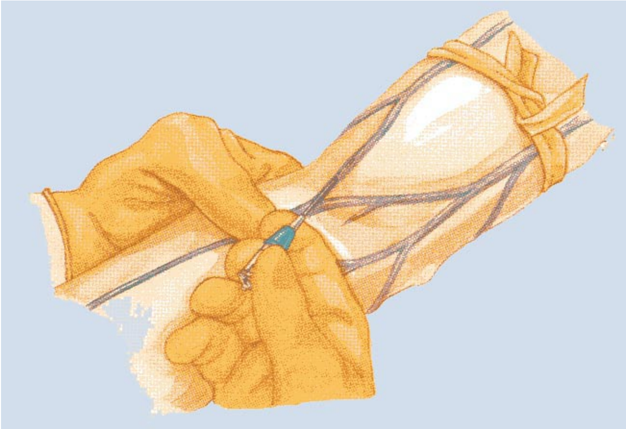
If the patient is hypotensive or shocky, do not give epinephrine or other vasopressor drugs. Support the blood pressure with IV Ringer's lactate or normal saline sufficient to maintain a systolic pressure of 100-110. Avoid sudden infusions of large volumes of IV fluid. It is better to give 200-300 cc. amounts and observe the effect over 5 minutes, then repeat as necessary. When the blood pressure is stable, change to IV D5W (or oral fluids if the patient is conscious) and observe the urine output.

If available, insert a urinary catheter (Foley) and give sufficient fluid IV or orally to maintain a urine volume of at least 60 cc. (2 ounces) per hour to avoid the possibility of kidney damage.

Complications-convulsions, stroke, or myocardial infarction may all occur in heat-stroke. Treatment is the same as in the usual setting.

Transfer the victim to the nearest hospital as soon as possible,even if improving. Heat stroke is a medical emergency; complications are common, including mental disorders, clotting defects, neurologic damage, and permanent heat intolerance.

LESSON 6_01 6_02 6_03 7_02 7_03 INTRAVENOUS INFUSIONS



Drug Administration

Safety considerations and procedures should be a high priority during administration of any medication.

Safety Considerations and Procedures

The paramedic should observe the following guidelines when administering drugs to patients:

When preparing or giving medicines, concentrate on the procedure and avoid distractions.

In the prehospital setting, ensure that medication orders received from medical direction are clearly understood. Repeat all orders back to medical direction for confirmation before administering a drug. In the emergency department or other patient care areas, make certain that you have a written order for every medication you administer. Verify the patient's name on the armband or identification tag and verify that the patient has no allergy to the medication. Be sure that the right patient receives the right dose of the right drug via the right route at the right time (the "five patient rights" of drug administration). Also ensure that correct and thorough documentation occurs (the sixth patient right of drug administration).

Make a habit of reading the label of the medicine and comparing it to the medication order at least three times before administration: (1) when removing the drug from the drug kit or supply area, (2) when preparing the medication for administration, and (3) just before administering it to the patient (before the container is discarded).

Always verify the route of administration. Some medications can be prepared for administration by several routes (e.g., intramuscular or intravenous).

Make certain that the information on the medication label corresponds exactly to the prescriber's order.

Never give a medicine from an unlabeled container or from a container on which the label is not legible.

If you are uncertain of your drug calculation, have a coworker check your calculation or contact medical direction for verification.

Handle multidose vials carefully and with aseptic technique, so that medicines are not wasted or contaminated.

When preparing multiple injections, always label the syringe immediately. Keep the medication container with the syringe. Do not rely on memory to determine which solution is in which syringe.

Never administer an unlabeled medication prepared by another person. In doing so, you accept the responsibility for accuracy, dose, and correct medication.

Never administer a medication that is outdated or that appears discolored, cloudy, or in any other way unusual or tampered with.

If the patient or your coworkers express doubt or concern about a medication or dose, recheck to make certain that there is no error before administering the medication. Be aware that the patient has the right to refuse medication.

Carefully monitor the patient for any adverse effects for at least 5 minutes after administration of any medication. (A longer observation time may be required for intramuscular and oral medications.)

Document all medications given. This documentation should include the name of the drug, the dosage, and the time and route of administration. When recording parenteral medications, note the site of injection. The patient's response, adverse as well as intended, should be recorded. Follow governmental guidelines and local EMS policies regarding the return and disposal of any unused medication.

Medication Errors

Medication errors occur with astonishing frequency. More than 700,000 patients receive the wrong medicine or the incorrect dose of medicine in U.S. hospitals each year . 4 Common causes of medication errors are as follows:

A wrong medication dose was ordered by the prescriber.

Drug calculations were in error.

Drugs were administered via the wrong route.

The wrong patient received the drug.

If an incident involving a medication error occurs, the paramedic should:

Accept professional responsibility for his or her actions.

Immediately advise medical direction or the prescriber.

Assess and carefully monitor the patient for effects of the drug.

Document the medication error as required by local and state drug administration policies and those of the medical direction institution.

Modify personal practice to avoid a similar error in the future.

Follow EMS agency procedures for documentation and quality improvement activities.

Medical Asepsis

Medical asepsis is the removal or destruction of disease-causing organisms or infected material. Medical asepsis is accomplished by using "clean" technique (versus sterile technique) that includes hygienic measures, cleaning agents, antiseptics, disinfectants, and barrier fields.

Antiseptics and Disinfectants

Antiseptics and disinfectants are chemical agents used to kill specific groups of micro organisms. They generally are not very effective against spores of bacteria and fungi, many viruses, and some resistant bacterial strains. Disinfectants are used only on nonliving objects and are toxic to living tissue. Antiseptics are applied only to living tissue and are more dilute to prevent cell damage. Some chemical agents (e.g., alcohol and some chlorine compounds) have both antiseptic and disinfectant properties.

Universal Precautions in Medication Administration

Universal precautions should be part of every patient encounter. When administering drugs, the paramedic should observe hand washing and gloving procedures if indicated; face shields are indicated during the administration of endotracheal drugs. Hand washing is frequently called the most important measure to reduce the risk of transmitting organisms from one person to another or from one site to another on the same patient. Hand washing offers protection for both the paramedic and the patient. If soap and water are not readily available, a waterless sanitizing solution should be used.

Parenteral Administration of Medications

Parenteral drugs are administered outside the gastrointestinal tract and usually refer to injections.

Parenteral administration of drugs can be especially hazardous because the drugs given by injection are usually considered irretrievable. In addition, there is a slight chance of infection because the integrity of the skin is broken. Other potential hazards associated with parenteral administration include lipodystrophy, cellulitis or abscess formation, necrosis, skin slough, nerve injury, prolonged pain, and periostitis. Aseptic technique, accurate drug dosage, proper rate of infection, and proper site of injection are essential to minimize the risk of harm.

Parenteral routes for drug administration include intradermal, subcutaneous, intramuscular, intravenous, and intraosseous. (Percutaneous medications will also be presented in this section.)

Equipment Used for Injections

Syringes and Needles

The choice of syringe and needle depends on the route of administration, characteristics of the fluid (e.g., aqueous, oil-based), and volume of medication. Syringes in common use today are made of disposable plastic. Sizes range from 1-mL tuberculin and insulin syringes to 60-ml, irrigation syringes. Tuberculin syringes are marked in 0.01-mL gradients and should be used when the volume to be administered is small. Insulin syringes are available in 0.5- and 1-ml, volumes and are marked in 1-unit increments. When used with the specified strength of insulin, this syringe allows the patient to easily draw up the correct dose without performing calculations. Tuberculin and insulin syringes should not be substituted for each other.

Needles vary in length and gauge from 3/8 inch to 3 or more inches in length and from 12 gauge (large lumen) to 30 gauge (small lumen). Smaller lumen (larger gauge) needles are usually used for intradermal injections. Subcutaneous injections are usually given with a 5/8-inch, 23- or 25-gauge needle. Intramuscular injections are usually given with a 19- or 21-gauge, 1- to 2-inch needle; occasionally a 16- or 18-gauge needle is used.

Some IV catheters provide additional protection against accidental need sticks by retracting the needle into case as the catheter is advanced. Needleless IV tubings and connectors also have been developed with built-in puncturing devices made of plastic that are sharp enough to pierce the rubber medication port on IV tubing. Other IV devices have locking ports with blunt ends or no puncturing device at all.

Needle and sharps injuries

Injuries to health care workers from conventional needles and sharps account for between 600,000 and one million injuries each year.* Although infection with the hepatitis C virus (HCV) is the most frequent infection resulting from needle stick and sharps injury the transmission of other diseases also is possible. These diseases include HIV, hepatitis B, syphilis, herpes simplex, herpes zoster, Rocky Mountain spotted fever, and tuberculosis. The following measures should be taken to avoid such exposures: • Health care personnel should obtain assistance when administering infusion therapy or injections to uncooperative patients.

• Needles should not be recapped, purposely bent or broken by hand, removed from disposable syringes, or otherwise manipulated by hand. If recapping or needle removal is necessary because no alternative is feasible or a specific medical procedure requires it, use of a mechanical device or a one-handed technique is recommended. Needleless products should be used when available.

• Disposable syringes and needles, scalpel blades, and other sharp items should be placed in puncture-resistant containers for disposal.

Parenteral Medication Containers

Medications used for injection are usually supplied in single-dose ampules, multidose vials, or prefilled syringes. Single-dose ampules are glass containers that hold one dose of a medication for injection, after which the ampule is discarded. Multidose vials are glass containers equipped with rubber stoppers that permit several medication doses to be withdrawn for injection.

To prepare a prescribed medication for injection, the paramedic should choose the appropriate needle and syringe. The size of the syringe should be in proportion to the volume of solution to be administered. To withdraw medication from an ampule or vial, the paramedic should do the following:

Assemble the necessary equipment (alcohol swab or gauze, syringe, 18-gauge needle to withdraw medication if using an ampule, and appropriate gauge needle for injection).

Compute the desired volume of medication to be administered.

If using a vial:

Clean the rubber stopper with alcohol.

Using the needle chosen for the injection, inject a volume of air into the vial equivalent to the amount of solution to be withdrawn; this prevents a vacuum in the vial, which can make the solution difficult to withdraw. Withdraw the volume required and remove the syringe from the vial.

Gently advance the plunger of the syringe to expel air from the solution.

If using an ampoule:

Lightly tap or shake the ampoule to dislodge any solution from the neck of the container.

Wrap the neck of the glass ampoule with an alcohol swab or gauze dressing for protection.

Grasp the ampoule, snap off the top, and discard the top in an appropriate medication disposal container. (The ampoule is designed to break easily when pressure is exerted at the neck.)

Carefully insert an 18-gauge needle into the solution without allowing it to touch the edges of the ampule and draw the solution into the syringe.

Carefully remove the 18-gauge needle and discard it in the appropriate container. Attach the needle to be used for injection.

Gently advance the plunger of the syringe to expel air.

Mixing medications. Two compatible drugs (e.g., meperidine [Demerol] and hydroxyzine [Vistaril]) can be mixed together into one injection if the total volume of the dosage is within accepted limits. When mixing medications, it is important not to contaminate one medication with another and to maintain aseptic technique. To mix medications, the paramedic should follow these steps:

Mixing Medications From Two Vials

Use only one syringe to mix the drugs.

Aspirate the volume of air equivalent to the first drug's dosage. Inject the air into vial A, ensuring that the needle does not touch the solution. Withdraw the needle.

Aspirate air equivalent to the second drug's dose and inject the volume of air into vial B. Withdraw the required medication from vial B.

Apply a new sterile needle to the syringe and insert it into vial A. Be careful not to push the plunger or expel the drug from the syringe into the vial.

Withdraw the desired amount of the drug from vial A into the syringe.

Apply a new sterile needle and administer the injection.

Mixing Medications From One Vial and One Ampoule

Withdraw the desired drug dose from the vial first.

Use the same syringe and needle to withdraw medication from the ampoule.

Apply a new sterile needle and administer the drug.

Prefilled syringes. There are several manufacturers of prefilled syringes, and the techniques for activating and using the products vary. The paramedic should be familiar with the devices used by particular EMS systems. The technique for activating a common type of prefilled syringe follows:

Calculate the desired volume of medication to be administered.

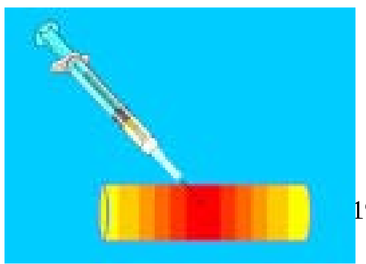
Pop off the protective caps from the syringe barrel and medication cartridge.

Screw the cartridge into the syringe barrel.

Gently advance the plunger of the syringe to expel air.

Preparing the Injection Site

The injection site should be prepared by cleansing the area with alcohol, iodine swabs, or both (per local protocol), using aseptic technique:



Thoroughly scrub the site with alcohol to remove dirt, dead skin, and other surface contaminants.

Disinfect the site with overlapping concentric circles, moving outward from the site.

Allow the site to dry.

Intradermal Injections

An intradermal injection is made just below the epidermis or outer layer of skin. This site is commonly used for allergy testing and for administration of local anesthetics. The syringe used for intradermal injection is usually a tuberculin syringe, and the volume injected is usually less than 0.5 mL. Common sites for intradermal injections are the medial surface of the forearm and the back. The procedure for these injections is as follows:

Choose the injection site and cleanse the skin surface.

Hold the skin taut with one hand.

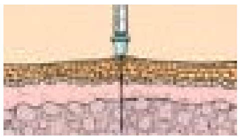
With the other hand, hold the syringe with the needle bevel up at a 10- to 15-degree angle from injection site.

Gently puncture the skin until the bevel is completely under the skin surface and inject the prescribed medication. The injection will usually produce a raised wheal resembling a mosquito bite.

Withdraw the needle and appropriately discard the equipment.

Subcutaneous Injections

Subcutaneous injections are given to place medication below the skin into the subcutaneous layer. The volume of a subcutaneous injection is usually less than 0.5 mL, administered through a 1/2 or 5/8 inch, 23- or 25-gauge needle. The most common drug administered via this route in the prehospital setting is epinephrine (Adrenalin). The procedure for subcutaneous injections follows:

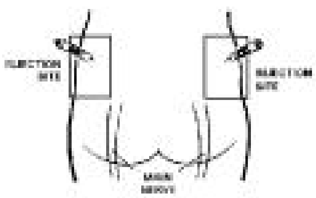


Choose the injection site.

Elevate the subcutaneous tissue by "pinching" the injection site.

With the needle bevel up, insert the needle at a 45-degree angle in one quick motion.

Pull back slightly on the plunger (aspirate) to ensure needle placement. If no blood is aspirated, gently but smoothly inject the medication. If blood is present on aspiration, withdraw the needle, discard the medication and equipment, and begin again.



After the injection, withdraw the needle at the same angle it was inserted. Use an alcohol swab to massage the site. This helps distribute medication and promote absorption by dilating blood vessels in the area and increasing blood flow.

Intramuscular Injections

Deeper injections are made into muscular tissue, passing through the skin and subcutaneous tissue, when a drug is too irritating to be given subcutaneously (although irritation may occur via this route as well) or when a greater volume or faster absorption is desired. A volume up to 5 mL may be given by intramuscular injection.

The type of needle used depends on the site of the injection, condition of the tissue, size of the patient, and nature of the drug to be injected (small lumens for thin solutions and larger lumens for suspensions and oils). Because the muscle layer is below the subcutaneous layer, a longer needle is generally used (usually 1 ½ inches and 19 or 21 gauge). The procedures for intramuscular injections are the same as those previously described, but the needle is inserted at a 90-degree angle and the skin is held taut, not pinched.

Several muscles are commonly used for intramuscular injections, including the deltoid muscle, dorsogluteal site, vastus lateralis muscle, rectus femoris muscle, and ventrogluteal muscle. The deltoid muscle is located in the upper arm. It forms a triangular shape, with the base of the triangle along the acromion process and the peak of the triangle ending approximately a third of the way down the lateral aspect of the upper arm. This muscle is used primarily for vaccinations with small volumes of injection, because the muscle is small and can accommodate only small doses of injection (1 ml or less). When injections are made in this location, care should be taken to avoid hitting the radial nerve. The patient should be sitting upright or lying flat and should be told to relax the arm muscles.

The dorsogluteal site consists of several gluteal muscles, although the gluteus medius muscle is most commonly used for injection. There are two ways to define this site: (1) Divide the buttocks on one side into imaginary quadrants, and administer the medication into the upper outer quadrant, or (2) locate the posterior superior iliac spine and the greater trochanter of the femur, drawing an imaginary line between the two landmarks. Then give the injection up and out from this line. This site should not be used for children under age 3 because the muscles are not yet well developed and because of the proximity of the sciatic nerve (the largest nerve in the body). Large, well-developed muscles can accommodate an injection up to 5 mL, but anything over 3 mL may be uncomfortable for the patient. When an injection is being administered via this route, the patient should be lying prone, with the toes pointing inward to promote muscle relaxation. Another complication resulting from gluteal injections is injection into the hip joint, although the risk of this is minimized by attention to anatomical landmarks.

The vastus lateralis and the rectus femoris muscles are located in the thigh and lie side by side. To identify necessary landmarks, the paramedic should place one hand on the patient's upper thigh and one hand on the lower thigh. The area between the paramedic's hands is the middle third of the thigh and the middle third of the underlying muscle. The vastus lateralis lies lateral to the midline and is the preferred injection site for children. It is well developed in all patients and has few major blood vessels and nerves that can be injured. The rectus femoris is most often used for self-injection because of its accessibility. Acceptable volumes for injection vary with the age of the patient and the size of the muscle. Up to 5 mL may be injected into a well-developed adult. The patient should be sitting upright or lying supine and should be advised to relax his or her muscles.

The ventrogluteal muscle is accessible when the patient lies in a supine or lateral recumbent position. The greater trochanter should be palpated with the palm, with the index finger pointing to the anterior superior iliac spine. The paramedic's remaining three fingers should extend toward the iliac crest. The injection is then made into the center of the V formed between the fingers. This injection site may be used for all patients. It is desirable because the site is free of large nerves and fat tissue. In the adult, this muscle may accommodate up to 5 mL of drug.

Intravenous Therapy

Intravenous cannulation is used to gain access to the body's circulation. Intravenous cannulation is indicated (1) to administer fluids, (2) to administer drugs,' and (3) to obtain specimens for laboratory determinations.

IV Fluid Administration

The route of choice for fluid therapy in the prehospital setting is through a peripheral vein in an extremity.Provided that the arms have no major injury, upper extremity veins should be used. (Some EMS services advise to avoid upper extremity sites when a major injury to the neck or upper thorax has occurred on that side.) When upper extremity sites are inappropriate, lower extremity sites may be used.

CHOICE OF INTRAVENOUS CATHETERS

Choice of intravenous catheters. There are three main types of intravenous catheters: (1) hollow needles ("butterfly" type), (2) indwelling plastic catheters over a hollow needle (e.g., Angiocath or Jelco), and (3) indwelling plastic catheters inserted through a hollow needle (e.g., Intracath; seldom used in the prehospital setting).

Hollow needles are not recommended for intravenous fluid replacement in the prehospital setting because of the difficulty in stabilizing the needle. Occasionally, the paramedic chooses the "butterfly" type needle for the pediatric patient if adequate stabilization can be maintained through the use of armboards or other immobilization devices. The over-the-needle catheter is generally preferred for use in the prehospital setting. It is easily secured and more comfortable for the patient.

PERIPHERAL INTRAVENOUS INSERTION.

Peripheral intravenous insertion. Common areas used for peripheral intravenous therapy are the hands and arms, including the antecubital fossae (AC space). Alternative sites include the long saphenous veins and the external jugular veins. However, the incidence of embolism and infection is higher at these alternative sites.

Another consideration in choosing a puncture site for intravenous therapy is the clinical status of the patient. Injuries or diseases involving an extremity interfere with the use of veins in the affected area for venipuncture or venous cannulation. Examples include trauma, dialysis fistula, and a history of mastectomy.

STEPS

If the patient is conscious, explain the procedure. This explanation should include why intravenous therapy is necessary and what the procedure entails.

Assemble the necessary equipment.

Inspect the prescribed fluid for contamination, appearance, and expiration date. Never use fluids that are cloudy, outdated, or in any other way suspected of contamination.

Prepare the microdrip or macrodrip infusion set, and attach the infusion set to the bag of solution.

Clamp the tubing and squeeze the reservoir on the infusion set until it fills half way. Then open the clamp and flush the air from the tubing. Close the clamp.

Select the catheter. A large-bore catheter (14 to 16 gauge) should be used for fluid replacement, and a smaller-bore catheter (18 to 20 gauge) should be used for "keep open" lines.

Prepare other equipment:

Alcohol or iodine wipes to cleanse the skin.

Antibiotic ointment or cream (per protocol).

Sterile dressings or 4 x 4 gauze pads

Adhesive tape, torn or cut into several strips

Syringes and Vacutainers for blood samples

Tourniquet (rubber drain tubing or blood pressure cuff may be used)

Apply gloves for personal and patient protection.

Select the puncture site. If using an upper extremity, allow the patient's arm to hang dependent, and apply the tourniquet above the antecubital space. (The tourniquet should be just tight enough to tamponade venous vessels but not occlude arterial flow.) When selecting a suitable vein, begin by looking at the dorsum of the hand and forearm. Choose a vein that is fairly straight and easily accessible. The forearm is better than the hand because it allows hand movement and is more easily secured after cannulation. If a second puncture attempt is necessary, the second puncture should always be proximal to the first puncture. Therefore the vein selected for initial cannulation should be the most suitable distal vein. Avoid veins near joints, where immobilization will be difficult, and veins near injured areas. If the long saphenous vein is chosen, begin site selection near the medial malleolus of the foot. To locate the external jugular vein, place the patient in a supine head-down position, and turn the patient's head toward the opposite side.

Prepare the puncture site. Cleanse the area with alcohol or iodine wipes (per protocol):

Thoroughly clean the site with alcohol to remove dirt, dead skin, blood, and other surface contaminants.

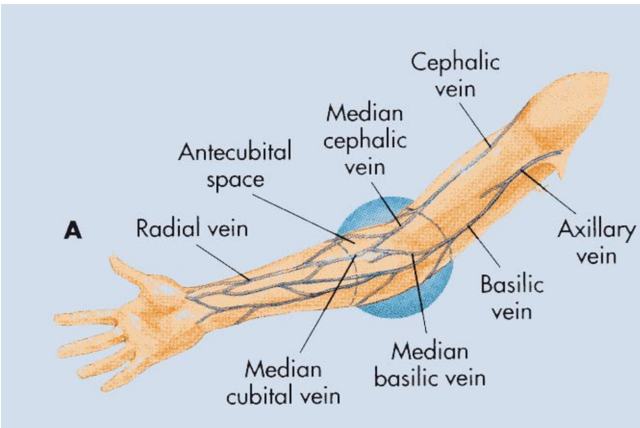
Disinfect the site with overlapping concentric circles, moving outward.

Stabilize the vein by applying distal pressure and tension to the point of entry. With the bevel of the needle up in adults (down in infants and children), pass through the skin and into the vein from the side or directly on top. Advance the needle and catheter about 2 mm beyond the point where blood return in the hub of the needle was first encountered. Slide the catheter over the needle and into the vein. Withdraw the needle while stabilizing the catheter. Apply pressure on the proximal end of the catheter to stop escaping blood. Obtain blood samples, if needed, with a syringe or vacutainer.

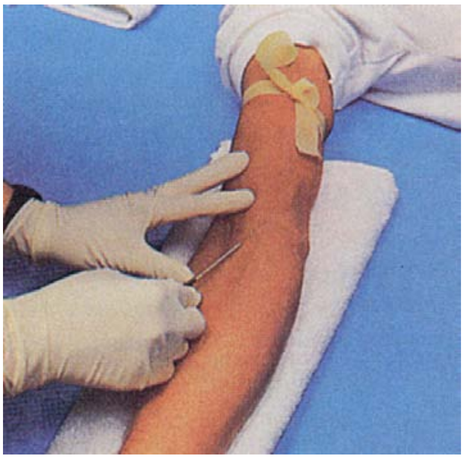
Release the tourniquet and attach tubing. Open the tubing clamp and allow fluid. infusion to begin at the prescribed flow rate.

	Catalog #	Length	Flow Rate	O.D.	I.D.	Catalog #	Length	Flow Rate	O.D.	I.D.
24 GA (0.7 mm)	381412	.75" (0.7mm x 19mm)	20 ml/min	.0260-.0290	.0190-.0220	381512	.75" (0.7mm x 19mm)	20 ml/min	.0260-.0290	.0190-.0220
22 GA (0.9 mm)	381423	1.00" (0.9mm x 25mm)	35 ml/min	.0330-.0360	.0240-.0270	381523	1.00" (0.9mm x 25mm)	35 ml/min	.0330-.0360	.0240-.0270
20 GA (1.1 mm)	381433 381434 381437	1.00" (1.1mm x 25mm) 1.16" (1.1mm x 30mm) 1.88" (1.1mm x 48mm)	65 ml/min 60 ml/min 55 ml/min	.0410-.0440 .0410-.0440 .0410-.0440	.0300-.0330 .0300-.0330 .0300-.0330	381533 381534 381537	1.00" (1.1mm x 25mm) 1.16" (1.1mm x 30mm) 1.88" (1.1mm x 48mm)	65 ml/min 60 ml/min 55 ml/min	.0410-.0440 .0410-.0440 .0410-.0440	.0300-.0330 .0300-.0330 .0300-.0330
18 GA (1.3 mm)	381444 381447	1.16" (1.3mm x 30mm) 1.88"(1.3mm x 48mm)	105 ml/min 95 ml/min	.0500-.0530 .0500-.0530	.0370-.0400 .0370-.0400	381544 381547	1.16" (1.3mm x 30mm) 1.88"(1.3mm x 48mm)	105 ml/min 95 ml/min	.0500-.0530 .0500-.0530	.0370-.0400 .0370-.0400
16 GA (1.7 mm)	381454 381457	1.16" (1.7mm x 30mm) 1.77" (1.7mm x 45mm)	220 ml/min 205 ml/min	.0670-.0700 .0670-.0700	.0520-.0550 .0520-.0550	381554 381557	1.16" (1.7mm x 30mm) 1.77" (1.7mm x 45mm)	220 ml/min 205 ml/min	.0670-.0700 .0670-.0700	.0520-.0550 .0520-.0550
14 GA (2.1 mm)	381467	1.75" (2.1mm x 45mm)	330 ml/min	.0830-.0860	.0665-.0705					
12 GA (2.8 mm)										
10 GA (3.4 mm)										

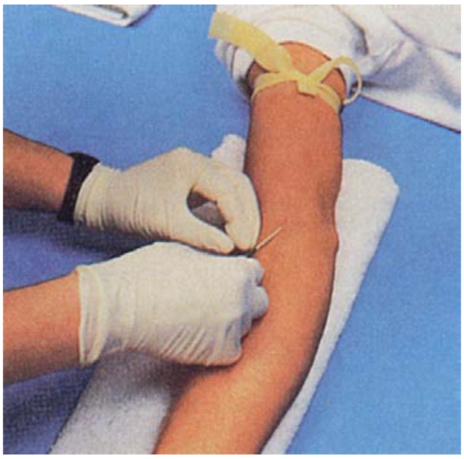
Clamp the tubing and squeeze the reservoir on the infusion set until it fills half way. Then open the clamp and flush the air from the tubing. Close the clamp.



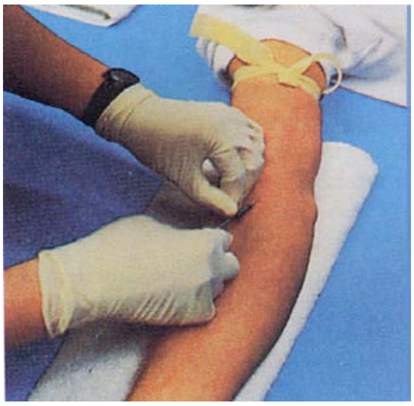
Select the puncture site



Stabilize the vein by applying distal pressure and tension to the point of entry. With the bevel of the needle up



Advance the needle and catheter about 2 mm beyond the point where blood return in the hub of the needle was first encountered. Slide the catheter over the needle and into the vein. Withdraw the needle while stabilizing the catheter



Release the tourniquet and attach tubing

. Open the tubing clamp and allow fluid. infusion to begin at the prescribed flow rate.

Complications of all IV techniques.

There are several possible complications associated with all intravenous techniques. These include local complications, systemic complications, infiltration, and air embolism.

Local and Systemic Complications. Local complications may involve hematoma formation, thrombosis, cellulitis, and phlebitis. Systemic complications include the following:

Sepsis

Pulmonary embolism

Catheter fragment embolism

Fiber embolism originating from cotton or paper fibers contained in the catheter irrigation solution, leading to foreign body reactions

Infiltration. Infiltration may occur when the needle or catheter has been displaced or when blood or fluid leaks from around the catheter. Signs and symptoms include the following:

Coolness of skin at the puncture site

Swelling at the puncture site, with or without pain

Sluggish or absent flow rate

If infiltration is suspected, the fluid reservoir should be lowered to a dependent position to check for the presence of backflow of blood into the tubing. (The absence of backflow suggests infiltration.) If any of these signs and symptoms are present, the intravenous flow should be discontinued, the needle or catheter immediately removed, and a pressure dressing applied to the site. An alternative puncture site should be chosen and the infusion restarted with new equipment. In addition, the incident should be documented.

Air Embolism. Air embolism is uncommon but can be fatal. Although the volume of air that the human blood stream can tolerate has not been firmly established, fatalities have been reported after 100 mL of air entering the cardiovascular systems A total of 10 ml, of air can be fatal in a critically ill patient.

The embolism is caused by air entering the blood stream via the catheter tubing. The risk of air embolism is greatest when a catheter is passed into the central circulation, where negative pressure may actually pull in air. Air can enter the circulation either on insertion of the catheter or when the tubing is disconnected to replace solutions or add new extension tubing (Box 9-6). With subsequent pumping, blood foaming occurs in the heart. If enough air enters the heart chamber, it can impede the flow of blood, leading to shock.

Signs and symptoms of air embolism include hypotension; cyanosis; weak, rapid pulse; and loss of consciousness. If air embolism is suspected, the following steps should be taken:

Close the tubing.

Turn the patient on his or her left side with head down. (If air has entered the heart chambers, this position may keep the air in the right side of the heart and away from the cardiac valves. The pulmonary artery may absorb small air bubbles.)

Check tubing for leaks.

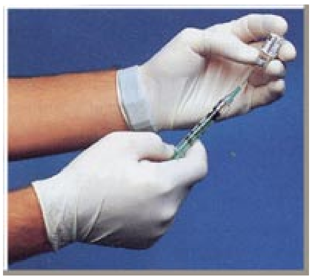
Administer high-concentration oxygen.

Notify medical direction.

The possibility of an air embolism can be minimized by ensuring that all tubing connections are secure and that fluid containers are changed before they are empty.

Intravenous Medications

Medications can be given directly into the vascular system via the intravenous route by injection or infusion. An intravenous injection can be administered through a previously established intravenous infusion line, heparin or saline lock, or implantable port (e.g., Port-A-Cath, Hickman catheter), or directly into the vein with a sterile needle or butterfly device. An intravenous infusion is administered by adding a drug to an infusing intravenous solution (e.g., normal saline), diluting the drug in a larger volume of fluid and administering the medication through a volume-control in-line device (e.g., burette, Volutrol, infusion pump), or intermittent infusion ("intravenous piggyback" or "secondary set").



Intravenous injections generally consist of a small amount of medication (usually less than 5 mL) and are called intravenous push or intravenous bolus medications. To administer an intravenous injection, the injection port of the intravenous line should be cleansed with alcohol or the cap from the needleless port removed. The prescribed medication is then injected slowly (usually from 1 to 3 minutes). The rate of injection depends on the type of medication and patient response. Most intravenous tubing is equipped with one-way valves to prevent backflow of medication. If such a valve is not present or cannot be identified, the tubing above the injection site should be clamped during drug administration. After the injection, the infusion of fluids is continued.

Intravenous infusions for drug administration can take several forms. To add a medication to the fluid reservoir of an established intravenous line, the paramedic should follow these steps:

Compute the volume of the drug to be added to the fluid reservoir.

Draw up the prescribed dose in a syringe. If prefilled syringes are used, note the volume of medication in the syringe and the dose to be used.

Cleanse the rubber sleeve of the fluid reservoir with an alcohol swab.

Puncture the rubber sleeve and inject the prescribed medication into the fluid reservoir.

Withdraw the needle and discard the needle and syringe. Gently mix the medication with the fluid by agitating the reservoir.

Label the fluid reservoir with the name of the medication added, amount of the medication added, resultant concentration of the medication in the reservoir, and date, time, and name of the paramedic who prepared the infusion.

Calculate the rate of administration in drops per minute as prescribed.

A number of in-line, volume-control devices allow more accurate delivery of medication diluted in precise amounts of fluids than is possible by simply setting the drip rate. They are often used to administer intravenous medications to children and adults who need precise doses of medication that can readily cause toxicity when administered too rapidly (e.g., antidysrhythmics, vasopressors). Inline devices include electronic flow-rate regulators that regulate fluid passage by a magnetically activated metal ball valve and infusion pumps that exert pressure on tubing or fluid by pumping against pressure gradients. The paramedic should follow the instructions of the equipment manufacturer and become familiar with these devices before using them.

Intermittent infusions are given via a setup that is secondary to the primary intravenous infusion. The piggyback medication is hung in tandem and connected to the primary. Most intermittent diluted drug infusions are meant to have a total infusion time of 20 or 30 minutes to 1 hour (depending on the drug and patient response). To prepare an intermittent infusion, the paramedic should follow these steps:

Prepare the prescribed medication and add it to the secondary fluid as described above.

Bleed the air out of the secondary administration set and attach a 1-inch, 18-gauge needle.

Cleanse the medication port of the primary infusion tubing and insert the needle or access pin of the piggyback medication.

Tape the needle (if present) securely to the medication port.

Calculate the flow rate of the secondary infusion in drops per minute.

Lower the primary infusion reservoir so that its center of gravity is lower than the secondary infusion reservoir.

Open the piggyback line flow clamp, and adjust the flow rate to the desired dose. Clamp the tubing of the primary infusion to allow the piggyback medication to infuse. After administration of the piggyback medication, restart the primary infusion, and discard the piggyback equipment.

Always label the bag with the medication.

Another device for intravenous drug administration is a drug "pump." Drug pumps are used by patients who need a slow injection of medication in the home (e.g., patients undergoing cancer chemotherapy). These devices usually consist of a syringe with a battery attachment that regulates the injection of medication. Drug pumps are used to administer medication subcutaneously or can be attached to indwelling vascular devices such as the Port-A-Cath or Hickman catheter.

Why should I use a safety IV catheter?

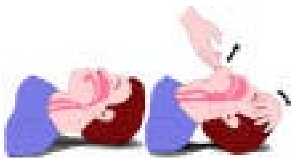
- Technology exists to protect end users from needlestick injuries.
- Over 200,000 new hepatitis C infections (HCV) occur annually, and estimates show 3.9 million Americans are infected. Forty percent of chronic liver disease is HCV-related. There is no cure for hepatitis C.
- An estimated 1-1.25 million people in the US are infected with hepatitis B (HBV). 10-85% of infants born to HBV infected mothers are at risk for perinatal infection. Screening pregnant women for hepatitis B surface antigen has failed to identify a high proportion of HBV-infected mothers. Children of HBV infected mothers have a high risk of acquiring chronic HBV infection during the first 5 years of life. There is no cure for hepatitis B.
- Hepatitis Delta (HDV) can cause co-infection or superinfection in an HBV carrier. All hepatitis viruses can cause active and chronic hepatitis. Annually, 4,000-5,000 people die of chronic liver disease while waiting for a liver transplant.
- Infectious disease statistics show that 28% of HIV infected adults have children. Up to 22% of HIV-infected mothers gave birth after diagnosis. There is no cure for HIV.
- Other high-risk occupations require the use of safety devices to protect workers. Consider the use of hard hats in the construction industry, protective goggles and gloves in the steel-working industry, or seat belts in automobiles. The use of all of these safety devices has proven results. Healthcare workers deserve proven protection from occupational risk also.
- Many states have legislated the use of safety devices on hollow bore needles used to access vessels and draw blood, and this trend is gaining speed.
- The federal government has legislated this movement toward safety.
- Worker's compensation statistics show using safety devices in the workplace decreases occupational injuries.
- Worker's compensation payouts are finite for on the job injuries. Healthcare expenses after acquiring a bloodborne disease are not finite.
- **Your job should not cost you your life.**

LESSON 6_04 6_05 AIRWAY MANAGEMENT TECHNIQUES

Airway Management

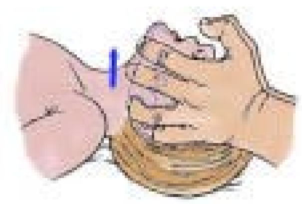
Science and technology have produced numerous adjuncts for providing airway management. However, the paramedic must not neglect basic airway management in favor of a procedure that is technically more difficult than necessary to secure a safe and functional airway. Airway management should progress rapidly from the least to the most invasive modality.

Manual Techniques for Airway Management



Manual techniques for airway management have been described by the AHA and the American Red Cross (ARC). These include the head-tilt chin-lift method, the jaw-thrust, and the jaw-thrust without head-tilt.

The head-tilt chin-lift method is preferred for opening the airway when a spinal injury is not suspected. The head-tilt is accomplished by placing one hand on the victim's forehead and applying firm backward pressure with the palm to tilt the head back. The fingers of the other hand then are placed under the bony part of the lower jaw (near the chin) and lifted to bring the chin forward, supporting the jaw and helping to maintain the head-tilt position.



If no spinal injury is suspected, the jaw-thrust maneuver may be used to gain additional forward displacement of the mandible. This is accomplished by grasping the angles of the patient's lower jaw and lifting with both hands, one on each side, displacing the mandible forward while tilting the head back.

If a spinal injury is suspected, the jaw-thrust without head-tilt maneuver should be used to open the airway During this maneuver, the patient's head should be stabilized and the cervical spine immobilized with neutral, in-line stabilization. The jaw-thrust maneuver should then proceed without extending the neck.

Suction

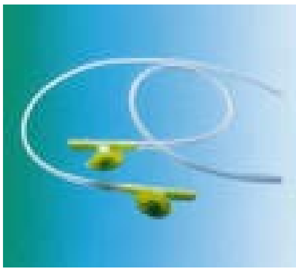
Suction can be used to remove vomitus, saliva, blood, food, and other foreign objects that might oclude the airway or increase the likelihood of pulmonary aspiration by inhalation. Because many factors can predispose an individual to aspiration, every patient should be regarded as a possible aspiration victim.

Suction Devices

Fixed and portable mechanical suction devices are available through a number of manufacturers. Fixed suction devices are mounted in patient care areas of hospitals and nursing homes and in many emergency vehicles. These systems are electrically operated by vacuum pumps or powered by the vacuum produced by a vehicle engine manifold. Fixed suction devices furnish an air intake of at least 30 L/min and provide a vacuum of more than 300 mm Hg when the tube is clamped.

Portable suction devices may be oxygen or air powered, electrically powered, or manually powered. These devices should furnish an air intake of no less than 20 L/min to operate effectively.

Suction Catheters



Suction catheters are used to clear the oral cavity and airway passages of secretions and debris. The two broad classifications of catheters are the whistle-tip suction catheter and the tonsil-tip suction catheter.

The whistle-tip catheter is a narrow, flexible tube used primarily for tracheobronchial suctioning to clear secretions through either an ET tube or the nasopharynx. This catheter is designed with molded ends and side holes to produce minimal trauma to the mucosa. A side opening in the proximal end is covered with the thumb to produce suction. Using sterile technique, the catheter is advanced to the desired location, and suction is applied intermittently as the catheter is withdrawn.

The tonsil-tip (Yankauer) suction catheter is a rigid pharyngeal catheter used to clear secretions, blood clots, and other foreign material from the mouth and pharynx. It is carefully inserted into the oral cavity under direct visualization and slowly withdrawn while suction is activated.

Before any suctioning procedure is initiated, all equipment should be checked and the suction set between 80 and 120 mm Hg. (Higher suction is needed for tracheobronchial suctioning.) The patient's lungs should be oxygenated with 100% oxygen for at least 2 minutes before suction is initiated, if possible. Suction should never be applied for longer than 10 to 15 seconds in adult patients or longer than 5 seconds in pediatric patients. If additional suctioning is needed, the patient's lungs should be reoxygenated before the procedure is repeated. Possible complications from suctioning include the following:

- Sudden hypoxemia that occurs secondary to decreased lung volume during the suction application
- Severe hypoxemia that may lead to cardiac

  rhythm disturbances and cardiac arrest
- Airway stimulation that may increase arterial

  pressure and cardiac rhythm disturbances
- Coughing that may result in increased intracranial pressure with reduced blood flow to the brain and increased risk of herniation in patients with head injury
- Soft tissue damage to the respiratory tract

Tracheobronchial Suctioning

Before tracheobronchial suctioning is performed through an ET tube, the patient must be oxygenated with 100% oxygen for 5 minutes.- Using sterile technique, the catheter is advanced to the desired location (about at the level of the carina). Suction is applied intermittently by closing the side opening as the catheter is withdrawn in a rotating motion. The patient's cardiac rhythm should be monitored throughout the procedure. If dysrhythmias or bradycardia develop, suction should be discontinued and the patient manually ventilated and oxygenated. Before the suction procedure is repeated, the patient should be ventilated with 100% oxygen for about 30 seconds.

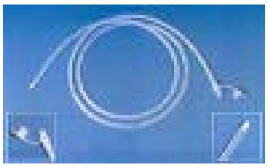
Gastric Distention

Gastric distention results from air being trapped in the stomach. As the stomach diameter increases from the trapped air, it pushes against the diaphragm and interferes with lung expansion. The abdomen becomes increasingly distended (especially in small children), and resistance may be felt to BVM ventilation.

Management. Management of gastric distention begins by slightly increasing the BVM ventilation inspiratory time. (Large-volume suction should be readily available.) If possible, the patient should be placed in a left lateral recumbent position, and manual pressure should be slowly applied to the epigastric region. Gastric distention that cannot be managed with these noninvasive techniques may require insertion of a gastric tube (Fig. 11-36).

Gastric Tubes

Gastric decompression for gastric distention or emesis control can be accomplished through nasogastric (NG) or orogastric decompression. The steps for each procedure are listed below:



NASOGASTRIC DECOMPRESSION

1. Prepare the patient.

a. Place the head in a neutral position.

b. Preoxygenate.

c. Instill a topical anesthetic or intravenous (IV) lidocaine (per medical direction or protocol).

d. Locate the larger naris.

2. Lubricate the NG tube with viscous lidocaine (Xylocaine) per protocol.

3. Advance the tube gently along the nasal floor and into the stomach. (Having the patient swallow during insertion may help advance the tube into the esophagus and prevent tracheal insertion.)

4. Confirm placement.

a. Auscultate the epigastric region while injecting 30 to 50 mL of air.

b. Note gastric contents in the NG tube.

Ensure that no reflux appears around the NG tube.

5. secure the NG tube in place.

OROGASTRIC DECOMPRESSION

1. Prepare the patient and tube as described above for NG insertion.
2. Introduce the orogastric tube down the midline of the oropharynx and into the stomach.
3. Ensure placement and secure the orogastric tube as described above for NG insertion.

Complications of gastric decompression. Regardless of the method chosen, gastric decompression is uncomfortable for the patient and may induce nausea and vomiting even when the gag reflex is suppressed. Gastric tubes also interfere with mask seals and with visualization of airway structures during intubation.

Complications of the procedures include nasal, esophageal, or gastric trauma, tracheal placement, supragastric placement, and gastric tube obstruction.

Mechanical Adjuncts in Airway Management

Use of mechanical devices in airway management should never delay the opening of a compromised airway. These devices should be used only after efforts have been made to open the airway manually.

Nasopharyngeal Airway (Nasal Airway)

The nasal airway is used to maintain an airway in a semiconscious or an unconscious patient. Insertion of a nasal airway may also be a useful temporizing maneuver to control the airway in patients with seizures or possible cervical spine injury and also before nasotracheal intubation (described later in this chapter). In addition, this adjunct may serve as a guide for insertion of a nasogastric tube.

Description

The nasal airway is soft and pliable. It has a gentle curve, and the outer end is flared. Nasal airways are available in a variety of sizes to accommodate infants and adults. They vary from 17 to 20 cm long and sizes 12 to 36 French. (As with most other catheters, the French Scale System is used to indicate internal diameter. Each unit of the scale equals about 1 /3 mm. A 21-French catheter, for example, is 7 mm in diameter.)

To determine the correct size, the paramedic should choose an airway that has a tube length equal to the distance between the tip of the patient's nose and the tragus of the ear, which is the cartilaginous area anterior to the external auditory canal (Fig. 11-38). The following are the recommended sizes of nasopharyngeal airways:

- Large adult: 8-9 mm internal diameter (24-27 French)
- Medium adult: 7-8 mm internal diameter (21-24 French)
- Small adult: 6-7 mm internal diameter (18-21 French)

Insertion

The nasal airway should be lubricated with a watersoluble lubricant to minimize resistance in the nasal cavity. The device is placed in the nostril with the beveled tip (designed to protect nasal structures) directed toward the nasal septum. The airway is gently passed close to the midline, along the floor of the nostril,

following the natural curvature of the nasal passage. The insertion should be made perpendicular to the coronal plane of the face. The airway should not be forced. If resistance is encountered, rotating the tube slightly may help, or insertion can be attempted through the other nostril.

After insertion, the nasal airway rests in the posterior pharynx behind the tongue. If the patient begins to gag after insertion of the airway, the tube may be stimulating the posterior pharynx. Removal of the airway or withdrawing it 0.5 to 1 cm and reinserting it may be indicated. The paramedic should remember to maintain displacement of the mandible by head-tilt chin-lift or by jaw-thrust without head-tilt when using this airway.

Advantages

A nasal airway is well tolerated by conscious and semiconscious patients with an intact gag reflex.

Insertion is a quick procedure.

A nasal airway may be used when insertion of an oropharyngeal airway is contraindicated or difficult because of oral trauma or soft tissue injury.

Possible Complications

Long nasal airways may enter the esophagus. The airway may precipitate laryngospasm and vomiting in patients with a gag reflex.

It may injure nasal mucosa, causing bleeding and possibly airway obstruction.

Small-diameter airways may become obstructed by mucus, blood, vomitus, and the soft tissues of the pharynx.

A nasal airway does not protect the lower airway from aspiration.

It is difficult to suction through.

Oropharyngeal Airway (Oral Airway)

Oral airways are designed to prevent the tongue from obstructing the glottis. They are indicated in unconscious or semiconscious patients who have no gag reflex.

Description

The oral airway is a semicircular device designed to hold the tongue away from the posterior wall of the pharynx. Most oropharyngeal airways are made of disposable plastic. The two types of airways most frequently used are the Guedel, distinguished by its tubular design, and the Berman, distinguished by airway channels along each side.Like nasopharyngeal airways, oral airways are available in a variety of sizes, from infant to adult. The size is based on the distance in millimeters from the flange to the distal tip. The proper size for the patient may be determined by placing the airway next to the face so that the flange is at the level of the patient's central incisors and the bite block segment is parallel to the patient's hard palate. The airway should extend from the corner of the mouth to the tip of the ear lobe or the angle of the jaw. The following sizes are recommended 5:

• Large adult: 100 mm (Guedel size 5)

• Medium adult: 90 mm (Guedel size 4)

• Small adult: 80 mm (Guedel size 3)

Insertion

Before any oral airway is inserted, the mouth and pharynx should be cleared of all secretions, blood, or vomitus. In an adult or older child, the oral airway may be inserted upside down or at a 90-degree angle to avoid catching the tongue during insertion. As the oral airway passes the crest of the tongue, it is rotated into the proper position so that it is situated against the posterior wall of the oropharynx. Another method of insertion, recommended for pediatric patients and usable in adult patients, is to use a tongue blade to displace the tongue inferiorly and anteriorly. The airway is then inserted and moved posteriorly toward the back of the oropharynx, following the normal curvature of the oral cavity. Regardless of the method of insertion, trauma to the face and oral cavity should be avoided. In addition, the paramedic should be sure that the patient's lips and tongue are not caught between the teeth and the airway.

Proper placement of the airway is confirmed by observable chest wall expansion and good breath sounds on auscultation of the lungs during ventilation. The paramedic should remember that even with an oral airway in place, the patient's head must be kept in proper position to help ensure a patent airway.

Advantages

- An oral airway secures the tongue forward and down, away from the posterior pharynx.
- It provides easy access for airway suction.
- It serves as a bite block to protect an ET tube and the airway in the event of convulsions.

Possible Complications

- Oral airways that are too small may fall back into the oral cavity, occluding the airway.
- Long airways may press the epiglottis against the entrance of the trachea, producing a complete airway obstruction.
- The airway may stimulate vomiting and laryngospasm in a patient with a gag reflex.

The Laryngeal mask airway (LMA)

Desciption:

The Laryngeal mask airway (LMA) is a silicone device for upper airway management. It was designed by British anesthesiologist Archie J. Brain as an alternative method of ventilation and provides an end-to-end connection between the natural airway and an artificial airway. Through research in cadaveric specimens, Brain discovered that a low pressure cuff provided an airtight seal around the glottis. The LMA provides a more effective seal than the face mask yet is less invasive than endotracheal intubation. Brain constructed the prototype from the cuff of a Goldman dental mask and a 10 mm tracheal tube

Indications:

* procedures where face masks are currently used or intubation is unnecessary
* orthopedics
* urology
* gynecological procedures
* short diagnostic procedures
* situations where intubation is difficult, hazardous or unsuccessful

Contraindications:

* morbidly obese patients
* patients with suspected gastric contents
* patients at risk for aspiration
* patients with high airway resistance, limited pulmonary compliance
* pharyngo-tracheal pathology (tumor, abscess, hemtoma)

LESSON 6_06 6_07 ASPHYXIA, HYPOXIA & ANOXIA

Anoxia

What is Anoxia/Hypoxia?

Specifically, anoxia is a condition in which there is an absence of oxygen supply to an organ's tissues although there is adequate blood flow to the tissue. Hypoxia is a condition in which there is a decrease of oxygen to the tissue in spite of adequate blood flow to the tissue. Anoxia and hypoxia, however, are often used interchangeably—without regard to their specific meanings—to describe a condition that occurs in an organ when there is a diminished supply of oxygen to the organ's tissues. Anoxia and hypoxia may be caused by a number of events, such as heart attack, severe asthma, smoke or carbon monoxide inhalation, high altitude exposure, strangulation, anesthetic accidents, or poisoning. In severe cases of anoxia and hypoxia, from any cause, the patient is often stuperous or comatose (in a state of unconsciousness) for periods ranging from hours to days, weeks, or months. Seizures, myoclonic jerks (muscle spasms or twitches), and neck stiffness may occur.

Is there any treatment?

Treatment of anoxia and hypoxia consists of establishing an adequate airway as soon as possible, using enough oxygen to saturate the blood, supporting the cardiovascular system as needed, and preventing or treating pneumonia. Respiratory assistance may be necessary.

What is the prognosis?

If the patient's respiratory and cardiovascular systems can be supported properly, recovery may occur, but depends upon the severity of injury. As recovery proceeds, a variety of psychological and neurological abnormalities may appear, persist for a time, and may improve. Mental confusion, personality regression, parietal lobe syndromes, amnesia, hallucinations, memory loss, and persistent myoclonus may also occur.

Cerebral ischemia

Cerebral ischemia must be distinguished from *cerebral hypoxia*. In cerebral hypoxia the oxygen supply to the brain is diminished even though blood flow and blood pressure may be normal. Discriminating between diagnoses of patients with acute neurological deficit is critical because patient management takes disparate paths.

There are generally distinct clinical outcomes in stroke versus cerebral hypoxia, although both sets of patients may suffer death or permanent damage. Hypoxia patients who survive past an acute life-threatening period usually show few immediate symptoms of long term damage. Instead, clinical manifestations such as mental deterioration, urinary and fecal incontinence, gait and speech distrubances, tremor and weakness are delayed for periods that may vary from days to weeks. Fortunately, the long term clinical prognosis is relatively good, with a majority of patients showing complete or near complete recovery from hypoxia within the first year.

The hypoxia patient who does not suffer a mortal episode has a much better clinical prognosis than their counterpart who suffered a stroke. Why is this the case? The answer resides in the fact that hypoxia does not involve dminished blood flow while stroke does. Blood plays many roles in preserving tissue homeostasis in addition to the delivery of oxygen. A prime example is the important role of blood in helping to regulate tissue pH. The happier fate of the hypoxia patient versus the stroke victim underscores the importance of blood flow above and beyond the delivery of oxygen.

Some major points on the effects of hypoxia

Cells obtain their energy from oxygen. Most cells have a limited ability to respire anaerobically but brain cells do not; not only do brain cells stop working if no oxygen is present but they are also killed if they are deprived of oxygen for a few minutes. The body has many responses to hypoxia that tend to reduce its severity. In an earlier lecture we noticed that there were 4 different ways in which hypoxia could be produced and the way in which the hypoxia is produced affects how the body responds.

Arterial partial pressure of oxygen, haemoglobin saturation and cyanosis

In hypoxic hypoxia, ther arterial partial pressure of oxygen (PaO2) is reduced and the haemoglobin is not fully saturated. In other forms of hypoxia, the arterial partial pressure is normal so the haemoglobin is fully saturated. In anaemic hypoxia there is little haemoglobin so that, despite such haemoglobin as there is being fully saturated, there is a small amount of oxygen carried in the blood.

Normal arterial blood contains 200ml/l of oxygen and only gives up 50ml/l as it goes through the average resting tissue, so it leaves the tissues with 150ml/l at a partial pressure of 5kPa. This reserve, however, is smaller than it seems because there has to be a partial pressure gradient to drive the oxygen from the blood to the working cells so, in practice, not all the oxygen can be removed from the blood as it goes through the tissues. Also, some tissues remove more than 50ml/l and when tissues are active they will remove more oxygen than at rest, further reducing the size of this reserve.

In hypoxic and anaemic hypoxias, there will be less oxygen than normal in the blood entering the organs, so there will be less oxygen than normal in the blood leaving the organs. In stagnant hypoxia there is 200ml/l of oxygen in arterial blood but the blood flow through the tissues is reduced, so the tissues will remove more oxygen from each unit volume of blood; again there will be a reduced amount of oxygen in the blood leaving the organs. In cyctotoxic hypoxia, the organs cannot use the oxygen that is brought to them, so there will be more oxygen than normal in the blood leaving the organ. In hypoxic and stagnant hypoxias, the low level of oxygen in capillary blood makes the affected organs go blue, a condition called cyanosis, but this does not occur in anaemic hypoxia. The blueness is due to the presence of more than 50g/l of deoxygenated haemoglobin in capillary blood; in normal people this will occur when one third of their haemoglobin is deoxygenated but in anaemic people with lower levels of haemoglobin a greater proportion of their haemoglobin would have to be deoxygenated before there would be 50g/l of it in their blood so anaemic people will not be cyanosed. For example, if an anaemic patient had only 75g/l of haemoglobin in her blood instead of the usual 150g/l, cyanosis would occur when two thirds of their haemoglobin was deoxygenated instead of the usual one third. Furthermore, if an anaemic patient is exposed additionally to hypoxic hypoxia, she will become cyanosed only at a much more severe degree of hypoxia than would a normal person. Therefore the presence of cyanosis indicates that hypoxia is present but the absence of cyanosis does not mean that there is no hypoxia.

Can you treat hypoxia by giving patients 100% oxygen to breathe? This would be effective in only hypoxic hypoxia because in other forms of hypoxia the blood leaving the lungs is fully saturated with oxygen; also there would be no benefit in right-to-left shunts where the blood going past functional alveoli leaves the lung fully saturated. Though some oxygen can be carried in solution, the amount is small so that the benefit of giving 100% oxygen in other forms of hypoxia would be slight and it could also lead to the loss of the Haldane effect, which would raise the level of carbon dioxide in the tissues.

The rate of ventilation

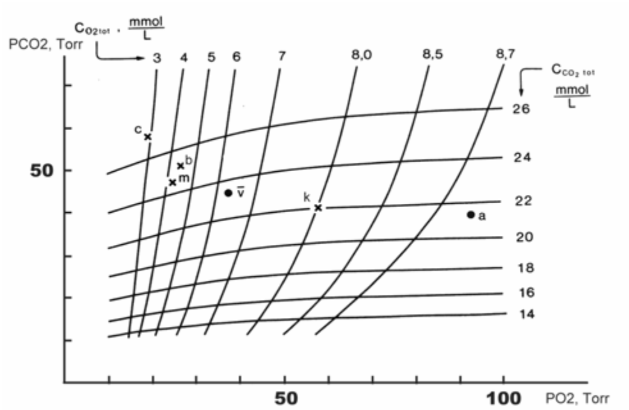
The increase in ventilation produced by hypoxia and hypercapnia (a raised partial pressure of carbon dioxide) acting together, is greater than the sum of the increases produced by the hypoxia and the hypercapnia acting on their own. The rise in the ventilation will reduce the partial pressure of carbon dioxide and increase the partial pressure of oxygen, returning the partial pressures of these gases towards normal; note that these mechanisms cannot return the partial pressures right back to normal because that would remove the stimulus which is increasing the ventilation.

The main receptors for carbon dioxide are the central chemoreceptors, in the brain stem, which are stimulated by hydrogen ions in the cerebral extracellular fluid, rather than directly by the partial pressure of carbon dioxide in arterial blood. The capillaries in the brain are very impermeable, forming the blood-brain barrier; not even small ions can go between the endothelial cells, so the pH of the extracellular fluid can be different from the pH of the plasma. Carbon dioxide is lipid soluble and can cross endothelial cell membranes, so the concentration of carbon dioxide in the plasma and extracellular fluid will be the same; because of the equilibrium:-

$$CO_2 + H_2O \rightleftharpoons H^+ + HCO_3^-$$

the pH of the extracellular fluid will be determined by the carbon dioxide concentration but not be directly affected by the plasma pH as the hydrogen ions cannot cross the barrier. The Henderson-Hasselbalch equation can be applied to the equilibrium to give:-

$$pH = pK + \log_{10}\frac{[HCO_3^-]}{[CO_2]}$$



Modifications of the content of O2 and CO2 in the blood in:

a = arterial blood

k = kidney veins

$\bar{v}$ = venous blend

m = muscular veins

b = brain veins

c = coronary veins

so the pH of the extracellular fluid is determined by the concentrations of both hydrogen carbonate ions and carbon dioxide. The extracellular fluid exchanges freely with the cerebrospinal fluid which fills the ventricles of the brain and the subarachnoid space; the cerebrospinal fluid is not a filtrate but an active secretion and its composition can be changed. When the partial pressure of carbon dioxide is raised, the pH of the cerebrospinal fluid will fall but, if the rise in carbon dioxide is prolonged, there may be an increase in the concentration of hydrogen carbonate ions, bringing the pH back to normal, so the central chemoreceptors are no longer stimulated. The patients will still be hypoxic so their peripheral chemoreceptors will be stimulated and keep the ventilation high. This can be a problem if the patients are given air with an increased partial pressure of oxygen to breathe; normally this would help the patients by increasing their alveolar and arterial partial pressures of oxygen but, if the hypoxia is driving the ventilation, the raised level of oxygen will reduce the ventilation, so there will be little increase in the amount of oxygen in the blood but the reduction in ventilation will increase the partial pressure of carbon dioxide even more.

If the partial pressure of oxygen in the inspired air is low, as at high altitudes, there will be hypoxia without a rise in the partial pressure of carbon dioxide and the ventilation will be increased by the hypoxia stimulating the peripheral chemoreceptors. Small decreases in the partial pressure of oxygen do not increase the ventilation; increases occur only when the partial pressure in arterial blood has fallen to somewhat below 10kPa, which corresponds to a partial pressure of 15kPa in inspired air or to altitudes of 3000 metres. This is a useful property because the haemoglobin is fully saturated above 10kPa so that increases in ventilation would not increase the amount of oxygen in arterial blood. Also, any increase in ventilation that did occur would reduce the partial pressure of carbon dioxide which is undesirable, as you learnt in the hyperventilation practical.

When the hypoxia is severe enough to increase the ventilation, the partial pressure of carbon dioxide in the alveolar air and arterial blood does fall and a low partial pressure of carbon dioxide (hypocapnia) inhibits the ventilation; the combination of hypoxia stimulating the ventilation and hypocapnia inhibiting it, increases the ventilation only slightly. This phenomenon can be demonstrated in the laboratory: if subjects are given air with a low partial pressure of oxygen to breathe, their ventilation increases and their end tidal partial pressure of carbon dioxide, which is a measure of the alveolar partial pressure of carbon dioxide, falls; if the air has a small amount of carbon dioxide added to it, so that the end tidal carbon dioxide remains constant, the ventilation will increase more than if there were no carbon dioxide in the inspired air. A related change happens during acclimatization to high altitudes: if people remain at high altitudes for a few days, their ventilation increases throughout this time so that it is higher 3 to 4 days after they reached these altitudes than it was on first arriving there. Initially the increased ventilation reduced the partial pressure of carbon dioxide, making the cerebrospinal fluid alkaline, which has an inhibitory effect on the ventilation, but the concentration of hydrogen carbonate ions in the cerebrospinal fluid decreases during acclimatization, bringing the pH of the cerebrospinal fluid back to normal, so that the inhibition due to the central chemoreceptors is lost despite the partial pressure of carbon dioxide remaining low; with the loss of the inhibition, the full effect of the hypoxia is seen and the ventilation increases further. Note that acclimatization and adaptation are not the same: acclimatization refers to the changes people from low altitudes experience when they go to higher altitudes; adaptations are the changes shown by populations that live at high altitudes.

In the other types of hypoxia (anaemic, stagnant and cytotoxic), the arterial partial pressure of oxygen is not reduced, so there will be no increase in the ventilation because the carotid bodies respond more to the partial pressure than to the amount of oxygen in the blood. The absence of an increase in the ventilation is an advantage because the haemoglobin is fully saturated when it leaves the lungs, so an increase in the ventilation would not increase the amount of oxygen carried in the blood, but it would reduce the arterial partial pressure of carbon dioxide which is not raised in the other forms of hypoxia.

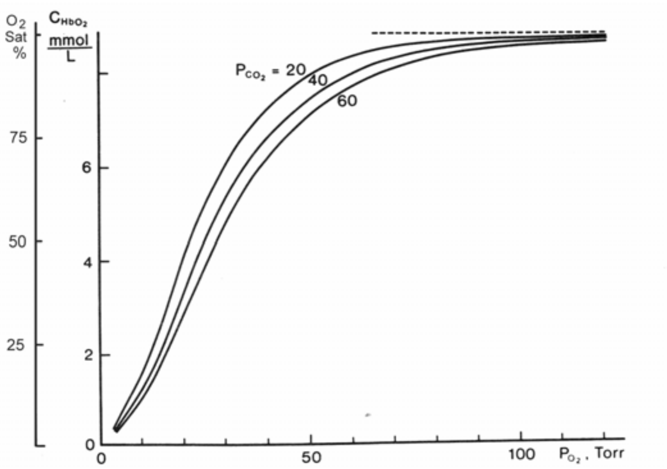
The red blood cell count

Prolonged hypoxia induces a slow rise in the red blood cell count (polycythaemia), which will increase the amount of haemoglobin in the blood, so increasing the amount of oxygen that the blood can carry at any partial pressure of oxygen; this increases the amount of oxygen being carried to the tissues. A disadvantage of polycythaemia is that the blood becomes more viscous, making it flow less readily. The increase in the red blood cell count is due to more red blood cells being formed, their destruction continues at normal rates. When new red cells enter the circulation they still contain strands of the messenger ribonucleic acid that was used to form their haemoglobin and stains which bind to ribonucleic acid (acidophilic stain) show up the strands as a net, so the new cells are called reticulocytes. When the rate of red cell formation (erythropoiesis) increases, the number of reticulocytes in the blood increases, which is called a reticulocytosis.

The increase in the rate of red cell production is produced by the effect of hypoxia on the kidney. The kidney secretes a renal erythrogenic factor, or erythrogenin, into the blood stream where it acts on a plasma protein, called erythropoietinogen, to produce erythropoietin which stimulates the red bone marrow to make more red cells.

The shape of the dissociation curve

Changes in the pH and the partial pressure of carbon dioxide move the dissociation curve. A reduction in the alveolar ventilation to half its normal value, for example, would reduce the alveolar and arterial partial pressures of oxygen to approximately 7.5kPa and increase the partial pressure of carbon dioxide to around 10.5kPa. If the position of the dissociation curve did not move, the amount of oxygen in arterial blood would be around 175ml/l but the movement of the curve (the Bohr effect) would reduce this figure to 160ml/l; you may find it helpful to look at a dissociation curve in one of your textbooks while reading this.



Bohr effect:

An increase of PCO_2 cause a lower affinity for O_2

As the tissues take 50ml of oxygen from each litre of blood passing through them, the amount of oxygen left in the blood as it leaves the tissues will be 125ml/l if the curve did not move and 110ml/l if the curve moves to the right; the partial pressures at which oxygen is released from the haemoglobin will be 4.4kPa if the curve had not moved but will be 4.8kPa after the Bohr shift occurs; this rise in pressure means there is a higher gradient driving the oxygen from the blood to the organs, imporiving the supply of oxygen. In stagnant hypoxia the reduced blood flow means that more carbon dioxide has to be added to each unit volume of blood flowing through the tissues, raising the partial pressure of carbon dioxide in the tissues. This is undesirable but it has the compensatory advantage that the raised partial pressure of carbon dioxide will move the oxygen dissociation curve to the right which favours the delivery of oxygen to the tissues.

If the partial pressure of carbon dioxide falls in hypoxic hypoxia, the dissociation curve will move to the left which will increase the amount of oxygen carried by the blood as it leaves the lungs but will also reduce the partial pressure at which the oxygen is released from the haemoglobin. This is undesirable because it reduces the partial pressure gradient driving oxygen from the blood into the tissues, reducing the supply of oxygen to the working cells. When the arterial blood becomes alkaline, as it will if the partial pressure of carbon dioxide falls, there is an increased formation inside the red cells of 2,3-diphosphoglycerate (2,3-DPG) which binds to haemoglobin, moving the dissociation curve to the right. The formation of 2,3-diphosphoglycerate occurs when the low partial pressure of carbon dioxide has shifted the curve to the left and one of 2,3-diphosphoglycerate's main functions may be to prevent or reduce this leftwards movement of the dissociation curve; as the formation of 2,3-diphosphoglycerate is increased when the pH is high, it will not be formed when the partial pressure of carbon dioxide is high, which will reduce the pH, and the curve has already moved to the right.

Anaemia does not affect the pCO_2 of pH so it will not generally alter the shape of the dissociation curve but remember that carbon monoxide poisoning is a form of anaemic hypoxia because it makes the haemoglobin unable to combine with oxygen. Also, carbon monoxide poisoning shifts the dissociation curve to the left so that, as well as reducing the amount of oxygen carried on haemoglobin, it makes the haemoglobin less willing to release the oxygen that it does have. Thus a patient who has 50% of his haemoglobin bound to carbon monoxide will be in a worse position than an anaemic patient with only half the normal concentration of haemoglobin. (What is the normal haemoglobin concentration?)

Blood flow through the tissues

Turning to the effects of hypoxia on bloodflow, a reduction in the partial pressure of oxygen in the tissues will cause dilatation of arterioles, increasing the bloodflow, so that the tissues need to remove less oxygen from each litre of blood flowing through them. If anaerobic metabolism occurs, hydrogen ions will be produced which add to the vasodilatation and further increase the supply of oxygen to the tissues. The hypoxia dilates precapillary sphincters as well as arterioles, so that more capillaries will be open, reducing the distance the oxygen has to cover getting from capillaries to the respiring cells, so that the diffusion of oxygen is increased; in chronic (prolonged) hypoxia new capillaries are formed, further reducing the distance over which diffusion has to occur.

In stagnant hypoxia and most forms of hypoxic hypoxia the concentration of carbon dioxide in the tissues will rise and contribute to the vasodilatation increasing the blood flow. The increased blood flow will helo to carry away the carbon dioxide so that the partial pressure of carbon dioxide would not be as high as it otherwise would be. In those forms of hypoxic hypoxia with a low carbon dioxide partial pressure, the fall in carbon dioxide's partial pressure can lead to a vasoconstriction which may be more potent in some organs than the effect of the hypoxia.

As well as the direct effect of the blood gases on arterioles, there may also be reflexes due to stimulation of chemoreceptors. When considering these reflexes, remember tha many organs can manage without oxygen for a long time and it is only the brain and heart that require a continuous supply of oxygen. Hypoxic stimulation of the carotid bodies produces a bradycardia, which reduces the cardiac output, by vagal stimulation and a vasoconstriction, which spares the coronary and cerebral circulations, by sympathetic stimulation. This response can be beneficial if you stop breathing completely because the blood then circulates mainly to the brain and heart which cannot manage without oxygen while the other organs that can respire anaerobically receive very little bloodflow, so the oxygen that is in the blood will go preferentially to the organs that cannot manage without it; also the reduced cardiac output will reduce the work the heart has to do, so reducing its oxygen needs. A similar effect is obtained in the diving response, where stimulation of the face or upper respiratory tract can produce a slowing of the heart (bradycardia). Stimulation of the aortic chemoreceptors may produce a slight tachycardia.

Stimulation of the carotid body usually increases the ventilation which will stimulate the lung stretch receptors more often and more intensely; the stretch receptors produce a tachycardia (increase the heart rate) and inhibit vasoconstrictor fibres. This will increase the flow of blood through tissues which can compensate for the reduced concentration of oxygen in the blood; it is a useful response where the breathing is continuing but the partial pressure of oxygen in the blood is reduced. During acclimatisation to high altitudes, the cardiac output, unlike the ventilation, returns to normal; the stroke volume falls but the tachycardia persists; the fall in cardiac output may be associated with the rise in the haematocrit.

The partial pressure of carbon dioxide in arterial blood may be either reduced or elevated in hypoxic hypoxia and these changes can produce reflex effects on the cardiovascular system. A raised partial pressure of carbon dioxide will stimulate the vasomotor centre, producing a generalised vasoconstriction which is called the central effect of carbon dioxide and is the opposite to the direct, or local, effect on the arterioles. Conversely, a low partial pressure of carbon dioxide can produce a vasodilatation by inhibiting sympathetic vasoconstrictor fibres and may also have a direct effect on the pacemaker cells of the heart, producing a tachycardia, which you may have observed in the hyperventilation practical.

Hypoxia can also stimulate the defence reaction in which there is vasoconstriction within most organs, but vasodilatation in skeletal muscle; there is also a tachycardia in the defence reaction. Hypoxia can also release adrenaline from the adrenal medulla which can produce a tachycardia and vasoconstriction in organs where adrenaline stimulates alpha receptors but vasodilatation in organs, such as skeletal muscle, that have many ß receptors. In summary, the response of blood vessels to hypoxia is complicated and the changes vary according to the organ and circumstances involved.

Changes in pH

If the partial pressure of carbon dioxide rises in hypoxia, the pH will fall which is called a respiratory acidosis. At high altitudes the increased ventilation reduces the partial pressure of carbon dioxide, raising the pH so producing a respiratory alkalosis. The kidney returns the pH towards normal by altering the hydrogen carbonate concentration in the plasma but does not affect the partial pressure of carbon dioxide.

Hydrogen carbonate ions are filtered at the glomerulus and reabsorbed in the tubule; the mechanism producing the reabsorption was covered in the renal course. Briefly, carbon dioxide in the tubular cells is turned into hydrogen ions and hydrogen carbonate ions. The hydrogen carbonate ions go into the blood while the hydrogen ions go into the tubule where they combine with a hydrogen carbonate ion, turning it into carbon dioxide which goes into the cell. Effectively, this mechanism reabsorbs hydrogen carbonate ions; one ion has been removed from the tubule and one added to the blood.

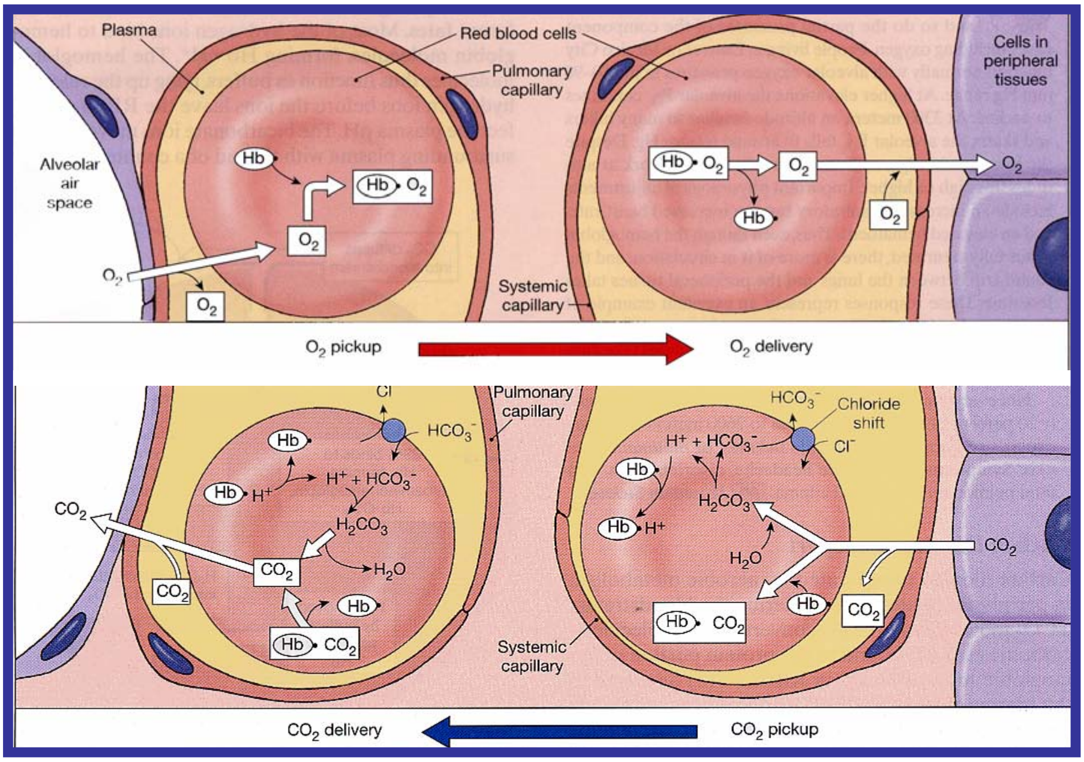
If fewer hydrogen ions are secreted than there are hydrogen carbonate filtered, fewer hydrogen carbonate ions will be returned to the blood than were filtered so the plasma concentration of hydrogen carbonate ions will fall, reducing the pH. Conversely, if more hydrogen ions are secreted than there are hydrogen carbonate filtered, the plasma concentration of hydrogen carbonate ions will rise increasing the plasma pH. The number of hydrogen ions secreted is determined by the partial pressure of carbon dioxide; the higher is the pressure, the more hydrogen ions are secreted.

In a respiratory acidosis the partial pressure of carbon dioxide is high so more hydrogen ions are secreted, more hydrogen carbonate ions are put back into the blood and the pH will rise back towards normal; conversely in a respiratory alkalosis there will be a fall in hydrogen ion secretion and hydrogen carbonate ions returned to the blood, making the pH fall.

The brighter ones of you may have realised from the equation above that in a respiratory acidosis, the hydrogen carbonate ion concentration will rise, increasing the amount of the ion filtered, so both the hydrogen ion secretion and the hydrogen carbonate filtration will have increased. However, looking at the Henderson-Hasselbalch equation will show you that the ratio of the hydrogen carbonate concentration to the carbon dioxide concentration will fall; therefore the rise in the hydrogen carbonate filtered is smaller than the rise in the hydrogen ion secretion. So there will still be more hydrogen ions secreted into the tubule and hydrogen carbonate put into the blood than there was hydrogen carbonate filtered. Similarly, in a respiratory alkalosis there will be a large fall in the hydrogen ion secretion but only a small fall in the hydrogen carbonate concentration.

A summary of the Primary Gas Transport Mechanisms:

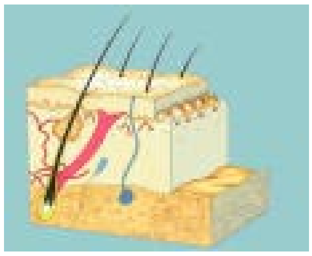
Oxygen transport and Carbon dioxide transport



LESSON 7_01 INJURIES TO SKIN AND EYES

Injuries, infections and disorders of the skin

Major or chronic skin problems are not covered in this book. It is assumed that an offshore worker with an important skin problem either can't pass the pre-employment physical or will bring bis own medications for known problems.



PRINCIPLES OF TREATMENT

Stop the cause — This is obvious but bears repeating. The problem may be a drug reaction, something in contact with the skin, or constant rubbing or scratching (see 3 below). Healthy skin bas a tremendous ability to heal itself without treatment if the provoking factor is removed. Stop all medicines, use protective garments, avoid suspicious jobs or areas, and cover the affected skin with a dressing or ointment.

Avoid over-treatment — Use simple remedies first or start with a more potent remedy, then go to a simple one after improvement occurs. An unexpected reaction to skin medicine may cause the treatment to make things worse. Ordinary remedies, applied with a certain amount of ceremony, will give the patient confidence that he will get better and help him in waiting for improvement.

Stop scratching — Itching is a symptom seen in hundreds of different skin disorders and leads to scratching. Scratching causes release of chemicals from certain cells in the skin. These chemicals cause more itching, thus the "itch-scratch cycle". Changes eventually occur in the skin due to persistent scratching which can hide the original problem. Constant scratching will overcome any treatment. Remind the patient constantly at first and cover the lesion if possible. Suggest covering the bands with gloves or socks during sleep and taping them to the wrists. Stopping constant scratching is often a very difficult problem since the patient usually does it thoughtlessly or during sleep and will sincerely deny that he is still scratching.

NON-SPECIFIC TREATMENTS

These are useful for a variety of problems, perhaps in addition to more specific measures.

For red, itching, oozing skin:

Soaks-Apply warm for infections, cool for other problems. Soak hands or feet in a basin, apply a wet strip of towel or gauze to other body areas. Apply for 15-30 minutes 2-3 times a day. The following are soothing, mixed with ordinary tap water:

Table salt, 2 teaspoons per quart or liter of water.

Baking soda (sodium bicarbonate) 8 teaspoons per quart of water.

Epsom salt (magnesium sulfate) 8 teaspoons per quart of water.

Topical medicines-Start with these for severe discomfort, then switch to simple soaks when improvement occurs:

Diphenhydramine cream-apply a thin film over the area, cover with a dressing, repeat 4 times a day until improvement occurs, then begin simple soaks. This is best for simple problems, as diphenhydramine cream sometimes sensitizes the skin, making things worse.

Cortisone cream (and derivatives) — apply the same as diphenhydramine. Penetration is greatly enhanced by covering the area with plastic film (Saran-wrap") or a dressing. Switch to simple soaks when improved.

Oral medicines-These can be helpful for itching, especially during sleep. They may cause drowsiness, so avoid or use with care around machinery or when operating equipment.

diphenhydramine-daytime 25-50 mg. every 4-6 hours, bedtime 50-100 mg.

hydroxyzine-saure dose as above.

Dry skin — The skin may itch and will be dry, cracked, rough, and flaking. The problem is often due to sun, wind, irritants, or simple chronic dry skin. Apply any oily material such as lotion, petroleum jelly, even butter or lard. An oily layer on the surface prevents evaporation of water and increases the moisture content of the skin.

BACTERIAL INFECTIONS

FOLLICULITIS (barber's itch)

This is most common on the face, the back of the neck, or in friction or rubbing areas. It may result from being shaved by unclean barber utensils.

The infected hair follicles result in many superficial pimples in the affected area.

Open each pimple with the tip of a needle and scrub gently with soap. if'not healed in '2-3 days, give oral antibiotics for 3-5 days.

BOIL (furuncle)

This is usually due to an infection in a hair follicle which penetrates deeper into the skin.

Apply hot soaks (see above); treat with penicillin, erythromycin, tetracycline, or cephalosporin.

If the boil "comes to a head" with pus appearing in the center in a soft area, open it with the tip of a needle and **gently** press out the pus. Boils will often rupture and drain spontaneously.

A **carbuncle** is a collection of boils connected by channels under the skin. The most common location is the back of the neck. Often there is fever and spasm of the neck muscles. It may come to a head or drain at several points. Use big doses of antibiotics to start and consider evacuation if the problem appears worse after 36-48 hours treatment (unlikely).

ERYSIPELAS

This is a strep infection of the skin, often on the cheek but can occur anywhere. It usually starts with a minor scratch or break in the skin.

The skin is hot, red, thick or swollen and can often be indented with a fingertip. The typical appearance shows a sharp border between the infected and normal skin which can be traced with a hall point pen and seen to advance in a few hours.

Give aspirin for pain and fever. Erysipelas responds to ordinary doses of penicillin or erythromycin as an alternative. It is usually better in 24-36 hours, healed in 3-5 days.

IMPETIGO

This is a local infection of the skin caused and spread by germs from under the fingernails, usually due to scratching insect bites or minor skin irritations.

It starts as a small bump or blister-litre area which turns into a honey-colored crust or scab with a "stuck-on" appearance. It itches but is not tender.

Minor cases usually heal by removing the crust, scrubbing with soap, and covering until healed. Have the patient cut his fingernails short and scrub the hands several times a day at first.

For numerous lesions, more severe lesions (large blisters) or an undependable patient, give antibiotics as for folliculitis.

FUNGAL INFECTIONS

TREATMENT

Except where noted, fungal skin infections may be treated with Tinactin® (tolnaftate), Halotex® (haloprogin), MicaTin® (miconazole), Lotrimin® (clotrimazole), or similar medications. The skin should be kept clean. Where sweat or moisture is a factor, keep the skip as dry as possible with loose garments and frequent changes of underwear or socks. Apply the medicine 4 times a day or more often in severe cases until improvement is noted.

COMMON FUNGAL INFECTIONS

Athlete's foot (tinea pedis)

There is itching, burning or stinging between the toes and cracking and peeling of the skin. There may be deep, blisterlike areas in severe cases.

Secondary infections are common in severe cases. In these cases give penicillin or erythromycin for 5-7 days along with the anti-fungal medicine.

It is usually restricted to the skin between the toes and nearby areas. If the problem areas are on top of the foot or the soles, suspect a contact dermatitis or neuro-dermatitis.

Ringworm

Infection of body surfaces (tinea corporis) is most common; infection of the scalp (tinea capitis) is usually seen in children.

It starts as a small collection of bumps or tiny blister-like areas which spread outward while clearing in the center, giving a ring-like or "C"-shaped appearance. The border of the ring is the active infection.

It heals quickly but itches; it may be necessary to cover the area to prevent spread by scratching.

Jock itch (tinea cruris)

This is very common in humid climates. It starts in the crease between the scrotum and inner thigh, then spreads to those areas. On the thigh, the infected skin is dark pink or light brown with a definite border from normal skin. The first symptom is usually itching, later becoming tender and inflamed.

Jockey-type shorts should be avoided and the area should be kept clean with soap and water.

Tinea versicolor

A harmless but very common superficial infection, seen on the upper portions of the chest, back and arms. It appears as light patches which do not tan or pale pink areas on white skin. Mainly a cosmetic problem; it can be treated with the medicines in "A" above or dandruff shampoos containing selenium sulfide by applying as a lotion for 10-20 minutes then rinsing off with water. Repeat daily until better, then twice weekly.

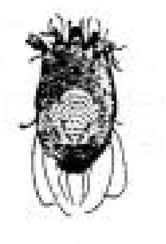
Commonly re-occurs in warm weather, then fades in the winter.

PARASITES

LICE

Head and body lice are usually due to poor hygiene but they spread readily in crowded quarters, even to people with good hygiene. The head lice nits can often be seen on shafts of the hair. Body lice are not usually seen but hide in seams of clothing. Pubic lice (crabs) may be seen or one may see tiny, dot-like droppings in the crotch of the underwear. Pubic lice are usually acquired during sexual activity. All are cured by the use of lindane lotion or shampoo. For body lice, boil the clothing or wash in strong detergent. In some geographical areas, body lice may cause trench fever, relapsing fever and typhus.

SCABIES



This is caused by a small mite which burrows under the skin and lays eggs. It usually begins on the hands and wrists or feet and ankles, and is usually not seen on the neck and face. It appears as small bumps or blisters, frequently seen in a pattern of lines or "runs". It itches most at night and spreads readily to close contacts (spouse, roommate). Treat with lindane lotion, applying a thin layer from the neck down. Leave on the skin 8-12 hours, then rinse off with water. Repeat in 5 days. Under-garments and bed clothes should be washed in a strong detergent.

OTHER SKIN PROBLEMS

CONTACT DERMATITIS

A problem caused by irritation of the skin from contact with some external material or chemical. The treatment consists of stopping or preventing contact plus the non-specific treatments outlined above. The key is to suspect the work-relatedness of the problem, though non work factors may also apply (cosmetics, deodorants). Straps, belts, boots, gloves, jewelry, and elastic are common causes which cause recognizable patterns on the body. The hands are affected most often from handling materials related to work.

NEURODERMATITIS (dyshydrotic dermatitis)

Usually seen as clear, pin-point blisters in the skin which itch intensely. The most common areas are the sides of the fingers, sometimes the palms; less commonly on the sides of the toes and soles of the feet. Use the non-specific treatments outlined above. This is often a stress-related problem seen in nervous, tense personality types. Constant scratching is a large factor in treatment.

DRUG ERUPTION

One common appearance is a measles like rash with itching but drug rashes may mimic almost any skin problem. They may cause little discomfort, even when pronounced. The rash usually involves much or most of the body, equal on the right and left sides. The onset is usually sudden and mostly occurs 1-2 days after beginning a new medicine. Always ask about recent medicines, even those which have been taken before. Treat by stopping all medicines, except perhaps those which have been taken for a long time without any problem. The rash usually clears quickly after stopping the guilty medicine, though non-specific treatment may be given.

HIVES (urticaria)

If this is part of an anaphylactic reaction, give epinephrine 1/1000 (concentration) , 0.3 - 0.5 cc. IM or subcutaneous. Rub the injection site vigorously for one minute, then repeat as necessary. The same dose can be given IV over 1-2 minutes if the patient is critical. Follow with hydrocortisone 500 to 1000 mg. IM or dexamethasone 8 to 12 mg. IM if available. This treatment is for anaphylaxis, not for ordinary hives.

Hives is an allergic reaction, though it very often occurs spontaneously without obvious cause. It may range from simple swelling of the lips or eyelids to a pattern of welts covering the body that may have a circular or curving pattern. The itching is often extreme. Treat with diphenhydramine, hydroxyzine, or any antihistamine including cold remedies or cough syrup. Cool the skin with a bath or cold towels and avoid irritants or heat. **No scratching.**

Injuries, infections and disorders of the eye

LIDS INJURIES

Lacerations

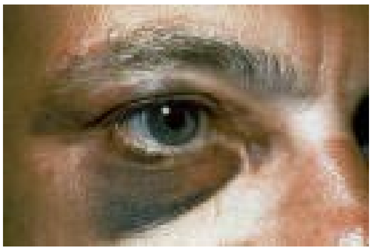
Simple tears of the skin of the lateral upper lid are common, caused by a blow to the lateral brow. Oriented transversely, they fit into the skin folds and the edges come together as swelling decreases. They usually don't need suture.

More severe lacerations of the lids should be inspected carefully, but most can be sutured in an ordinary fashion. If a laceration is jagged and complex, the lid cartilage is damaged, or the lid is torn clear through, clean and irrigate thoroughly. Then put the lid together with a few loose skin sutures, cover and send to a physician.

Lacerations into the nasal corners of the upper and lower lids may cross tear ducts or the small eyelid tendon which requires precise repair. Clean thoroughly, use a few skin sutures, and transport the patient to a physician.

Cuts across the edge of the lid must have the margin sutured exactly together to avoid notching of the lid margin. Use 5-0 or 6-0 suture, or smallest available.

Contusions ("black eye")



Very common from a blow to the eye, brow, lower forehead or upper cheek. Even severely discolored and swollen lids heal quickly. An ice pack for the first few hours may help reduce swelling. If the lids are swollen shut, retract the lid to examine the eyeball for damage. As swelling goes down, check for possible blow-out fracture.

Two black eyes from a severe blow to the skull (with no direct eye injury) may be a sign of a skull fracture. Check for blood behind the ear drum or blood-tinged spinal fluid flowing from ears or nose. If available, antibiotics are desirable to prevent infection within the skull; the medic should check with the supervising doctor.

EYEBALL INJURIES

Lacerations

Simple lacerations with no escape of eyeball contents can usually be sutured by a specialist with good results. Drip IV fluid across the surface of the eye to remove clots and foreign material, but do not irrigate with force. Cover the eye with a soft dressing, avoiding pressure. Place an eye shield over the dressing to prevent pressure on the eyeball.(Cut bottom off a paper cup.)

Lacerations with eye contents escaping are much more serious and should be repaired as soon as possible by a specialist. There may be loss of vision. Clean and dress as above.

Puncture wounds

Those due to pointed objects usually cause the patient to know or suspect his injury and seek examination. The wound may be obvious, or hard to spot if caused by a fine-pointed object (e.g. thorn). Look carefully where the patient states he feels the injury, but also inspect the entire eye. Check and record vision in both eyes (good eye for comparison to injured eye). Diminished vision may be a clue to the injury, but tears and blurring may make the exam unreliable. Repeat later.

Those due to small projectiles may be very hard to spot, a good reason to continually emphasize protective goggles and face shields while hammering, chipping, or grinding. Small metallic fragments may attain high velocity for a short distance and penetrate to the eye's interior, leaving little or no wound on the surface. These may be very hard to remove in surgery, especially if they are non-magnetic. Later, infection or inflammatory reaction may cause blindness.

Tips in spotting an injury:

There may be a corresponding injury to the eyelid - since the eye may have been open or closed, look along a vertical line under the eyelid injury.

Penetration through the sclera may show as a cut in the overlying conjunctiva, seen as a disruption in the light reflection off the surface.

Penetration through the scleral conjunctiva may sever a conjunctival vessel, causing subconjunctival hemorrhage ("flame" hemorrhage).

Penetration through the sclera with the axis of the object across the scleral fibers may show an obvious defect as the fibers retract; parallel to fibers, a penetration may leave little or no trace.

Penetration trough the transparent cornea or lens may cause a defect resembling a crack in an ice cube.

Penetration trough the iris may cause a blood clot on the iris, a hole in the iris, or a misshaped or notched pupil.

Penetration anywhere around the iris, pupil or cornea may result in blood in the anterior chamber (hyphema).

given a suitable accident (steel-on-steel) and evidence of a wound on the surface of the eye, consult with the supervising doctor regarding possible transport to get an X-ray of the eye socket.

Hyphema — (blood in the anterior chamber)

May be due to a penetrating wound, but more usually due to a blow or other blunt trauma.

Right after the injury, the area between the cornea and iris looks bloody; later, the blood cells settle, giving a red bottom layer with clear fluid above.

The main complication is blood cells clogging the drainage channels of the eye, causing a type of glaucoma. Since the first episode of bleeding usually stops, the goal is to prevent further bleeding.

Treatment of the patient:

The patient should be carried to bed if possible, handled gently, avoiding all bumping or bouncing.

Prop in bed with pillows, head and shoulders up 30-45° from horizontal.

Patch both eyes, uncovering good eye only when necessary to eat or to prevent panic. The patient can be led to the bathroom.

The patient must avoid coughing, sneezing, or straining with bowel movements as increasing abdominal pressure increases pressure in the head and perhaps more bleeding (if necessary, give a laxative).

The question of when to transport is a judgment call, balancing the desire to avoid all unnecessary handling right after the accident versus the need for a specialist's examination as soon as possible. The decision depends on the location, distance to a specialist, and the transport available.

If a physician's advice is not available, a suggested compromise: if the patient and injury are stable, hold for 4-5 days, or better for one week if there is no further bleeding. This allows solid clots to form and hopefully decreases the chances for further bleeding during transport; if further bleeding occurs sooner, despite all care, transport as soon as possible, no matter what the distance.

Detached retina

Occurs spontaneously in older patients (50+ years), sometimes in young adults, and also as the result of blunt trauma to the eye; the retina pulls away from the back of the eye like wallpaper peeling off a wall.

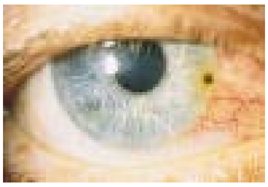
Symptom is the loss of a portion of the field of vision, often compared to a dark curtain across the visual field.

Through an ophthalmoscope, the detached portion of the retina may appear like a cloud hanging in the back of the eye.

The patient should be transported to an eye surgeon at the soonest opportunity. The chance to restore vision is good with surgery, but almost all will go blind without.

Spontaneous or traumatic bleeding in the back of the eye (vitreous haemorrhage) is less common, but serious. The symptoms are similar but the prospects are much worse.

Corneal foreign body



A very common injury, especially around welding.

Anaesthetize the surface of the eye and use magnification if available. The object is usually best seen from an angle and/or with light shining across the eye. Have the patient look at a distant or overhead point.

Dislodge the foreign body by directing a stream of irrigating solution, wiping away with a small loop of monofilament nylon or the moistened end of a cotton-tipped applicator.

The bevel (not the point) of an 18 g. needle may be used in a light, sidewise scraping motion. Steady the hand on the table or the patient's cheek.

Iron or steel particles can sometimes be removed with a small magnet.

If a foreign body is present for 24-48 hours, a white halo forms around the particle, but goes away gradually after removal. This is not a cause for concern.

After removal, apply antibiotic ointment and patch the eye overnight; usually heals in 12-36 hours.

If unable to remove, apply ointment and patch, evacuate on the next routine flight. An emergency flight is seldom necessary. Give pain medication if needed.

Corneal abrasion

Very common, frequently occurs from rubbing the eye to remove a foreign body. Sometimes occurs from blinking with a foreign body caught inside the upper lid, scratching the cornea.

Anaesthetize the eye first and inspect for a foreign body on the cornea or under the lids.

The abrasion can sometimes be seen by moving a light reflection across the surface of the cornea. It is much easier to see by staining with fluoroscein, causing the abrasion to appear yellow-green.

Do not let the patient self-administer anesthetic drops; the effectiveness drops off quickly and may interfere with healing.

Apply ointment and patch. These will usually heal in 24-48 hours. Inspect daily until the abrasion is no longer visible and the eye feels normal.

NOTE: Pain or irritation of the cornea from an abrasion or removal of a foreign body is often helped by cooling the eye. After patching, place an ice cube in a plastic bag and hold against the outside of the patch; as the cold penetrates, the eye usually feels better. Discomfort is usually much better in 3-6 hours anyway.

Welder's burn (ultraviolet Keratitis)

A common injury from an unshielded exposure to the welder's arc with the onset of pain and burning about 12 hours later.

Patch both eyes, or have the patient lie quietly in a dark room; sedation or pain killers may help.

Mild cases heal in 8-24 hours, more severe in 24-36 hours.

Subconjunctival hemorrhage ("flame" hemorrhage)

Rupture of the fine vessels in the loose scleral conjunctiva causing a thin layer of blood under the conjunctiva.

May be due to mild trauma (rubbing the eyes) or a blow to the eye, frequently is due to coughing or vomiting.

Looks serious, but is not; heals without treatment.

Blow-out fracture

Actually not an injury of the eyeball, rather an injury to the floor of the eye socket (orbit).

A blow to the eye with a sudden pressure build-up in the eye socket leads to rupture of the thin boney floor downward into the sinus cavity in the cheek (maxillary sinus).

The eye may appear sunken, or sit low in the orbit; the pupils are not level.

The eye muscles under the eyeball may be trapped in the damaged area, preventing the eye from rolling upward; the patient has double vision on upward gaze and the eyes do not move equally.

This is not a true emergency, but usually requires surgery; the patient should see a specialist within 3-4 days if possible.

Chemical injuries

A time-honored rule of thumb: flood the eye for 5 minutes by the clock; use an eye wash or IV fluid, tap water or any clean liquid.

Most such injuries are only irritation, causing simple redness and tears temporarily; observe the eye at intervals until improvement is obvious.

If the cornea looks burned or cloudy, cover the eye and evacuate the patient.

Acids : will usually wash away quickly; these look worse than they are.

Alkali : these are hard to remove, tend to burn deep, and are worse than they look.

LIDS INFECTIONS

Orbital cellulitis

Usually begins as an infection of the lid, then spreads to the tissue surrounding the eyeball in the eye socket.

The eyeball may bulge outward and the patient is sick with pain, fever and vomiting.

Can be dangerous, but usually responds well to antibiotics; give in large doses, IV if possible.

Conjunctivitis ("pink eye")

A very common infection of the membrane (conjunctiva) which covers the sclera and folds back to line the inside of the eye-lids; due to virus or bacteria.

Viral conjunctivitis is the milder form, frequently associated with sniffles or scratchy throat. There may be an outbreak among the crew, which is a good tip-off.

The sclera is usually mildly bloodshot, though it may be pronounced; there is less discomfort than would be expected from the appearance, usually being mildly irritated or itchy, rather than painful. Drainage is watery rather than puslike (ignore accumulated matter first thing in the morning).

Often begins in one eye, improves after 2-4 days, only to begin identically in the opposite eye — this is typical of viral.

No treatment is necessary, but eyewash or irrigations are soothing.

Also typical is an enlarged, tender lymph node in front of the ear on the same side (pre-auricular node).

Bacterial conjunctivitis usually causes discomfort restricted to one eye only, with no enlarged pre-auricular node.

The sclera is very bloodshot, drainage is thick and puslike, and the inside of the lower lid is often granular or pebbled in appearance. The eye is painful and tender on the surface.

Apply a warm, moist compress to the eye for 20-30 minutes four times a day; use antibiotic drops several times daily. Usually heals without difficulty.

In the uncertain case, it is reasonable to start antibiotic drops. If a second eye or a tender node develops, stop the medication as it is probably a virus, and antibiotics will not help.

NOTE: Avoid using drops with neomycin if possible, as a certain percentage of the general population is allergic to the medicine. This makes it difficult to tell if the condition is worsening, or if the patient is reacting to the medication.

Sty (hordeolum)

An infection of a gland along the lid margin, a pimple-like area with the lid somewhat red and swollen.

As the infection localises, it will come to a head at the lid margin, or just inside; it will drain spontaneously or it can be opened with the point of a needle.

Apply moist heat and use antibiotic drops several times a day; usually heals in about 48 hours.

Chalazion

Inflammation of a gland in the eyelid, usually a pea-sized knot which is painless or only slightly tender.

If not causing discomfort, it should be left alone to be seen by a doctor at the next routine opportunity.

If tender, treat like a sty with moist heat and antibiotic drops. It will usually subside, but may drain on the inner surface of the lid. It is not a serious condition.

EYEBALL

In the absence of direct injury or puncture, actual infections of the eyeball are uncommon. Infections of the cornea rarely occur (keratitis).

Bacterial keratitis (corneal ulcer)

A very unusual problem, usually an infection which develops after removal of a corneal foreign body. Most commonly heals quickly with treatment but certain bacteria can perforate the cornea in 48 hours, leading to a loss of vision. All will perforate if untreated.

Appears as a grey or bluish-green ulcer on the surface of the cornea.

Use antibiotic cream, ointment, or drops; obtain evaluation by an eye doctor as soon as possible.

Herpes simplex keratitis

More common than the bacterial infection, but still seldom seen.

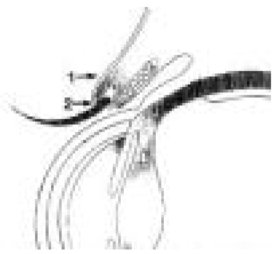
Appears as a gray ulcer having a branched or twisting pattern.

May be associated with a herpes virus infection elsewhere on the face ("fever blister", "cold sore"), or even an ordinary viral respiratory infection.

Should be seen by an eye doctor as soon as possible, as the treatment involves special medication or procedures. If an antibiotic preparation is used in the eye, it must NOT contain cortisone or its derivatives (a common ingredient in eye medications). Cortisone may cause the infection to spread rapidly.

LIDS, DISEASES AND DISORDERS

Blepharitis



An inflammation of the lid margins. The lids are slightly swollen and red with dandruff-like flakes in the lashes.

The patient often has trouble with seborrhoea or severe dandruff.

There may be reddened, flaking skin also in the eyebrows, along the hairline and sideburns, behind the ears and alongside the nose (seborrhoea).

Putting dandruff shampoo on the skin may help, rinsing off after 10-15 minutes; cortisone cream will help.

Contact dermatitis

Frequently caused by irritating chemicals on the cheeks or eyelids (from wiping sweat with hands or gloves); commonly caused by cosmetics in women.

Treat by ceasing contact, wash the skin if necessary, and apply cortisone cream.

EYEBALL, DISEASES AND DISORDERS

Acute glaucoma

Caused by blocked drainage of fluid from the eye, causing pressure in the eye to increase.

Causes pain deep in the eye, not superficial; the patient often feels sick and nauseated.

The cornea may appear opaque or steamy; the pupil is dilated and doesn't react to light. The eyeball feels hard and may look swollen or congested.

A fringe of fine, dilated scleral vessels may lie at the edge of the cornea (ciliary flare or ciliary flush).

An uncommon disorder, but occurs over a period of hours; a true emergency, as permanent loss of vision may begin in 24 hours with blindness in 2-5 days.

Problems that mimic eye pain

Migraine — Usually has a recurring pattern, and the pain is not just in the eye, but also in the forehead and/or temple.

Sinus infection — Has sinus symptoms and nasal drainage.

"**Tension" headache —** This is stress or fatigue-related, and usually starts in the neck and shoulders.

Inspecting for foreign body

On the cornea

These often are hard to see looking directly into the eye, especially with a patient having brown or black eyes.

The foreign body is easier to see looking directly at the eye if a strong penlight is shined obliquely across the cornea.

Lacking a penlight, look obliquely across the cornea, changing position so as to move a light reflection around the surface of the cornea; the foreign body will show in the pool of light.

Under the lid

Foreign bodies beneath the lower lid are seldom a problem and are often removed by the patient himself. Pull the lid downward and have the patient look up, then side to side.

Beneath the upper lid:

Grasp the lashes and pull the lid away from the eyeball. Have the patient look downward and shine a light under the lid.

Grasp the lashes and pull the lid away from the eyeball ; press downward on the middle of the lid with a small object (e.g. cotton-tipped applicator) while lifting upward on the lashes. The lid will turn inside out (evert), allowing inspection of about 2/3 of the inside of the lid.

Using an eyelid retractor or a bent paperclip, lift the eyelid away from the eyeball, lifting perpendicular to the eyeball, not upward toward the eyebrow (it is not painful). Have the patient look downward, then down-left, down-right. This allows inspection of the entire area under the upper lid.

tests of vision

This is important since vision should be checked before and/or after treatment of almost any eye injury and compared with the vision in the opposite eye. Check again on follow-up visits, as tears and blinking often cause blurred vision on the first visit.

Eye charts

Standard is the Snellen Chart but charts using pictures instead of letters are available also.

The patient stands 20 feet (6 meters) away. Have good light on the chart without a glare.

One eye is covered with a cupped hand; do not have pressure on the eyeball, as this blurs the vision.

The patient's vision is the smallest line on which he can identify at least half oft he characters.

Simple tests

The following can be done ifa chart is not available, or the patient's vision is very limited. A comparison is made with the uninjured eye and with the medic's (or other person's) normal vision.

Different sized print: using a magazine or newspaper, have the patient read this and record the approximate distance.

Counting fingers: show the patient different combinations and record the distance.

Seeing motion: move a hand or fingers and have the patient state if it is still or moving.

Light or dark: with the patient in a dim room, open the door or turn on a light and have the patient state when this is done.

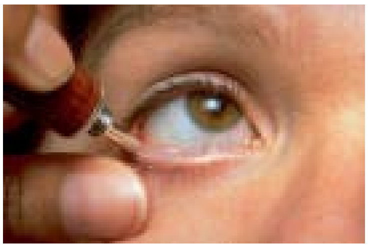
Using eye drops or ointement

The patient will usually avoid letting anything touch his cornea by closing his eye.

Eye drops

If the patient is lying down, have him close the eye gently, then place one drop in the nasal corner of the eye. Open the eye and the drop will flow into the eye.

If the patient is sitting or standing, tilt his head backward a bit. Pulling down slightly on the lower lid creates a cuplike pouch; have him look upward, place a drop in the pouch, then close the eye momentarily.



The eye holds only one drop, more will just run out.

Ointment

Pull the lower lid down and run a trail of ointment from side to side. Close the lids and let the lashes stick together.

Dressing the eye

Build up the dressing sufficiently to fill the eyesocket (orbit) and put slight pressure on the eye to hold the lid closed. Use an oval eye pad, gauze, or cotton. Tape firmly from forehead to cheek. However, with eyeball trauma, avoid pressure on the eye. Place a loose dressing over the eye and tape an oval shield of cardboard or plastic from the brow to the cheek. Perforated oval aluminium shields are made for this purpose; the bottom of a cardboard or plastic cup will also work.

LESSON 7_04 MEDICAL RECORD KEEPING § LIAISON WITH MEDICAL SERVICES

Part 1

ESSENTIAL INFORMATION FOR TRANSMISSION
ASHORE IN EVENT OF AN EMERGENCY

Part 1 Section A

GENERAL INFORMATION

1 Patient surname: Christian Name:

2 Company:

3 Worksite:

4 Date of incident: Time:

5 Type of incident:

6 Is the general condition of the patient:

Good	☐
Fair	☐
Critical	☐

Part 1 Section B

INFORMATION ABOUT THE DIVE RELATED TO THE INCIDENT (If the illness or injury is not related to diving, skip to Section E)

7 Method

Scuba	☐	Bell bounce	☐
Surface supplied	☐	Saturation	☐
Wet bell	☐		

8 BREATHING MIXTURE:

Air	☐	Nitrox	☐
Heliox	☐	Trimix	☐

9 Job:

Diver	☐	Other	☐
Bellman	☐	(Specify : …………... ………..)	

10 WORKING DEPTH: METRES

11 BELL DEPTH (WHERE RELEVANT): METRES

12 STORAGE DEPTH (WHERE RELEVANT): METRES

13 **TIME SPENT AT WORKING DEPTH:** **MINUTES**

14 **DECOMPRESSION TABLE SELECTED:**

Depth selected	________________ metres
Bottom time selected	________________ metres
Surface interval selected (repetitive dives)	_______ hrs______ minutes

15 Type of work performed: ____

____

____

____

16 Adverse conditions, if any: (e.g. sea state, tidal stream, temperature, fouling, disorderly ascent, hard work, etc.)

____

____

17 **DID THE INCIDENT BEGIN:**

in the water	☐	in the deck chamber	☐
in the bell	☐	other?	☐
		(specify: ______________________)	

18 At the time of onset of symptoms, was the patient:

descending	☐	ascending	☐
on the bottom	☐	on the surface	☐

Part 1 Section C

COMPRESSION/DECOMPRESSION INCIDENT (If the incident is not related to a change in pressure, skip to Section E)

19 Incident during or immediately following compression	YES	NO
20 Incident during normal decompression:	YES	NO
21 Incident after surfacing following normal decompression	YES	NO

END OF DECOMPRESSION AT **HRS** **MINS**

22 Incident following excursion from saturation:	YES	NO

TIME OF OUTSET AFTER DECOMPRESSION HRS MIN.

23 Incident following blow-up/drop in pressure	YES	NO

FROM DEPTH METRES; TIME HRS MINS

TO DEPTH METRES; TIME HRS MINS

24 IN OTHER CIRCUMSTANCES

Specify:____

____

____

____

25 ONSET OF FIRST SYMPTOM AT: TIME HRS MINS

DEPTH METRES

26 Niggles	YES	NO
27 Pain in joints	YES	NO
(state location:)		
28 Pain in muscles	YES	NO
(state location:)		
29 Pins and needles	YES	NO
(state location:)		
30 Patches of numbness or tingling, or altered sensation	YES	NO
(state location:)		
31 Muscle weakness or paralysis	YES	NO
(state location:)		
32 Difficulty in urinating	YES	NO
33 Pain in the lumbar region, around waist, or in the abdomen	YES	NO
34 Standing upright difficult or impossible	YES	NO
35 Nausea	YES	NO
36 Vomiting	YES	NO
37 Vertigo, loss of balance	YES	NO

38 Deafness, hearing problems	YES	NO
39 Speech problems	YES	NO
40 Visual problems	YES	NO
41 Drowsiness, confusion (Specify: ________________________________)	YES	NO
42 Loss of consciousness	YES	NO
43 Paleness, anxiety, sweating, collapse (Specify: ________________________________)	YES	NO
44 Cyanosis, blue skin	YES	NO
45 Breathlessness, painful breathing, chokes (Specify: ________________________________)	YES	NO
46 Blood-stained troth in airways	YES	NO
47 Respiratory distress worsening with decompression	YES	NO
48 Others (specify below:)	YES	NO

____

____

Part 1 Section D

PREVIOUS DIVE
(If ended less than 24 hrs before the accident)
49 Method:

Scuba	☐	Bell bounce	☐
Surface supplied	☐	Saturation	☐
Wet bell	☐	Excursion from saturation	

50 Breathing mixture:

Air	☐	Nitrox	☐
Heliox	☐	Trimix	☐

51 DEPTH: METRES

52 BOTTOM TIME (WHERE RELEVANT): MINUTES

53 TABLE SELECTED:

Depth selected ________________ metres

Time selected ________________ metres

54 Normal decompression: YES NO

55 END OF DECOMPRESSION:

DAY TIME. HRS MINS

56 IF SATURATION, BACK TO STORAGE DEPTH FROM LAST WORKING DIVE:

DAY / TIME HRS MINS

Part 1 Section E

ACCIDENT OR ILLNESS NOT RELATED TO DECOMPRESSION

57 NATURE OF ACCIDENT OR ILLNESS:

58 Does he have difficulty or pain with breathing?	YES	NO
59 Is he bleeding?	YES	NO
60 If yes, is bleeding controlled?	YES	NO

61 STATE OF CONSCIOUSNESS:

Fully alert and orientated	YES	NO
Drowsy	YES	NO
Confused	YES	NO
Unconscious but responds to stimuli	YES	NO
UNCONSCIOUS AND UNRESPONSIVE	YES	NO

62 DETAIL SYMPTOMS:

63 TREATMENT GIVEN:

Part 2

ADDITIONAL INFORMATION FOR RECORD PURPOSES

N. B. Do NOT delay transmission of Part 1 in order to complete this part of the Form

Part 2 Section A

GENERAL INFORMATION

1 Name of patient: ______________________________

2 Date of birth: ______________________________

3 Date of last medical examination: ______________________________

4 Where medical records are held: ______________________________

____

5 Details of previous decompression sickness: ______________________________

____

____

____

____

6 Any significant past or recent medical history: ______________________________

____

____

____

7 Name of diving supervisor: ______________________________

8 Name of medical attendant: ______________________________

9 Time of transmission of Part 1: ______________ GMT ______________ Date

10 Addressee: ______________________________

____

11 Copied to: ______________________________

____

12 Telex confirmation sent at: ______________ GMT ______________ Date

13 Time message acknowledged: ______________ GMT ______________ Date

14 Reason for contacting shore doctor:

Assistance required urgently	☐
Assistance required as soon as possible	☐
Assistance required when practicable	☐
Assistance required when patient gets ashore	☐
For information only	☐

Part 2 Section B

Brief statement of the problem: ____

____

____

____

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____

Part 2 Section C

Summary of advice/ instructions received from ashore:______________________________

____

____

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____

Part 2 Section D

Details of treatment given (including therapeutic tables by number as well as depth, duration and gases, and all supplementary therapy). State also times of implementation: ______________________

Part 2 Section E

Record of progress. Summary of history of the condition, with times of significant changes: __________

Part 2 Section F

Final outcome (e.g. fully recovered, transferred ashore under pressure etc.): _____________________

Part 3

RECORD OF MEDICAL EXAMINATION

All or part of this examination may be carried out at the request of the onshore doctor. Results should be recorded in the appropriate section and the questions which are not relevant to the particular incident left blank.

Part 3 Section A

EXAMINATION / GENERAL

1 Is the patient in pain? YES NO

If "yes", describe site, intensity and any factors which exacerbate or relieve it: ______________________

2 Has he any major injury? YES NO

If "yes", name the site and describe briefly. If there is bleeding give an estimate of blood loss: ________

3 What is his temperature? °c

4 Has he any skin rashes? YES NO

If "yes", describe appearance and site: ______________________

Part 3 Section B

CARDIORESPIRATORY SYSTEMS

5 Is his colour:

Normal ☐

Pale ☐

Cyanosed (blue) ☐

6 Is he sweating? YES NO

7 What is his:

(i) pulse ______________________ per minute

(ii) blood pressure __________ Syst. ________ Diast.

(iii) respiratory rate _____________________ per minute

8 Does he have difficulty with breathing? YES NO

9 Does he have pain on breathing? YES NO

If "yes", describe: ____

____

____

____

10 Has he a cough? YES NO

If "yes", has he coughed blood? YES NO

11 Is he short of breath? YES NO

If "yes", has this been affected by:

(i) increase of pressure YES NO

(ii) decrease of pressure YES NO

If so, how? ____

____

____

12 Is the trachea (windpipe) central (i.e. normal)? YES NO

13 Is the apex (cardiac impulse) beat of the heart within 1 " of the mid-clavicular line? YES NO

14 Are breath sounds audible equally on both sides of the chest? YES NO

15 Is there any subcutaneous emphysema (crackling sensation in tissues)? YES NO

Part 3 Section C

ABDOMEN

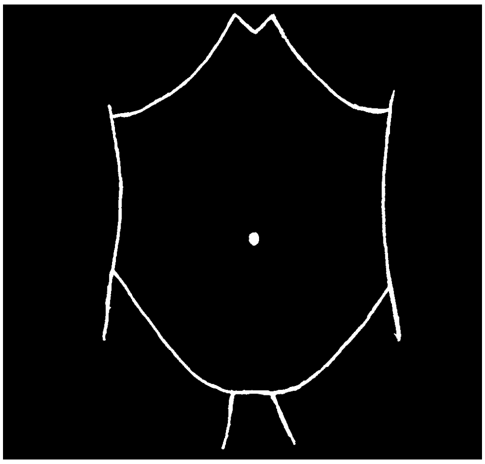
16 Does the patient have abdominal pain? YES NO

If 'yes', specify site by writing 16 on chart, and character:______________________________

____

____

____



17 Does the patient have diarrhoea? YES NO

18 Has the patient vomited? YES NO

If"yes": a) When did the patient last vomit? _________ GMT

b) If he is still vomiting, specify frequency and character: ______________________________

____

____

19 Has he vomited blood? YES ☐ NO ☐

20 Can the patient pass urine without difficulty? YES ☐ NO ☐

21 Is the urine clear ☐ blood stained ☐

22 Is urinating painful? YES ☐ NO ☐

23 Is the abdomen soft to palpation? YES ☐ NO ☐

If "no", specify the site by writing 23 on chart

24 Are there any swellings in the abdomen? YES ☐ NO ☐

If 'yes', describe site (by writing 24 on chart), size and consistency ______________________

____

____

25 Can you hear bowel sounds? YES ☐ NO ☐

Part 3 Section D

NERVOUS SYSTEM

26 Has he any visual disturbance? YES ☐ NO ☐

If"yes", specify: ____

____

____

____

27 Has he a headache? YES ☐ NO ☐

28 State of consciousness:

Fully alert and orientated ☐

Confused ☐

Drowsy ☐

Unconscious but responds to stimuli ☐

Unconscious and unresponsive ☐

29 Are pupils normal and equal in response to light? YES ☐ NO ☐

If “no”, amplify: ____

____

____

30 Is the corneal (blink) reflex normal?	YES	NO
31 Does the patient have vertigo (dizziness)?	YES	NO
32 Does the patient have nystagmus (eye flickering)?	YES	NO
33 Is hearing equal and normal in both ears?	YES	NO

If 'no', specify: ____

____

____

____

34 Are the remainder of the cranial nerves normal?

Eye movements	YES	NO	Facial movement	YES	NO
Swallowing reflex	YES	NO	Soft palate movement	YES	NO
Facial sensation	YES	NO	Shrugging of shoulders	YES	NO
Tongue movement	YES	NO			

35 Can the patient voluntarily move his:

R. Shoulder	YES	NO	L. Shoulder	YES	NO
R. Elbow	YES	NO	L. Elbow	YES	NO
R. Wrist	YES	NO	L. Wrist	YES	NO
R. Fingers	YES	NO	L. Fingers	YES	NO
R. Hip	YES	NO	L. Hip	YES	NO
R. Knee	YES	NO	L. Knee	YES	NO
R. Ankle	YES	NO	L. Ankle	YES	NO
R. Toes	YES	NO	L. Toes	YES	NO
36 Has he any weakness?	YES	NO			

If “yes”, specify: ____

____

____

____

____

37 Are reflexes (tendon jerks):

		Normal	Increased	Absent	?
Triceps	R.				
	L				
Biceps	R				
	L				
Knee	R				
	L				
Ankle	R				
	L				

38 Is the plantar response:

	↑ R			↑ L
or	↓ R			↓ L
Or not clear	R			L

39 Does he have `pins and needles'? YES NO

If 'no', specify: ______________________________

____

____

40 Is there a normal sensory response to pinprick? YES NO

If 'no', specify: ______________________________

____

____

Can you detect a level of sensory change? YES NO

41 Can he pass urine? YES NO

Part 3 Section E

ANY OTHER RELEVANT FINDINGS NOT LISTED ABOVE:

____

____

____

LESSON 7_05 USE OF MEDICAL EQUIPMENT TO BE HELD AT THE SITE OF AN OFFSHORE DIVING OPERATION

Commercial diving operations include both surface supplied and saturation diving operations and cover a wide range of work activities. Appropriate medical equipment to be held at any particular site is best determined by an occupational health service with special knowledge of commercial diving operations. This list is designed to provide guidance where such advice is not available. It is recognised that in certain circumstances similar or greater facilities may be available from other sources which are sufficiently close and reliable.

The list covers equipment necessary and suitable for the treatment of diving related disorders on the surface or in a recompression chamber and for other potential problems eg. trauma which may occur during diving operations. The list takes account of situations where the diving operation may be remote from a vessel or installation sickbay and medical services. It includes equipment for use in an immediate first aid situation, equipment and drugs which may be used by personnel with advanced first aid training as well as equipment which would almost certainly only be used by medical staff. Medical staff who attend a casualty at a dive site may not necessarily be able to bring the necessary equipment.

It is anticipated that except in emergency situations, equipment other than that in the bell or chamber first aid kits would be for use by or on the direction of medical staff.

There should be an appropriate system for the control and maintainance of the equipment and responsibility for the equipment should be vested in the Diving Superintendant or vessel Medic. Equipment should be stored in a locked container and appropriately labelled. The diving supervisor must have access to the equipment at all times. Scheduled drugs should be held in a secure double locked container (with vessel medical supplies or installation sickbay). A logbook should be maintained with the equipment in which all use of equipment and drugs is recorded. The equipment should be inspected regularly (at least every three months) to ensure that all items are in working order (eg batteries) and to exchange drugs and other equipment which is nearing the end of its shelf life. These regular inspections should be recorded in the logbook. Consideration should be given to the need for pressure testing mechanical or electrical equipment.

EQUIPMENT TO BE HELD IN A DIVING BELL

1 x Torniquet

1 x Pocket resuscitator (eg.Laerdal pocket mask)

1 x Tuf cut scissors

1 x Large dressing

1 x Role of 1 inch adhesive tape

1 x Hand operated suction pump (eg. Vitalograph)

1 x Suction catheters sizes 12 and 14

3 x Polythene bags

1 x Airway size 4 (eg. Guedel type)

1 x Medium dressing

2 x Triangular bandage

2 x Crepe bandage 3 in

1 x Water tight bag

[(20 x Hyoscine dermal patches for Hyperbaric evacuation chamber (eg. Scopoderm plasters)]

The same equipment should be held in each living chamber of a saturation system, in air diving chambers and in hyperbaric lifeboats. In living chambers a foot or gas powered suction pump may be prefered.

EQUIPMENT TO BE HELD AT THE DIVE SITE

Diagnostic equipment

Pencil torch

Stethoscope

Reflex hammer

Tuning fork (256 Hz)

Tongue depressors

Otoscope (with spare bulb and,batteries)

Thermometer (electronic) - inc low range

Aneroid sphygmomanometer

Tape measure

Pins for testing sensation (eg. Neurotips)

Urine testing strips

Thoracocentecis

Intercostal drain/trocar and drainage kit (eg. Portex type) Heimlich valve

Urinary catheterisation

2 x Urinary catheters sizes 16 and 18 (eg. Foley type)

2 x Catheter spigots

2 x Urethral anaesthetic gel

2 x Urine collection bags

2 x 20m1 sterile water

Dressings

10 x pkts Gauze squares 10 * l0cm

10 x pkts Cotton wool balls

2 x Adhesive bandage 75mm * 3m

2 x Adhesive bandage 25mm * 3m

2 x Large dressing

2 x Medium dressings

2 x Small dressings

2 x Ambulance dressings

6 x Triangular bandages

12 x Safety pins

40 x Adhesive bandages

2 x Crepe bandages Sin

2 x Crepe bandages Gin

2 x Dressing bowls

4 x Eye pads

Sterile supplies general

4 x Universal containers

10 x Alcohol swabs

5 x Gloves (selection of sizes)

4 x Sutures nylon (2/0 and 3/0)

5 x 20ml Syringes

10 x 18g Needles 38mm

6 x Sachets skin disinfectant (eg. Cetrimide solution)

2 x Drapes

4 x Sutures silk (2/0 and 3/0)

5 x 2m1 Syringes

5 x 10ml Syringes

10 x 21g Needles

2 x l8g Needles 90mm

Sterile instruments

2 Spencer Wells forceps 5 inch

1 Spencer Wells forceps 7 inch

1 Scissors fine pointed

1 Forceps fine toothed

1 pr Mosquito forceps

1 Dressing forceps

2 Disposable scalpels

1 Dressing scissors

1 Aneursym needle

Intravenous access

3 Giving sets

4 Butterfly infusion sets 19g

4 Infusion bottle holders

4 iv cannulae 16g

4 iv cannulae 18g

2 long needles (for venting infusion bottles)

Resuscitation

Resuscitator to include reservoir and connection for BIBS gas. (eg. Laerdal type) *

3 resuscitation masks (varied sizes)

Pocket resuscitator with with one way valve. (eg. Laerdal pocket mask)

Laryngoscope and batteries and spare bulb

3 Endotracheal tubes sizes 7, 8 and 9

1 ET tube coupling and mount

Foot operated suction device

2 endotracheal suction catheters

2 Airways sizes 3+4 (eg. Guedel type)

Torniquet

2 wide bore suckers

* Resuscitators may require modification to gas inlet to ensure adequate filling at pressure.

** Consideration may be given to inclusion of a laryngeal mask airway if staff are suitably trained in its use.

Drugs

ANAESTHESIA/ANALGESIA

5 x l0ml 1 % Lignoocaine amps

25 x 500mg Paracetamol tabs

20 x 30mg Dihydrocodeine tabs

20 x 300mg Soluble aspirin tabs (or 100mg pethidine amps **)

5 x l0mg Morphine sulphate amps

2 x lml Naloxone 0.4mg/ml amps

RESUSCITATION

2 x 40mg Frusemide amps

2 x 0.1 % Adrenaline lml amps

2 x 1.2mg Atropine amps

2 x 8mg Dexamethasone amps

2 x 25mg Prochlorperazine amps

5 x 100mg hydrocortisone amps

VARIOUS

2 x l0mg Chlorpheniramine amps

2 x 50mg Chlorpromazine amps

5 x l0mg Diazepam amps

10 x 5mg Diazepam tablets

1 tube Silver Sulphadiazine cream 1 %

1 x 200 ml 8.4 % Sodium bicarbonate

6 x 500m1 Normal saline

20 x 250mg Amoxycillin tabs

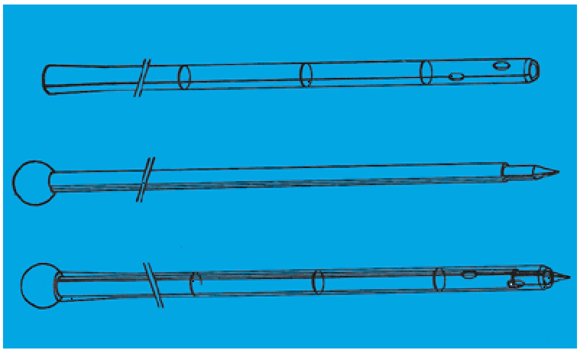
20 x 250mg Erythromycin tabs

1 x bottles antibiotic ear drops

2 x l0mg Diazepam (rectal)

LESSON 7_06 INSERTION OF PLEURAL DRAINS

The safest way to eliminate a pneumothorax and re-expand the lung is through use of pressure and oxygen. If this is not possible, try to leave the diver at a comfortable depth and await the doctor. Thoracentesis to evacuate air is safe, but it is only reasonable to do this if a diver must be brought up for some reason or if the diver develops a tension pneumothorax with no change in depth.



SIMPLEST WAY (simple puncture)

do this at a depth where the diver is having some difficulty breathing but is not in distress.

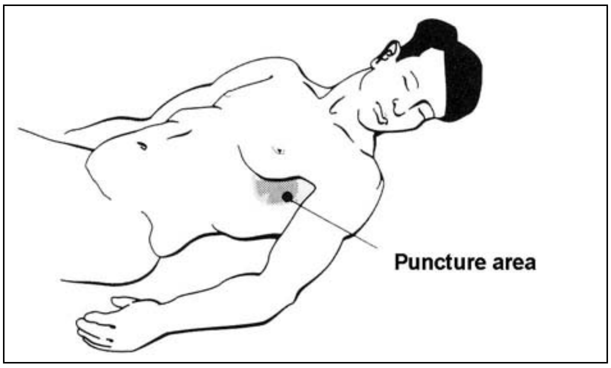
1. Prepare the skin area at the level of the nipple in the triangular space between the front of the arm and the side of the pectoral muscle where the ribs are easy to feel. Wash the skin with soap, then paint with disinfectant.
2. Make puncture
    a. Use at least a one-inch needle, one and a half to two inch is better. Wear sterile gloves if possible. Use clean, scrubbed hands as a minimum.
    b. Attach the needle to a syringe full of sterile water or saline.
    c. Push the needle through the skin, aiming at the upper part of a rib, just below the top edge. When the point hits the rib, "walk" the point upward until it just clears the top edge of the rib.
    d. Pull back slightly on the syringe plunger, creating some suction on the needle. With one hand holding the syringe and plunger, the other the needle, advance the needle over the top of the rib, directly into the chest.
    e. When the tip of the needle just enters the chest bubbles will appear in the syringe. If the diver feels sharp pain and no bubbles appear, the pneumothorax is on the other side.
    f. If bubbles appear, tell the diver to stop breathing at mid-cycle, neither inhaled nor exhaled. Hold the needle firmly with one hand to keep the same depth of penetration, then detach the syringe. Air under pressure will escape through the needle. When the sound of air dies down, quickly withdraw the needle. Tell the diver to breathe.
3. This will not relieve the entire pneumothorax, but will make the diver more comfortable and allow further decompression. It can be repeated as necessary. Remember that long holds on air are possible at 100 feet and essentially indefinitely at 60-80 feet.
4. If the situation is critical, and the diver cannot be immediately recompressed, quickly insert only a needle through both sides of the chest (there may be a pneumothorax on both sides).

If there is no pneumothorax on one side, a simple needle puncture will not harm the lung. Take care not to move the needle tip sideways-only straight in and straight out.

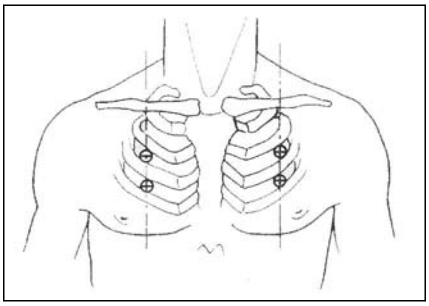
ANOTHER WAY (IV catheter and one-way valve)

This will allow full decompression, but is not as simple as an ordinary puncture.

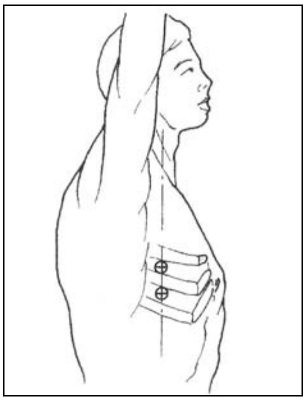
1. Use the same site and skin preparation as above.
2. Cut off the last six inches of some IV tubing, keeping the end that plugs into the needle. Keep this six-inch segment with the male fitting, discard the rest.
3. Cut off the finger of a rubber glove and cut a small hole in the fingertip.
4. Place the cut end of the tube segment (opposite end from the male fitting) just into the hole in the glove fingertip. Fasten the fingertip around the end of the tubing with string, suture, rubber band, etc. Set this aside for a moment.
5. As above, use a needle and fluid-filled syringe to ensure that there is free air in the chest. If not, test the opposite side. As a refinement, the fluid used can be lidocaine or other local anesthetic. As the needle is advanced through the chest wall, lidocaine can be injected in advance of the needle tip, then the piston can be pulled back to check for air. The lidocaine will make the later punctures less painful.
6. Have the patient stop breathing in mid-position. Using an IV catheter-over-needle (14 or 16 gauge), make a puncture in the same area as tested, passing just over the top of a rib. Assuming the victim is lying on his back, start with the point and needle catheter horizontal and perpendicular to the skin, stretching the skin with fingers of the opposite hand to ease the puncture. After the point is just through the skin, raise the hub to 45° from horizontal, so that the point is directed approximately toward the shoulder blade on the same side. This is so the catheter will penetrate the chest wall diagonally and lie flat against the inside chest wall when the lung expands. If the catheter is put in perpendicular, the expanding lung will cause a right-angle bend, kinking the catheter.
7. Once the point is through the chest wall,pull the needle back until it is just inside the tip of the catheter and advance both until the hub touches the skin. Withdraw the needle from the catheter and connect the IV tubing-glove finger to the catheter hub. Allow the patient to breathe. Suture the catheter hub to the skin, if possible. Place a small amount of antibiotic cream or ointment at the puncture site. Cover with a protective dressing.
8. As the lung re-expands, air will be seen passing through the glove finger. After re-expansion, there will usually not be much more air, as the leak in the lung normally seals quickly. When the patient inhales, slight suction may be noticeable on the glove finger. If the catheter is thought to be plugged, have the patient stop breathing, detach the tubing from the catheter hub and inject 1-2 cc of air from an empty syringe to clear the catheter.



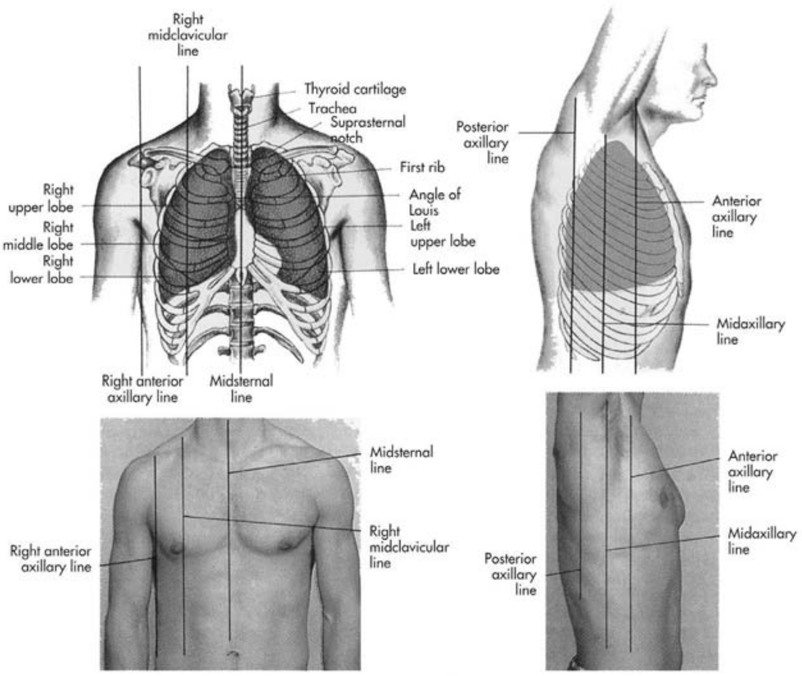
Puncture area is at about nipple level, between front of arm and side of pectoral muscle.



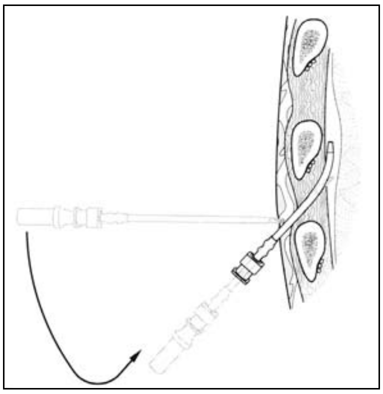
The anterior insertion point (2 and 3 rib space) on midclavicular line



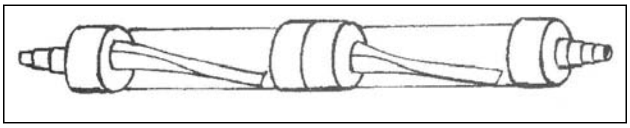
The lateral insertion point (4 and 5 rib space) on anterior axillary line.



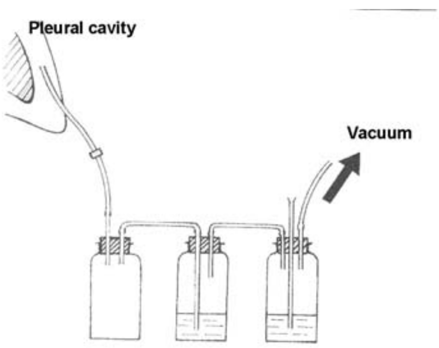
Thoracic landmarks. **A,** Anterior thorax. **B,** Right lateral thorax. (From Seidel H: *Mosby's guide to physical examination*, ed 2, St Louis, 1991, Mosby.



After point pierces skin, just over the top of a rib, catheterneedle is swung so chest wall is penetrated diagonally. Needle is removed. When lung re-expands, catheter lies against chest wall and does not kink.



The HEIMLICH valve is a double one-way valve



A vaccum system must be adapted at the end.

LESSON 7_07 SUTURING

Introduction

First consider: Is suturing necessary?

close with skin tapes: clean the skin and paint with benzoin which will dry sticky. Put tape on one side, press the edges together, and press the tape on the opposite side. Cover with a dressing.

do not suture deeper than the subcutaneous fat unless you are very experienced. If a cut or laceration extends deeper than the fat, pack sterile gauze to the bottom of the wound. Change every day allowing healing from the bottom upward.

do not suture a wound of doubtful cleanliness. If unable to clean thoroughly, pack with gauze and change twice a day. Closing up a contaminated wound guarantees infection. Packed open, the infection will usually drain into the dressing. Give antibiotics. If infection does not occur, then the wound can still be sutured in 5 days.

it is usually best to do no (or minimal) suturing on jagged or complex lacerations. Concentrate on cleaning the wound. Wounds always look worse fresh than after healing. Most scars can be made acceptable with plastic surgery. (Exception: wounds on the face should be closed as well as circumstances permit.)

Rules for suturing:

a) to avoid dead space, suture in two layers if necessary (subcutaneous fat, then skin).

b) use absorbable suture for subcutaneous fat (plain or chromic catgut) and non-absorbable for skin (nylon, silk).

c)remove sutures in 7-10 days, on the face in 5 days. Some redness along the wound edges and around the suture is part of the normal healing reaction. If redness is increasing, with heat and pain, remove the sutures, even if the wound reopens. Start antibiotics.

d) place sutures near the wound edges (2-3 mm. back) and snug the suture down until the wound edges just touch.

e) it is better to suture a little loose than too tight, as wounds swell and sutures will tighten.

f) do not take deep, blind bites with the needle; the needle point should be visible passing across the wound.

Types of suture

There are literally pages and pages of different types of stitches; the medic will do very well if he masters the simple stitch, using more than one layer if necessary. Others may be learned as opportunity and experience permit.

- **interrupted**: tie and cut each stitch individually.

- **running**: tied only at the ends.
- **simple** (through-and-through) suture: best to use whenever possible; a two layer closure is only one row of simple sutures over another. The needle path goes slightly farther from the wound edge deep than it does at the surface. This causes the skin edges to fold outward slightly, desirable for best healing.
- **vertical mattress**: often holds the skin edges better than a deep single-layer closure where the cut is too shallow for a two layer closure. Do not pull too tight, as the suture tends to sink into the skin and is hard to remove.
- **corner stitch**: for " V" shaped lacerations. Use at the tip of the cut, use simple sutures elsewhere. The stitch passes through the tip (under the skin), with the tip being pulled into place as the stitch is snugged down.
- **blanket stitch**: (running lock): good for scalp and other cuts with freely bleeding edges. The interlocking stitches will snug down and stop the bleeding.
- **instrument tie**: the easiest way to tie a square knot when suturing. The long end of the suture is looped around the needle holder. The needle holder then grasps the short end of the suture, protruding from the skin. The loop is pulled off the end of the needle holder, forming the first throw of the knot. The long end of the suture is then again looped around the end of the needle holder, this time in the opposite direction from the first loop, as this is what creates the square knot. The second throw is snugged down on top of the first. Note that one of the throws will require that the hands be crossed as it is snugged down. It is a common practice to put a third throw (a "square knot and a half'), to ensure the knot does not untie.

Bleeding vessels

lidocaine with epinephrine usually stops the bleeding in 5-15 minutes (not used on fingers or toes).

Avoid clamping small skin vessels if possible; sutures will stop the bleeding.

Bleeding is usually controllable with pressure, elevation or both. Even when inadequate, this will usually slow the bleeding, making the bleeding vessel easier to spot. Be patient and apply pressure for ten minutes, by the clock.

Do not clamp blindly, as healthy tissue may be crushed and nerves are found near many arteries. After irrigating the wound thoroughly, release finger pressure slowly to see the site of bleeding. Clamp the end of the artery, including as little other tissue as possible; tie around the artery (square knot), then release the clamp.

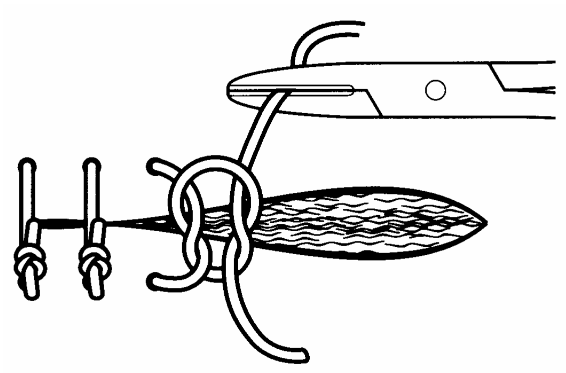


Figure 2 : Interrupted Stitch

each stitch is placed separately and tied with a square knot

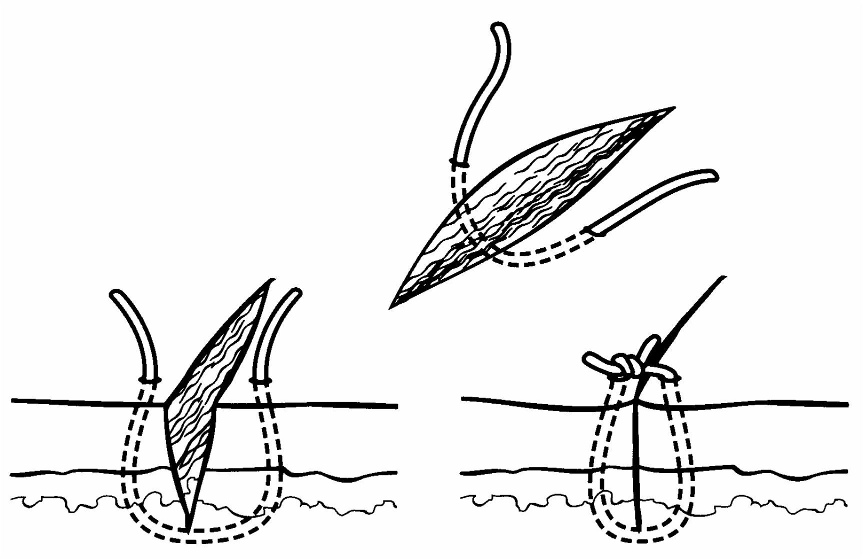


Figure 3 : Simple Stitch

This is used most often. Needle path is slightly wider at the bottom than at skin surface. This causes skin edges to fold outward slightly tying, improving healing.

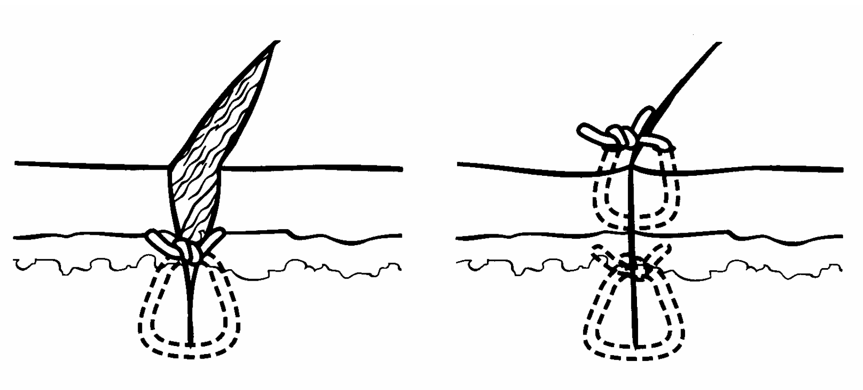


Figure 4 : Two-Layer Closure

Useful for deeper cuts. One simple suture atop another.

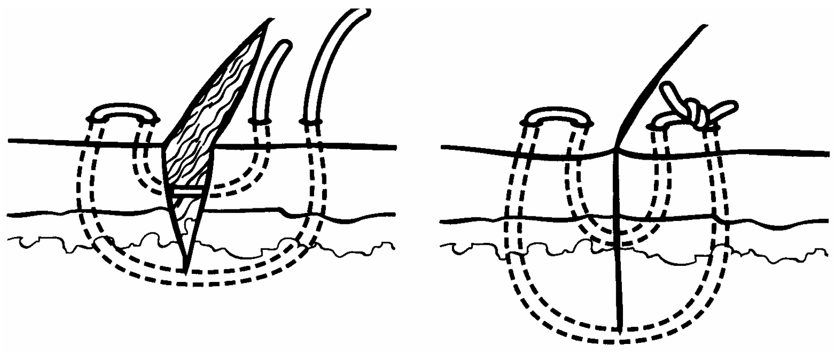


Figure 5 : Vertical Mattress Stitch

Useful for deeper cuts that do not require two-layer closure.

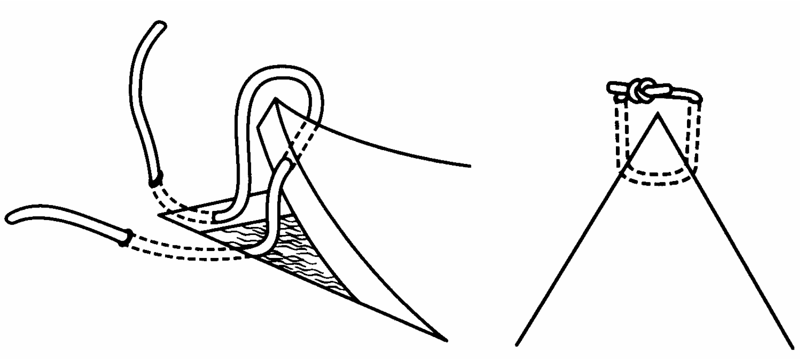


Figure 6 : Corner Stitch

Proper method for sewing the tip of a V-shaped cut; rest of cut is sutured in a normal way.

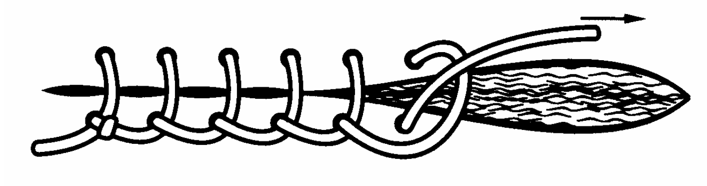
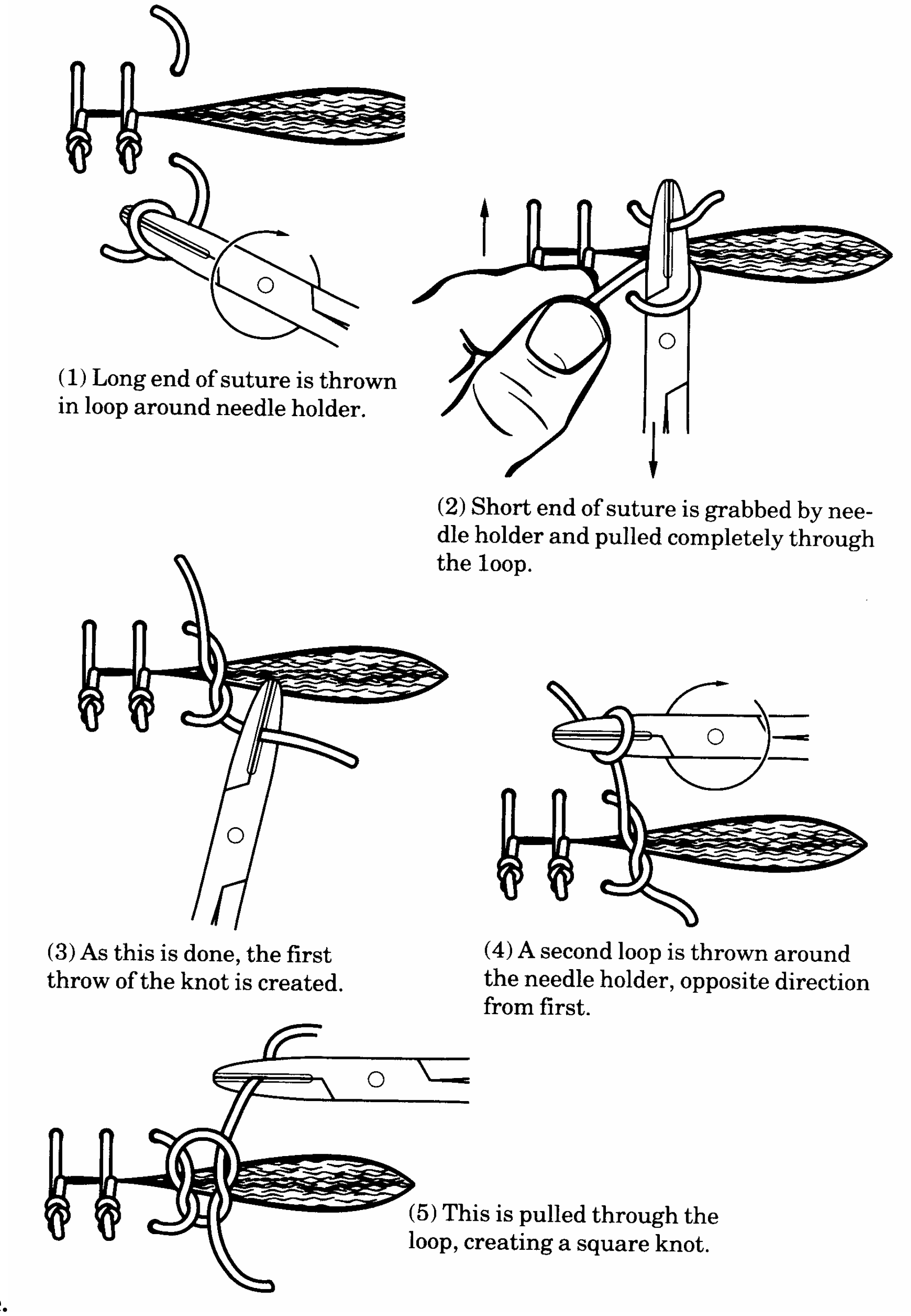


Figure 7 : Blanket Stitch

A running stitch good for bleeding skin edge, especially scalp. Do not use on face or where excessive scar formation is



undesirable.

Figure 8 : Instrument Tie

LESSON 8_01 8_02 DECOMPRESSION ILLNESS INCLUDING PULMONARY BAROTRAUMA AND GAS EMBOLISM

Diving Disorders Requiring Recompression Therapy

This section describes the diagnosis of diving disorders that either require recompression therapy or that may complicate recompression therapy. There are two basic classes of medical emergencies which require treatment by recompression: arterial gas embolism (AGE) and decompression sickness (DCS).

Arterial gas embolism, also called simply gas embolism, may cause rapid deterioration in, which case it must be treated as an extreme emergency. Gas embolism can strike during any dive where underwater breathing equipment is used, even a brief, shallow dive, or one made in a swimming pool. The condition may develop rapidly causing severe symptoms which must be treated quickly. Decompression sickness can be just as serious, but usually develops gradually, even after the completion of a seemingly routine and uneventful dive. However, serious decompression sickness may occur very soon after surfacing and in some cases may be impossible to distinguish from arterial gas embolism. Decompression sickness is not unique to diving. It can affect aviators (altitude bends) or men working in pressure chambers or caissons, but occurs only when decompression (a reduction in the pressure surrounding the body) has taken place.

In the past, treatment of arterial gas embolism was always instituted by direct compression to 165 fsw. Modern experience and research studies have shown that this is not always necessary or desirable. Initial compression to 60 fsw, identical to initial treatment for decompression sickness, will be effective in the majority of cases. Modern research has shown that the symptoms caused by bubbles depend on their ultimate location and not their source. Current treatment recommendations all begin with an initial compression to 60 fsw, with deeper compression depending on the response of the injured individual after initial compression. In order to administer the appropriate recompression treatment, it is necessary to be able to evaluate the stricken diver's initial condition as well as his response to initial therapy. It is also important to understand the causes of arterial gas embolism and decompression sickness as well as other disorders which may accompany or complicate these disorders.

PULMONARY OVERINFLATION SYNDROMES

Pulmonary overinflation syndromes are disorders which are caused by gas expanding within the lung. The disorders encountered in diving are arterial gas embolism, pneumothorax, mediastinal emphysema, and subcutaneous emphysema.

Arterial Gas Embolism

Arterial gas embolism is caused by entry of gas bubbles into the arterial circulation which then act as blood vessel obstructions called emboli. These emboli are frequently the result of pulmonary barotrauma caused by the expansion of gas taken into the lungs while breathing under pressure and held in the lungs during ascent. The gas might have been retained in the lungs by choice (voluntary breathholding) or by accident (blocked air passages). The gas could have become trapped in an obstructed portion of the lung which has been damaged from some previous disease or accident; or the diver, reacting with panic to a difficult situation, may breath-hold without realising it. If there is enough gas, and if it expands sufficiently, the pressure will force gas through the alveolar walls into surrounding tissues and into the bloodstream. If the gas enters the arterial circulation, it will be dispersed to all organs of the body. The organs which are especially susceptible to arterial gas embolism and which are responsible for the life threatening symptoms are the central nervous system (CNS) and heart. In all cases of arterial gas embolism, associated pneumothorax is possible and should not be overlooked.

Arterial gas embolism, if severe, must be diagnosed quickly and correctly. The supply of blood to the central nervous system is almost always involved, and unless treated promptly and properly by recompression, arterial gas embolism is likely to result in death or permanent brain damage. Because the brain is rapidly affected, definite symptoms of arterial gas embolism usually appear within a minute or two after surfacing.

Dramatic and severe symptoms of arterial gas embolism are usually quite evident and require immediate and prompt treatment. As a basic rule, any diver who has obtained a breath of compressed gas from any source at depth, whether from diving apparatus or from a diving bell, and who surfaces and remains unconscious or loses consciousness within ten minutes of reaching the surface, must be assumed to be suffering from arterial gas embolism. Recompression treatment must be started immediately. A diver who surfaces unconscious and recovers when exposed to fresh air shall receive a neurological evaluation to rule out arterial gas embolism.

Divers surfacing with sensations of tingling or numbness, a sensation of weakness without obvious paralysis, or complaints of difficulty in thinking without obvious confusion, and who are awake or easily arousable, are probably not suffering from a condition which could not await a thorough medical evaluation before beginning recompression. In these cases, there is time to rule out other causes of symptoms by conducting a neurological evaluation. The type and urgency of recompression is dictated by the state of the diver during the initial evaluation.

Other factors to consider in diagnosing arterial gas embolism are:

The onset is usually sudden and dramatic, often occurring within seconds after arrival on the surface or even before reaching the surface. The signs and symptoms may include dizziness, paralysis or weakness in the extremities, large areas of abnormal sensation, blurred vision, or convulsions. During ascent, the diver may have noticed a sensation similar to that of a blow to the chest. The victim may become unconscious without warning and may even stop breathing.

If pain is the only symptom, arterial gas embolism is unlikely and decompression sickness or one of the other pulmonary overinflation syndromes should be considered.

Some symptoms may be masked by environmental factors or by other, less significant, symptoms. A diver who is chilled may not be concerned with numbness in an arm, which may actually be the sign of CNS involvement. Pain from any source may divert attention from other symptoms. The natural anxiety that accompanies an emergency situation, such as the failure of the diver's air supply, might mask a state of confusion caused by an arterial gas embolism to the brain. A diver who is coughing up blood (which could be confused with bloody froth) may be showing signs of ruptured lung tissue, or may have bitten the tongue or experienced sinus or middle ear squeeze.

Administering Advanced Cardiac Life Support (ACLS) in the Embolised Diver

Arterial gas embolism with stable pulse and respiration is termed Category I. Arterial gas embolism with absence of pulse and respiration (cardiopulmonary arrest) is termed Category II arterial gas embolism. Category II patients may require advanced cardiac life support (ACLS). ACLS is a difficult medical procedure which requires immediate availability (within 30 minutes) of ACLS equipment and an ACLS-trained physician or paramedical specialist in contact with a physician. ACLS procedures include diagnosis of abnormal heart rhythms and correction with the administration of drugs and electrical countershock (cardioversion or defibrillation). Many ACLS procedures can be administered while the patient is undergoing recompression but electrical countershock must be conducted at atmospheric pressure. Even the use of a cardiac monitor on a patient under pressure may not always be possible. If the patient is pulseless, then a Diving Medical Officer must decide whether to delay recompression until

ACLS equipment arrives or to begin recompression to a depth of 60 fsw with the patient undergoing Basic Cardiac Life Support (BCLS). If a Diving Medical Officer cannot be reached or is unavailable, compress to 60 feet, continue BCLS, and attempt to contact a Diving Medical Officer. If recompression is begun and the Diving Medical Officer determines that electrical countershock is necessary, the patient is decompressed to the surface at 30 fpm and electrical countershock is performed. The patient is then recompressed to the recompression treatment depth as directed by the Diving Medical Officer.

CAUTION: If the tender is outside of no-decompression limits, he should not be brought directly to the surface. Either take the decompression stops appropriate to the tender or lock in a new tender and decompress the patient leaving the original tender to complete decompression.

Other Pulmonary Overinflation Syndromes

Expanding gas trapped in the lung may enter tissue spaces, causing mediastinal emphysema, subcutaneous emphysema, or pneumothorax. Suspicion of any of these conditions warrants prompt referral to medical personnel to rule out pneumothorax. Administration of 100-percent oxygen on the surface is appropriate initial treatment for all suspected cases. Recompression is not generally required except for cases of tension pneumothorax occurring during ascent.

MEDIASTINAL AND SUBCUTANEOUS EMPHYSEMA

Mediastinal emphysema is caused by gas expanding in the tissues behind the breast bone. Symptoms include mild to moderate pain under the breast bone, often described as a dull ache or feeling of tightness. The pain is made worse with deep inspiration, coughing, or swallowing. The pain may radiate to the shoulder, neck, or back.

Subcutaneous emphysema results from movement of the gas from the mediastinum to the region under the skin of the neck and lower face. It often goes unnoticed by the diver in mild cases. In more severe cases, the diver may experience a feeling of fullness around the neck and may have difficulty in swallowing. The diver's voice may change in pitch. An observer may note a swelling or apparent inflation of the neck. Movement of the skin near the windpipe or about the collar bone may produce a cracking or crunching sound (crepitation).

Treatment of mediastinal or subcutaneous emphysema with mild symptoms consists of breathing 100-percent oxygen at the surface. If symptoms are severe, shallow recompression may be beneficial. Recompression should only be carried out upon the recommendation of a Diving Medical Officer who has ruled out the occurrence of pneumothorax. Recompression is performed with the diver breathing 100-percent oxygen and using the shallowest depth of relief (usually five or ten feet). An hour of breathing oxygen should be sufficient for resolution, but longer stays may be necessary. Decompression will be dictated by the tender's decompression obligation. The appropriate air table should be used but the ascent rate should not exceed one foot per minute. In this specific case the delay in ascent should be included in bottom time, when choosing the proper decompression table.

PNEUMOTHORAX

Pneumothorax is usually accompanied by a sharp pain in the chest, shoulder, or upper back that is aggravated by deep breathing. To minimise this pain, the victim will often breathe in a shallow, rapid manner. The victim may appear pale and exhibit a tendency to bend the chest toward the involved side. If a lung has collapsed, it may be detected by listening to both sides of the chest with the ear or a stethoscope. A completely collapsed lung will not produce audible sounds of breathing. In cases of partial pneumothorax, however, breath sounds may be present and the condition must be suspected on the basis of history and symptoms. In some instances, the damaged lung tissue acts as a one-way valve, allowing gas to enter the chest cavity, but not to leave. Under these circumstances, the size of the pneumothorax increases with each breath. This condition is called tension pneumothorax. In simple pneumothorax, the respiratory distress usually does not get worse after the initial gas leakage out of the lung. In tension pneumothorax, however, the respiratory distress worsens with each breath and can progress rapidly to shock and death if the trapped gas is not vented by insertion of a catheter, chest tube or other device designed to remove gas from the chest cavity.

Mild pneumothorax can be treated by breathing 100-percent oxygen. Cases of pneumothorax which demonstrate cardiorespiratory compromise may require the insertion of a chest tube, large bore intravenous (IV) catheter or other device designed to remove intrathoracic gas. These devices should only be inserted by personnel trained in their use and the use of other accessory devices (one-way valves, underwater suction, etc.) necessary to safely decompress the thoracic cavity. Divers recompressed for treatment of arterial gas embolism or decompression sickness, who a so have a pneumothorax, will experience relief upon recompression. A chest tube or other device and a one-way relief valve may need to be inserted at depth to prevent expansion of the trapped gas during subsequent ascent. If a diver's condition deteriorates rapidly during ascent, especially if the symptoms are respiratory, tension pneumothorax should always be suspected. If a tension pneumothorax is found, recompression to depth of relief is warranted to relieve symptoms until the thoracic cavity can be properly vented. Pneumothorax, if present in combination with arterial gas embolism or decompression sickness, should not prevent immediate recompression therapy. However, a pneumothorax may need to be vented as described above before ascent from treatment depth.

Prevention of Pulmonary Overinflation Syndrome

The potential hazard of the pulmonary overinflation syndromes may be prevented or substantially reduced by careful attention to the following:

Medical selection of diving personnel, with particular attention to elimination of those who show evidence of lung disease or who have a past history of respiratory disorders. Divers who have had a spontaneous pneumothorax have a high incidence of recurrence and should not dive. Divers who have had pneumothorax from other reasons (e.g., surgery, trauma, etc.) should have their fitness for continued diving reviewed by an experienced Diving Medical Officer, in consultation with appropriate respiratory specialists.

Evaluation of the diver's physical condition immediately before a dive. Any impairment of respiration, such as a cold, bronchitis, etc., may be considered as a temporary restriction from diving.

Proper, intensive training in diving physics and physiology for every diver, as well as instruction in the correct use of various diving equipment. Particular attention must be given to the training of SCUBA divers, because SCUBA operations produce a comparatively high incidence of embolism accidents.

A diver must never interrupt breathing during ascent from a dive in which compressed gas has been breathed.

When making an emergency ascent, the diver must exhale continuously. The rate of exhalation must match the rate of ascent. For a free ascent, where the diver uses natural buoyancy to be carried toward the surface, the rate of exhalation must be great enough to prevent embolism, but not so great that the buoyancy factors are cancelled. With a buoyant ascent, where the diver is assisted by an external source of buoyancy such as a life preserver or buoyancy compensator, the rate of ascent may far exceed that of a free ascent. The exhalation must begin before the ascent, and must be a strong, steady forceful exhalation. It is difficult for an untrained diver to execute an emergency ascent properly. It is also often dangerous to train a diver in the proper technique. No ascent training may be conducted unless fully qualified instructors are present, a recompression chamber and Diving Medical Technician are on scene, and a Diving Medical Officer is able to provide an immediate response to an accident. Ascent training is distinctly different from ascent operations as performed by Navy Special Warfare groups. Ascent operations are conducted by qualified divers or combat swimmers. These operations require the supervision of an Ascent Supervisor but operational conditions preclude the use of instructors.

Other factors in the prevention of gas embolism include good planning and adherence to the established dive plan. Trying to extend a dive to finish a task can too easily lead to the exhaustion of the air supply and the need for an emergency ascent. The diver must know and follow good diving practices and keep in good physical condition. The diver must not hesitate to report any illnesses, especially respiratory illnesses such as colds, to the Diving Supervisor or Diving Medical Officer prior to diving.

Decompression Sickness

Decompression sickness results from the formation of bubbles in the blood or body tissues and is caused by inadequate elimination of dissolved gas after a dive or other exposure to high pressure. Decompression sickness may also occur with exposure to subatmospheric pressures (altitude exposure), as in an altitude chamber, or sudden loss of cabin pressure in an aircraft. In certain individuals, decompression sickness may occur from no-decompression dives, or decompression dives even when decompression procedures are followed meticulously. Various conditions in the diver or in his surroundings may cause him to absorb an excessive amount of inert gas or may inhibit the elimination of the dissolved gas during normal controlled decompression. Any decompression sickness that occurs must be treated by recompression. The following paragraphs discuss the diagnosis of the various forms of decompression sickness. Once the correct diagnosis is made, the appropriate treatment can be chosen based on the initial evaluation.

A wide range of symptoms may accompany the initial episode of decompression sickness. The diver may exhibit certain signs that only trained observers will identify as decompression sickness. Some of the symptoms or signs will be so pronounced that there will be little doubt as to the cause. Others may be subtle, and some of the more important signs could be overlooked in a cursory examination.

For purposes of deciding the appropriate treatment, symptoms of decompression sickness are generally divided into two categories. Type I decompression sickness (also called pain-only decompression sickness) includes skin symptoms, lymph node swelling, and joint and/or musde pain and is not life threatening. Type II decompression sickness (also called serious decompression sickness) includes symptoms involving the CNS, respiratory system, or circulatory system. Type II decompression sickness may become life threatening. Because the treatment of Type f and Type fl symptoms is different, it is important to distinguish between these two types of decompression sicknesses. Type f and Type II symptoms may or may not be present at the same time.

Type I Decompression Sickness

Type I decompression sickness includes joint pain (musculoskeletal or pain-only symptoms) and symptoms involving the skin (cutaneous symptoms), or swelling and pain in lymph nodes.

Musculoskeletal Pain-Only Symptoms

The most common symptom of decompression sickness is joint pain. Other types of pain may occur which do not involve joints. The pain may be mild or excruciating. The most common sites of joint pain are the shoulder, elbow, wrist, hand, hip, knee, and ankle. The characteristic pain of Type I decompression sickness usually begins gradually, is slight when first noticed, and may be difficult to localise. It may be located in a joint or muscle, increasing in intensity, and usually described as a deep, dull ache. The pain may or may not be increased by movement of the affected joint and the limb may be held preferentially in certain positions to reduce the pain intensity (so-called guarding). The hallmark of Type I pain is its dull, aching quality and confinement to particular areas. It is always present at rest; it may or may not be made worse with movement. The pain may lessen if local pressure is applied manually or with a blood pressure cuff.

The most difficult differentiation is between the pain of Type I decompression sickness and the pain resulting from a muscle sprain or bruise. If there is any doubt as to the cause of the pain, assume the diver is suffering from decompression sickness and treat accordingly. Frequent pain may mask other more significant symptoms. Pain should not be treated with drugs in an effort to make the patient more comfortable. The pain may be the only way to localise the problem and monitor the progress of treatment.

Pain in the abdominal and thoracic areas may be localised to joints between the ribs and spinal column, joints between the ribs and sternum, present a shooting-type pain that radiates from the back around the body (radicular or girdle pain), or appear as a vague, aching (visceral) pain. Because it is difficult for non-medical personnel to differentiate between the Type I joint pain and Type 11 radicular or visceral pain in the abdominal and thoracic areas, any pain occurring in these regions should be considered by non-medical personnel as arising from spinal cord Involvement. Treat it as Type II decompression sickness, unless it is dearly non-radiating and dearly related to a painful hip or shoulder joint.

Because the treatment of Type I decompression sickness is different from the treatment of Type II decompression sickness, making the distinction between these two categories is important. Musculoskeletal Type I (pain-only) decompression sickness is defined as any extremity joint pain or any non-radiating type of pain or soreness in the extremities. When joint pain occurs, it is not uncommon to have aching pain in the muscles around the joint. Muscle pain may also occur in the back, trunk, or abdominal area in muscles associated with a painful hip or shoulder joint. Any back or trunk pain which cannot be dearly related to a painful hip or shoulder joint, or that radiates down an extremity, should be considered by non-medical personnel as Type 11 decompression sickness and treated as such. Divers with Type I symptoms must be monitored carefully because they may progress to Type II or a previously unrecognised Type II symptom may become apparent.

Cutaneous (Skin) Symptoms

The most common skin manifestation of diving is itching. Itching by itself is generally transient and does not require recompression. Faint skin rashes may be present in conjunction with itching. These rashes also are transient and do not require recompression. Mottling or marbling of the skin, known as cutis marmorata (marbleisation), however, is a symptom of decompression sickness and should be treated by recompression. This condition starts as intense itching, progresses to redness, and then gives way to a patchy, dark bluish discoloration of the skin. The skin may feel thickened. In some cases the rash may be raised.

Lymphatic Symptoms

Lymphatic obstruction may occur, creating localised pain in involved lymph nodes and swelling of the tissues drained by these nodes. Recompression will usually provide prompt relief from pain. The swelling, however, may take longer to resolve completely, and may still be present at the completion of treatment.

Type II Decompression Sickness

In the early stages, symptoms of Type 11 decompression sickness may not be obvious and the stricken diver may consider them inconsequential. The diver may feel fatigued or weak and attribute the condition to overexertion. Even as weakness becomes more severe, the diver may not seek treatment until walking, hearing, or urinating becomes difficult. For this reason, symptoms must be anticipated during the postdive period and treated before they become too severe.

Many of the symptoms of Type II decompression sickness are the same as those of arterial gas embolism, although the time course is generally different. Since the initial treatment of these two conditions is the same and since subsequent treatment conditions are based on the response of the patient to treatment, treatment should not be delayed unnecessarily in order to make the diagnosis in severely ill patients (see initial evaluation).

Type II, or serious symptoms, are divided into neurological and cardiorespiratory symptoms.

Type I symptoms may or may not be present at the same time.

Neurological Symptoms

These symptoms may be the result of involvement of any level of the nervous system. Numbness, tingling, and decreased sensation to touch or paresthesias (tingling, "pins and needles", or "electric sensations"), muscle weakness or paralysis, and mental status or motor performance alterations are the most common symptoms. Vertigo, dizziness, ringing in the ears, and hearing loss can also occur. These symptoms may be difficult to distinguish from a round or oval window rupture. Disturbances of higher brain function may result in personality changes, amnesia, bizarre behaviour, light-headedness, incoordination, and tremors. Lower spinal cord involvement can cause disruption of urinary function. Some of these signs may be subtle and can be overlooked or dismissed by the stricken diver as being of no consequence.

The occurrence of any neurological symptom is abnormal after a dive, and should be considered a symptom of Type II decompression sickness or arterial gas embolism, unless another specific cause can be found. Normal fatigue is not uncommon after long dives and, by itself, is not usually treated as decompression sickness. If the fatigue is unusually severe, however, it is cause to do a complete neurological examination to ensure there is no CNS involvement.

Pulmonary Symptoms

If profuse intravascular bubbling (chokes) occurs, symptoms may develop due to congestion of the lung circulation. Chokes may start as chest pain aggravated by inspiration, and/or as an irritating cough. Increased breathing rate is usually observed. Symptoms of increasing lung congestion may progress to complete circulatory collapse, loss of consciousness, and death if recompression is not instituted immediately.

Time Course of Symptoms

Decompression sickness symptoms usually occur within a short period of time following the dive or other pressure exposure. If the controlled decompression during ascent has been shortened or omitted, the diver could be suffering from decompression sickness before reaching the surface.

In analysing several thousand air dives in a data base set up by the U.S. Navy for developing decompression models, the time of onset of symptoms after surfacing was as follows:

42% occurred within one hour

60% occurred within three hours

83% occurred within eight hours

98% occurred within 24 hours

This time distribution is similar to that observed at the Naval Diving and Salvage Training Center.

If a diver has been completely asymptomatic for 48 hours following a dive, symptoms that begin subsequently are probably not caused by decompression sickness.

While a history of diving (or altitude exposure) is necessary for the diagnosis of decompression sickness to be made, the depth and duration of the dive are useful only in establishing if required decompression was missed.

NOTE : Decompression sickness may occur in divers well within no-decompression limits or who have carefully followed decompression tables.

If the reason for postdive symptoms is firmly established to be due to causes other than decompression sickness or arterial gas embolism (e.g., injury, sprain, poorly fitting equipment), then recompression is not necessary. If qualified medical personnel are not available to rule out the need for recompression, then it should be carried out if any reasonable doubt as to the cause of symptoms exists.

Altitude Decompression Sickness

Aviators exposed to altitude may experience symptoms of decompression sickness similar to those experienced by divers. The only major difference is that symptoms of spinal cord involvement are rarer and symptoms of brain involvement are more frequent in altitude decompression sickness than hyperbaric decompression sickness. Simple pain, however, accounts for the majority of symptoms.

If only joint pain was present but resolved before reaching one ATA from altitude, then the individual may be treated with two hours of 100% oxygen breathing at one atmosphere followed by 24 hours of observation. If symptoms of altitude decompression sickness persist after return to one ATA from altitude, the stricken individual should be transferred to a recompression facility for treatment.

If Type II symptoms were present at any time then treatment should be done, even if symptoms resolve at one ATA.

Individuals should be kept on 100% oxygen during transfer to the recompression facility. Recompression is carried out identically to that for treating decompression sickness for diving. If symptoms have resolved by the time the individual has reached a recompression facility, they should be examined for any residual symptoms. If a Type II symptom had been present at any time or if even the most minor symptom is present they should be treated as if the original symptoms were still present. If no symptoms are found, and it can be confirmed that the only symptoms ever present were joint pain, then a minimum two hour observation period may be carried out at the surface after which the individual can be assumed symptom free.

Initial Evaluation And Patient Response

The goal of recompression therapy is to prevent permanent injury from decompression sickness or arterial gas embolism. While the initial phases of these two diseases are different, the mechanisms by which permanent injury is caused are in many ways similar. Proper application of recompression therapy can abort these mechanisms and in many cases lead to complete resolution of symptoms. Once recompression therapy is begun, choosing the appropriate course to follow will depend mainly on the patient's response to treatment, not the initiating disease. Also, the urgency with which treatment must be initiated will depend on the patient's condition, and less on the cause of the condition.

Initial Evaluation

When a diver is suspected of having decompression sickness or arterial gas embolism, evaluating him for the symptoms described in earlier sections will help establish the diagnosis. However, the length of lime one can delay treatment to establish the diagnosis or the degree of urgency necessary in beginning treatment depends on the patient's condition. The patient's initial condition is categorized by the severity of the symptoms, the organ systems affected, and how symptoms are changing with lime (evolution).

Severity is judged by how much distress or pain the patient is in. Any obvious disorders of consciousness, mental ability, gain, limb movement, respiration, or circulation are severe symptoms.

The organ systems which are considered are the musculoskeletal system, the central nervous system, the inner ear, and the cardio respiratory system (heart and lungs).

The evolution describes how symptoms are changing with time. "Static" means little or no change, e-g- the patient's condition has changed little within the past half hour or so. "Progressive" means that the symptoms are worsening or new symptoms are occurring as time goes on. "Spontaneous improvement" means that symptoms are getting better by themselves and "relapsing" means that symptoms are recurring after having improved substantially for some time.

Based on the severity, organ system, and lime course, three degrees of urgency are defined.

Category A (Emergent):

Symptoms are severe, involve the inner ear, cardio respiratory system or central nervous system and/or are progressive or relapsing.

These individuals are obviously sick. Neurological signs are present and obvious even without an examination. The diver may be unconscious, confused, or have difficulty breathing. initial minor symptoms have progressed to more severe symptoms within a relatively short period of lime, or may have relapsed. Instituting treatment in these individuals should be considered an extreme emergency. Examination of the patient should not delay treatment or transport. Transportation should be arranged by the fastest means available, with the patient level; feet should not be elevated nor the head lowered. Ail available resources should be mobilized to ensure treatment will be obtained as soon as possible.

Category B (Urgent):

The only severe symptom is pain. Other symptoms are not obvious without conducting an examination. Symptoms are static or have progressed slowly over the past few hours. The patient is not in any distress except possibly from joint pain.

The patient will need recompression as soon as it can be arranged but there is time to conduct a full examination before beginning recompression. Emergency transportation will need to be arranged but high speed ambulance rides or commandeering air transport is not necessary. Recompression is not an extreme emergency and should not be started until all normal chamber preparations are completed. Treatment may be delayed up to 15 minutes to await arrival of a Diving Medical officer or supporting medical equipment.

Category C (Timely):

Symptoms are net severe and net obvious without conducting a detailed examination. Any organ system can be affected but the patient is in no distress. Symptoms are static or progressing slowly over a period of hours.

These patients have time for a more complete diagnostic workup before recompression is staffed. In these cases there is time to rule out causes of symptoms which will net require recompression. However, only a Diving Medical Officer may make the decision net to treat Category C patients.

These three categories are net inclusive and at times it may be hard to place someone in a single category. If in doubt, treat as if he were in the more urgent category. Additionally, a patient's category may change. Therefore, careful observation is required for each case irrespective of its category. The purpose of categorizing patients based on the initial evaluation is net to decide whether to treat or how to treat. Its purpose is to provide a rational method of deciding how fast treatment must be started and how much time there is to prepare the chamber and conduct medical examinations. It is inappropriate to institute recompression on Category C patients without having taken the time to do an adequate examination just as it would be indefensible to delay treatment to finish a neurological examination in a Category A patient.

Patient Response. All recompressions now begin with initial compression to 60 fsw. Alter that, decisions are made based on response. "Deterioration" means the patient is in a life threatening situation. "Progressive" means the patient is getting worse. "Stable" means symptoms are largely unchanged. "improving" or "relief" means that the patient reports there is a clear decrease in the number or severity of symptoms. "Significant improvement or relief" means that it is clear to personnel other than the patient that the number and/or severity of symptoms have decreased. Complete relief means that no symptoms are reported by the patient or are detected by examination. Training is required to adequately assess patient response, but it can be conducted by non-medical personnel. However, consultation with a Diving Medical Officer is always desirable.

Management of Diving Accidents

Introduction

In this section, it is assumed the medic is familiar with basic concepts and terminology in diving medicine. For the medic who is not a diver there are courses and publications about diving medicine which are listed in Appendix A. The diving manuals of the U.S. Navy, the U.S. National 0ceanic and Atmospheric Administration (NOAA) and the Royal Navy give much useful information as do the manuals of many major diving contractors.

Some medical problems seen in diving are discussed elsewhere in this course: sinus and ear squeeze, round window rupture, external otitis, and vertigo, pulmonary overpressure and pneumothorax , and pulmonary decompression sickness ("chokes") also in specifics chapters.

DECOMPRESSION SICKNESS (DCS)

GENERAL COMMENTS

A constant feature of DCS is its inconstant nature. Puzzling, inconsistent mixtures of symptoms are common. Never say: "I'm sure it isn't decompression sickness".

The practice of classifying DCS as minor (Type I) or serious (II) is long-standing but can cause misconceptions, the most common being that bends starts as type I and may then develop further into type II. Type I and II DCS are not different stages of bends, but rather different forms of it which present different threats to the diver. Minor symptoms are not warning signs that precede serious ones (such as a sore throat might come before pneumonia). Serious symptoms are often the first sign of DCS. It must always be remembered that DCS is a total-body disease because inadequate decompression is a total-body process. Regardless of his particular symptoms, "minor" or otherwise, a bent diver is sick all over.

FORMS OF DCS

"MINOR" Skin

A common minor symptom is itching in the skin after a short, deep chamber dive, perhaps with a red, pin-point rash around the hair follicles. No treatment is required and it fades in minutes or hours.

Skin changes resembling hives, orange peel skin, or pale skin with a mottled blue pattern (marble skin) are usually treated as a serious symptom because of fear they may represent other abnormalities hidden inside the body. Treatment usually gets rid of local burning and color changes but not oedema or swelling, which takes a few to several days to clear. It is important to examine the diver for other signs of DCS.

Joint pain-usually called a "pain-only" bend.

The shoulder is most commonly affected in divers but any joint of the extremities can be involved. In ordinary diving, the upper extremity joints are more commonly affected than the lower; in saturation diving, the reverse is true.

Pain-only bends involving more than one joint should probably be treated as serious or kept under close observation after treatment as a minimum.

In "classic" bends there is severe pain in multiple areas; the diver may be doubled over and hardly able to walk. "Classic" cases should probably be treated as a serious symptom.

The discomfort of pain-only bends ("pain-only" pain) is an ache in or around a joint; shoulder pain is usually felt deep in the deltoid muscle. It may bc a mild "niggle" that seems to need only stretching or exercise or it may be such an intense ache the diver avoids using the extremity. Most importantly, pain-only pain:

is not a "radiating" pain (pain that shoots up or down an extremity)

is not a burning, electric, stabbing, jolting, or lightning-like pain.

is not associated with muscle weakness or sensory abnormalities, which can only bc detected with a neuro exam (unless the diver conveniently mentions it first).

The correct diagnosis of pain-only bends requires that:

the diver be questioned as to the kind of pain he is having and where he feels it. To accept a diver's simple report of "joint pain" without further investigation is asking for trouble.

a careful neuro exam must be done and there must be no sign of weakness or sensory abnormalities. Since pain demands attention, the diver will often not notice slight weakness or tingling elsewhere; this must be looked for. Do not assume it isn't there because it wasn't reported by the diver.

Failure to perform the above two steps accounts for very many "comebacks" and supposed treatment failures in pain-only bends. If these steps are omitted, an early spinal hit may be mis-classified as pain-only or spinal symptoms mixed with joint pain will not be detected. It is important that every case of "minor" DCS receive a neuro exam before treatment is started (see next section).

"SERIOUS" *Spinal cord*

This is the most common form of serious DCS in commercial diving and the most feared.

It usually starts as pain around the waist or deep in the upper abdomen. Symptoms (told by the diver) and signs (observed by the medic) usually quickly follow in both lower extremities, though not always equally on both sides.

If the upper spinal cord is involved, the first pain is in the shoulders or chest, followed quickly by symptoms and signs in the arms or all four limbs.

Spinal cord DCS victims often are unable to urinate and may need catheterisation. Ask the victim to urinate often and watch for bladder distension.

There are three classic symptoms of spinal cord DCS and at least two of these will be present when they are looked for (see section on neuro exam):

PAIN that "radiates" (shoots up or down an extremity) and bas a burning, tingling, shocking or electric quality. It is not an aching pain that is in or around a joint.

ABNORMAL SENSATION or feeling somewhere in the extremity. This is usually a tingling, gone-to-sleep feeling (paresthesia) or reduced ability to feel as sensitively as usual (hypoesthesia). It may feel hot and cold, burning, or like pins and needles. The key finding is that an simple stimulation such as pin prick does not feel the way it should and especially does not feel the same on opposite sides of the body in the same location. This is the most reliable finding since people aren't always sure how something should feel, but can very accurately compare their right and left sides. Do not ask the diver, "Can you feel this?", because he will usually have some kind of feeling. Ask instead: "Does this feel normal?" or even better, "Does this [testing an area on the right side] feel the same as this? [testing the same area on the left]"

MUSCLE WEAKNESS on resistive or repetitive muscle testing. The weakness may be obvious or the muscle may seem normal at first but then fatigue very rapidly.

Brain (cerebral) — Can produce almost literally any symptom or combination and is often impossible to distinguish from cerebral air embolism.

Unconsciousness, blindness, abnormal behavior, weakness or sensory abnormalities, abnormal gait and balance, and speech problems are all possible.

Mild forms of cerebral DCS are easy to miss because of similarity to normal nuisance symptoms or moods which are common. Mild confusion, mental disorganization, headache or a "spacey" feeling may not bc reported because the diver fears ridicule or doesn't suspect DCS. Since his brain may not be working right, the diver may be the last one to believe he has a problem and may give misleading information to others who suspect trouble.

Subtle cerebral symptoms are usually noted by the mental status portion of the neuro exam. Personality changes may not be obvious to strangers but only to those who know the diver.

Vestibular ("the staggers") — DCS involving the inner ear causes vertigo, difficulty with balance, nausea and vomiting. It may also feature a hearing loss and ringing or roaring in the ears. Since the symptoms are obvious, diagnosis and treatment are usually rapid. Vestibular DCS may occur after a rapid gas switch and may be hard to distinguish from other causes of vertigo.

Lung ("the chokes") — Is due to numerous bubbles in branches of the pulmonary artery. It causes coughing and shortness of breath and there may be cyanosis and hypoxia due to interference with oxygen uptake by the lung. Struggling to breathe may worsen the symptoms. The bubbles clogging the lung may cause chemical and hormone disturbances in the lung, leading to wheezing. The chokes is often associated with spinal DCS and may mean generalized bubbling throughout the body.

Saturation — Saturation diving is least likely to cause DCS. The usual symptom is pain in the knees. Saturation DCS is often very sensitive to depth and will sometimes clear by going only 1-2 feet deeper. A common procedure is to go to the depth of improvement for 4-8 hours, giving treatment mix), then resume decompression when pain is gone.

Complications of DCS — These are usually seen with delayed treatment or in severe blowups where massive bubbling occurs despite quick treatment. Contact of the bubble surface with blood causes numerous biochemical and physiologic reactions. These may lead to clotting defects, abnormal circulation and shock, abnormal lung function and severe loss of fluid from blood into body tissues. Since recompression is much less effective once these reactions have started, a greater percentage of complicated cases have poor outcomes. This emphasizes the major importance of speed and suspicion in treating DCS.

Common Errors

The most important rule in medicine is: *primum non nocere,* "first, do no harm". Avoiding an error can be more important than doing something right.

Not treating promptly — the most significant error by far and probably the most common. Consider this:

Cases treated within 30 minutes-90% success rate (or better).

Cases with treatment delayed 5-6 hours-50% success, residual symptoms frequent (minor or serious).

Cases delayed over 12 hours-often a poor outcome.

There are numerous reasons why treatment is not started promptly, among which are:

The diver doesn't report symptoms early-Possibly due to male pride, fear of ridicule over reporting vague or mild symptoms, or reluctance to re-enter the chamber. After decompression, divers may be observed to rub sore joints or limp and should be encouraged to report symptoms or suspicion as soon as the diver's attention is drawn to something abnormal.

Failure to suspect DCS-Usually due to the normal tendency to rely on past experience in a puzzling situation. Early bends symptoms are often like everyday nuisances (headache, fatigue, soreness) which are common; the bends is unusual and few people have seen many cases. Therefore, the classic trap for the unwary medic or supervisor is-if the symptom seems ordinary-to assume it is not the bends. Since there is considerable psychological and operational pressure towards this assumption, which will often be true, the medic or supervisor must discipline himself to be suspicious. Ask yourself: Why should the diver have this symptom now when he doesn't normally feel this way after an ordinary dive ?

Certain rationalisations occur repeatedly:

The no-decompression dive — while no-D dives are low risk dives, they are not bends-proof, especially very long, shallow dives. Strictly speaking, there is no such thing as a "no-decompression" dive, only no-stop dives.

The "pulled muscle" — possibly the most common trap of all, for what is more common than a pulled muscle? Consider this: a hard, strenuous dive could cause both the bends or a pulled muscle and the early symptoms are much the same. If they can not be reliably distinguished, all the more cause for suspicion. There is no logical reason for preferring to believe the diver bas a "pulled muscle" instead of DCS.

Long time at the dive site — it is commonly believed that divers become less prone to bends after the first 48-72 hours at a dive site. However, regular deep air dives at the same location will sometimes result in outbreaks of bends after the fourth or fifth day, even on standard decompression schedules. One way to deal with this is to give each diver 24 hours off diving, in rotation. Another is to systematically increase decompression time for each diver.

The most time-honoured rule in diving medicine:

Treat the Uncertain Case

Treat the Suspicious Case

Inadequate treatment — If he is treated promptly, the diver will often be cured even on the wrong table. Where treatment proves inadequate, it may be due to inaccurate evaluation of the diver, lack of aggressive follow-up, or simply a bad break.

Inaccurate evaluation — The usual error is that a diver's report of pain is taken at face value, assumed to be a pain-only bend, and the diver receives an automatic USN table 5. This is an error for two reasons:

The diver may actually have pain that is typical of a spinal bit and not know the difference.

The diver may truly have joint pain but also have symptoms of spinal cord DCS which bc hasn't noticed but could be detected with a neuro exam

If a diver reports pain, it must be determined whether it is joint pain or spinal cord pain. If it is joint pain, a careful neuro exam must be done to be sure serious symptoms are not present also. If a diver reports a neurologic symptom this can quickly be verified, if necessary, then he should be immediately recompressed.

Inadequate follow-up — A treatment table is a one-shot dose of medicine (oxygen under pressure) and, litre any medicine, sometimes bas to be repeated-good treatment is not necessarily enough treatment. Although long experience has shown that standard treatment tables offer a high probability of cure when used properly, there is never any guarantee of success. Principles of follow-up after apparently successful treatment are:

A diver should not be considered cured until he bas been cured for 12 hours.

Following treatment, he should be kept in the chamber area for one hour. During this time, breathing oxygen at 1 ATA for 30-45 minutes will help ensure the success of the treatment. After this hour, he should be instructed to report any recurrence of symptoms or any new symptoms immediately.

During the 12-hour follow-up, neuro exams should be done upon exiting the chamber and after 1, 6, and 12 hours. Divers with pain-only bends can usually return to diving in 24-36 hours.

Divers who were treated for serious symptoms should have neuro exams upon exiting the chamber, in one hour, then every 6 hours as long as they are at the dive site. Unless a doctor and chamber are nearby (two hours or less), they should be kept at the dive site for 12 hours observation, perhaps even 24 hours, so that they do not find themselves far from a chamber if there is a recurrence.

After treatment for serious symptoms, the diver may not return to diving until be is examined and cleared by a qualified doctor.

Inappropriate use of U.S. Navy Tables 5 and 6 — Many American diving contractors are using Table 6 as the minimum treatment for pain-only bends. This bas led to misunderstandings about Table 5 and potential problems from using Table 6 in this way.

Table 5 — proper use of this table requires the following:

The diver must have pain that is in or around a joint and is not typical of spinal cord pain.

A careful neuro exam must be normal (no weakness or sensory abnormalities) and there must be no other serious symptoms.

After recompression, the joint pain must be relieved completely within 10 minutes; otherwise, treat on Table 6. When used properly, U.S. Navy statistics show Table 5 bas a success rate of 93-96 %. Though it is commonly believed in commercial diving this table has a significant failure rate, the usual failure is not using it correctly.

Table 6 — the standard use of this table is for the various serious symptoms listed above. Using proper precautions, it can be extended virtually indefinitely at 60 and/or 30 feet. If it is used as treatment for pain-only bends, beware of the following pitfalls:

The pain-only case must still be diagnosed as outlined above. Using a serious-symptom table does not remove this duty.

If the pain-only case also has neurologic symptoms, these must be found in advance so the table can be extended if they are slow to clear.

If the neurologic symptoms are missed, the diver treated only for pain may be prematurely returned to diving and be at risk of further DCS.

Unnecessary use of Table 6 may increase the risk of oxygen toxicity, obligate the chamber for extended periods of time, and interfere with diving operations.

While deliberately giving excess treatment can often be medically and operationally justified, treatment tables should always be used as precisely and rigorously as possible.

Failure to use the Test of Pressure (TOP) — used properly, the TOP helps avoid the following error: A diver's symptoms seem so trivial or unlike bends that the decision is not to treat, yet he actually bas early bends. The TOP tends to catch this, showing that the diver actually needs treatment. It also supports an accurate decision not to treat, giving confidence to both the diver and supervisor that everything appropriate bas been done.

the **TOP IS NOT (!)** used as a quick way of deciding whether to treat, i.e., deciding if the diver is bent. If this is done and the diver fails to improve within the 20-minute test period, he may be misclassified as not needing treatment. The decision about treatment is made only after evaluating the divers symptoms and performing a careful neuro exam.

If the decision is not to treat (the diver is not believed to have the bends), the TOP is done by putting the diver on oxygen at 60 feet in a chamber for 20 minutes. If his symptoms are unchanged after 20 minutes, this tends to verify he does not need treatment and supports the decision not to treat. If the symptoms are actually due to DCS, they are typically so mild they clear instantly, often at just a few feet of depth. In this case, the decision is changed and the diver is treated.

In a series of six TOP's done by the author, where the decision had already been made not to treat, four showed the decision was incorrect. These divers all received treatment for cases of DCS when their evaluation seemed to show they did not need it. In summary:

If the diver seems to have DCS, he should be treated.

If the diver might have DCS, or his problem is not understood, he should usually be treated (the suspicious or uncertain case).

If the diver does not seem to have DCS and treatment does not seem justified, a TOP should be done to reinforce the decision not to treat. This gives the greatest opportunity to treat every case as early as possible.

Uncertainty about treatment depth — When a badly injured victim does not respond promptly, there is a tendency to impulsively take him deeper, perhaps cancelling a sound treatment plan. While this is often a reasonable decision, deep treatments usually require a saturation decompression, which may be beyond the experience or capability at the dive site. Simple and straightforward treatment on oxygen at 60 feet offers very great benefit to the victim, though signs of improvement may not come quickly since severe, delayed cases need more time to respond. The decision to take the victim deeper, while often a sound one, should only be made with full understanding of the operational and logistical problems that might result. Often the best decision is to continue the original treatment plan; anxiously changing plans may do more harm than good.

General Method for Evaluating Possible Bends Case

When the diver reports a symptom which is not obviously serious but could be due to DCS, he must be questioned for details and a neuro exam performed. Then a decision must be made whether to treat.

Symptom probably not due to DCS, no treatment planned

Perform a test of pressure: compress diver to 60 feet on oxygen for 20 minutes.

If symptom not relieved or clearly improved, decision not to treat is confirmed.

If symptom is relieved or clearly improved, decision is not confirmed-start USN Table 5 as minimum, Table 6 if symptom might be neurological.

Symptom probably/definitely DCS, treatment planned a) Type I ("minor", pain-only)-must meet three conditions:

pain is in or around a joint, does not radiate, not associated with sensory changes or muscle weakness

neuro exam before treatment is normal

pain is relieved within 10 minutes at 60 feet on oxygen

Minimum treatment USN table 5; give generous fluids during treatment. Repeat neuro exam at end of 60-foot stop, on deck after treatment, and 1, 6, and 12 hours after treatment. If still clear after 12 hours, diver can usually return to diving 24-36 hours after completing treatment table. b) Type II (serious symptoms)-minimum treatment USN Table 6,

follow flow chart and review treatment options.

Repeat neuro frequently early in treatment, at end of 60-foot stop, on deck after treatment, one hour after treatment, then every 6 hours as long as diver is at work site.

If new symptoms develop or old symptoms return after treatment, compress diver to 60 feet and contact authority for instructions.

It is best not to send the diver away from the chamber for the first 12 hours unless medical attention and another chamber are close.

AIR EMBOLISM

SYMPTOMS

The major "symptom" is the time of onset, which may be at the surface and is almost always within ten minutes of surfacing. The usual bodily symptom is loss of consciousness and/or a convulsion. There may be a stroke-like picture with weakness on one side of the body or abnormal behavior, speech or vision. The key factor is a dramatic, obvious neurologic symptom of sudden onset. The diagnosis is usually easy and obvious.

TREATMENT

Use U.S. Navy Table 6-A, a brief, deep bounce to 165 feet (50 m) followed by treatment on oxygen at 60 feet (18 m). If available, give the patient 50-50 nitrox at 165 feet with an air break after 20-25 minutes .

In theory, the initial deep bounce collapses the bubble(s) in the brain; the victim may indeed make a quick, total recovery. However, oxygen treatment is necessary to nourish any damaged brain tissue. If the damaged area is small, symptoms may not be seen, or may be indefinite. Swelling of the damaged brain tissue may occur later and delayed deterioration in recovered victims is sometimes seen during or after treatment.

Victims are often combative or incoherent as they recover. Severe cases may require careful attention to the airway. Repeated examinations are important.

If recompression cannot be done immediately, put the victim on his back if he is conscious. If he is unconscious, roll him on his side to guard against vomiting and aspiration. Placing him head-down is not necessary but legs may be slightly elevated.

Give 100% oxygen if possible, using a spare BIBS mask or band mask. If necessary, welding oxygen may be used for breathing. Even ambulance-type oxygen tank and mask will help; use 6-7 liter flow rate.

If available, start an IV with Ringers' lactate or normal saline; run in 200 cc rapidly, then 100 cc per hour until victim can take fluids by mouth.

PROBLEMS

With prompt treatment, results are usually good. Problems usually involve incomplete or no improvement in the victim at the end of the 30 minute bottom time or relapses during or alter travel to 60 feet. Both are much less likely if the victim is given 50-50 nitrox at 165 feet.

Incomplete or no improvement-One of the classic potential traps in embolism treatment exists when the victim shows only partial improvement-or none at all-after 30 minutes at 165 feet. Those in charge of treatment fear that bringing the chamber up to 60 feet will endanger the victim but perhaps believe that no other options are available. The actual decision to stay longer or not depends on the particular situation.

Some factors in the decision are:

Limited benefit of depth — The effects of depth (pressure) are instantaneous and, in theory, the bubble should collapse quickly. After 30 minutes at 165 feet, the good effects of depth should be well in hand. In contrast, depth steadily adds nitrogen to the victim (and his tender) and eventually this price must be paid. The administration of 1001h oxygen at 60 feet offers great benefit to the victim and there is some evidence that USN table 6 is as good as 6-A for treating embolism. The presumed good of staying deeper, especially on air, must be balanced against the known benefit of going on oxygen at 60 feet.

Gases available-If 50-50 nitrox is available, the victim can breathe this at 165 feet (50 m). His inspired pO_2 (3.0 ATA) will be virtually the same as on pure oxygen at 60 feet (2.8 ATA). The increased nitrogen load will be less than on air. He will have the benefit of both a high pO_2 and increased depth.

Time since onset-A fresh case is more likely to respond quickly and justify staying a little longer at depth. An old case (over 5-6 hours) is more likely to have brain damage and not show quick improvement, even if the bubble disappears.

Degree of improvement-It is not necessary that the embolism victim show a complete cure during the 30 minutes at 165 feet, only that life-threatening problems be gone. Other symptoms will usually continue to clear after the victim is brought to 60 feet and placed on 100% oxygen.

Ability to saturate-Saturation is the safest method of treatment and allows plenty of time for the victim to stabilise. However, saturation treatments are very long and can place great strain on supplies and personnel (especially the inside tender).

After 30 minutes at 165 feet the usual options are:

Stay at depth up to two hours-Decompression with conventional tables is possible since the goal is only to reach 60 feet where a long oxygen table is started. The victim can be brought to 60 feet using the USN 170/120 exceptional exposure table, USN table 4, or Royal Navy table 72. After 2 hours at 165 feet, at 60 feet the tender should be put on oxygen.

Stay at depth over two hours-The victim is held at depth for 2-4 hours, then decompressed on any standard saturation schedule. A treatment mix may be made up (pO_2 1.5-2.5 ATA) and given regularly during decompression.

Good result, then deterioration at 60 feet — Early deterioration is usually due to enlargement of a bubble persisting in the brain. Later deterioration is due to swelling of the brain in the damaged area.

Early deterioration — usually occurs shortly after arrival at 60 feet or during travel. If the deterioration is not severe and life-threatening, stay at 60 feet for the following reasons:

Compared to air at 165 feet, 100% oxygen at 60 feet offers over twice the oxygen to the damaged brain (1.26 vs 2.8 ATA oxygen). Even areas without blood flow may receive oxygen by diffusion.

The effect of depth on the bubble is more or less immediate and ought to be accomplished within 30 minutes; returning to depth adds more nitrogen to the victim.

100% oxygen creates a strong gradient for off-gassing nitrogen, which is 80% of the bubble. After the quick effects of pressure have been obtained, this is the next fastest way to rid the victim of his bubble.

If the deterioration is life-threatening (shock, convulsion, absent respiration) return to the depth of improvement, which may be less than 165 feet. A hold at 100 feet may produce enough improvement to stabilise the victim; a return to 60 feet is attempted after 30 minutes. If there is not good improvement after 5 minutes at 100 feet, return to 165 feet; additional bottom time is possible with conventional tables.

Late deterioration — This may be noted well after arrival at 60 feet,1-2 hours or longer. This is not from bubbles but rather from swelling of damaged brain tissue and is not treated by return to depth. Oxygen tables are continued, often with extensions.

Treatment of Accidents

Basic emergency medical skills are not covered in this section. The medic should never forget the essential value of these skills in any accident or emergency. Despite the unique and specialized care given to diving victims, these basic skills are as important here as anywhere.

GENERAL PRINCIPLES

The traditional principles in the treatment of diving accidents are oxygen, pressure, and time. For many years, emphasis bas also been placed on fluids. Currently, medications are recommended only in particular situations.

Oxygen — Breathing a high partial pressure of oxygen nourishes tissue which may be deprived of its blood supply and creates a gradient to remove nitrogen from the body.

Start immediately — Start oxygen as soon as a decompression accident is recognised or even if it is only suspected. Give 100% if possible (use a BIBS mask or band mask). Oxygen breathing may be interrupted for necessary neurological exams. Otherwise, continue until the victim is placed in the chamber.

Maximum during treatment — Modern treatment tables emphasize aggressive use of oxygen with regular air breaks. Deeper than 60 feet, 50-50 nitrox can be given to 165 feet. The PO, of 50-50 nitrox at 165 feet (3.0 ATA) is essentially the same as 1001/c oxygen at 60 feet (2.8 ATA). Deeper than 165 feet, the treatment mix should have an oxygen partial pressure of 1.5 to 2.5 ATA. General limits for CNS and lung toxicity must be kept in mind at all times.

Give after treatment — Giving oxygen at the surface after treatment may help prevent recurrences, especially in severe pain-only cases. If given, use 100%. oxygen for 30-60 minutes, perhaps repeated once in a few hours.

Pressure — The most direct treatment of decompression accidents, as it attacks the immediate cause. The most common error in handling accidents is delay in recompression. Cases that are quickly recompressed usually recover, even on the wrong table.

Old cases — Pressure (depth) is relatively less important in cases over 5-6 hours old. Treatment with oxygen at 60 feet and 30 feet is often best, usually with long extensions.

Fresh cases — Pressure is relatively more effective the more recent the accident. In severe, sudden cases (e.g., blow-up), bubbles may continue enlarging even after recompression.

Time — Although prompt treatment usually produces quick results, this is not always true, especially in severe cases. Failure of the victim to improve understandably causes anxiety in his rescuers. This may lead to meddlesome tinkering with the treatment plan. Once a rational treatment plan bas been chosen, appropriate to the case at hand, the only remaining factor is sufficient time for the plan to take effect. A technique of value in tough cases is the 12-hour or overnight "soak", where decompression is halted for a time. With proper equipment and gas supplies, this can be done at any depth. On air, long holds are possible at 100 feet and are virtually indefinite at 60-80 feet (see page 126). A soak offers these possible benefits:

Bubbles may disappear before commencing decompression.

Supersaturated tissues may equilibrate within the victim's body, and the body as a whole with the chamber atmosphere.

Uniform oxygen levels may be reached in blood-deprived nervous tissue.

Topside and chamber personnel can organise and regroup for a difficult and trying experience.

Fluids — All bends cases should be given ample fluids, either by mouth or intravenously, as this tends to correct many of the secondary problems which develop. Any non-alcoholic fluid may be given by mouth (avoid large amounts of caffeine). For unconscious victims or those unable to swallow, Ringer's lactate or normal saline should be used intravenously. A good starting point with IV fluids is 200-300 cc run in rapidly, then about 100 cc. per hour, adjusted downward when urine output becomes adequate. Whether by mouth or vein, intake should be sufficient to produce a urine output of 3060 cc. per hour (1-2 ounces).

Drugs — No medications are currently recommenced for routine use in diving accidents, but the medic may be ordered to give medications in specific situations. The following points should be remembered:

The medic should only administer drugs on the order of a physician, either verbal or written. Verbal orders should be repeated and decimal points clearly stated.

The medic should be familiar with the major properties of the drugs he has on hand. To guard against errors, he should be able to check the common doses used for average-sized males.

While drugs are usually helpful, they are always potentially harmful. The exact benefit of drugs in diving accidents is frequently unclear and occasionally controversial.

The use of drugs is usually in delayed or complicated cases. The need for drugs can largely be eliminated by prompt recompression, aggressive use of oxygen, generous fluid intake and sufficient time.

Miscellaneous — the medic should always remain conscious of the following fundamental information:

Oxygen is a drug or medication; administered under pressure, it is the drug used to treat diving accidents.

The various standard treatment tables are different doses of treatment which have been found to be effective for various forms of DCS.

A treatment table is a one-shot treatment, like one injection of an antibiotic. The severity of the bends case is estimated and the appropriate table is chosen based on this estimate.

Since severity and treatment are estimated in advance, it follows that the victim must be observed for the desired response and treatment lengthened if necessary. Remember: good treatment is not necessarily enough treatment.

Old cases usually respond to treatment slower than fresh cases. Even the worst symptoms usually disappear quickly when the victim is treated soon after onset.

Since many early bends symptoms imitate more ordinary problems and the ideal is to treat every bends victim early, it follows that some divers will be treated who turn out not to have the bends. The nuisance of unnecessary treatment is less than that of inadequate treatment.

Divers should be observed and re-examined after successful treatment and instructed to report new or recurring symptoms.

TREATMENT FLOW CHART FOR DECOMPRESSION ACCIDENTS

The following section presents a decision tree to aid medics and supervisors in the logical treatment of diving accidents. It is similar, and in parts identical, to numerous others which are in use throughout the world. The steps recommended are conventional, orthodox, and routinely recommended by diving physicians. What may seem different to some are the following points:

1. The scheme does not rely exclusively on U.S. Navy tables but also on others of proven value.

2. Entering the decision tree doesn't depend on a specific diagnosis but rather on straight-forward observations which can be made quickly by any alert observer.

3. All steps are unified into one all-purpose chart. This avoids the need to distinguish between brain bends, air embolism and other diagnostic categories and using different pages for each.

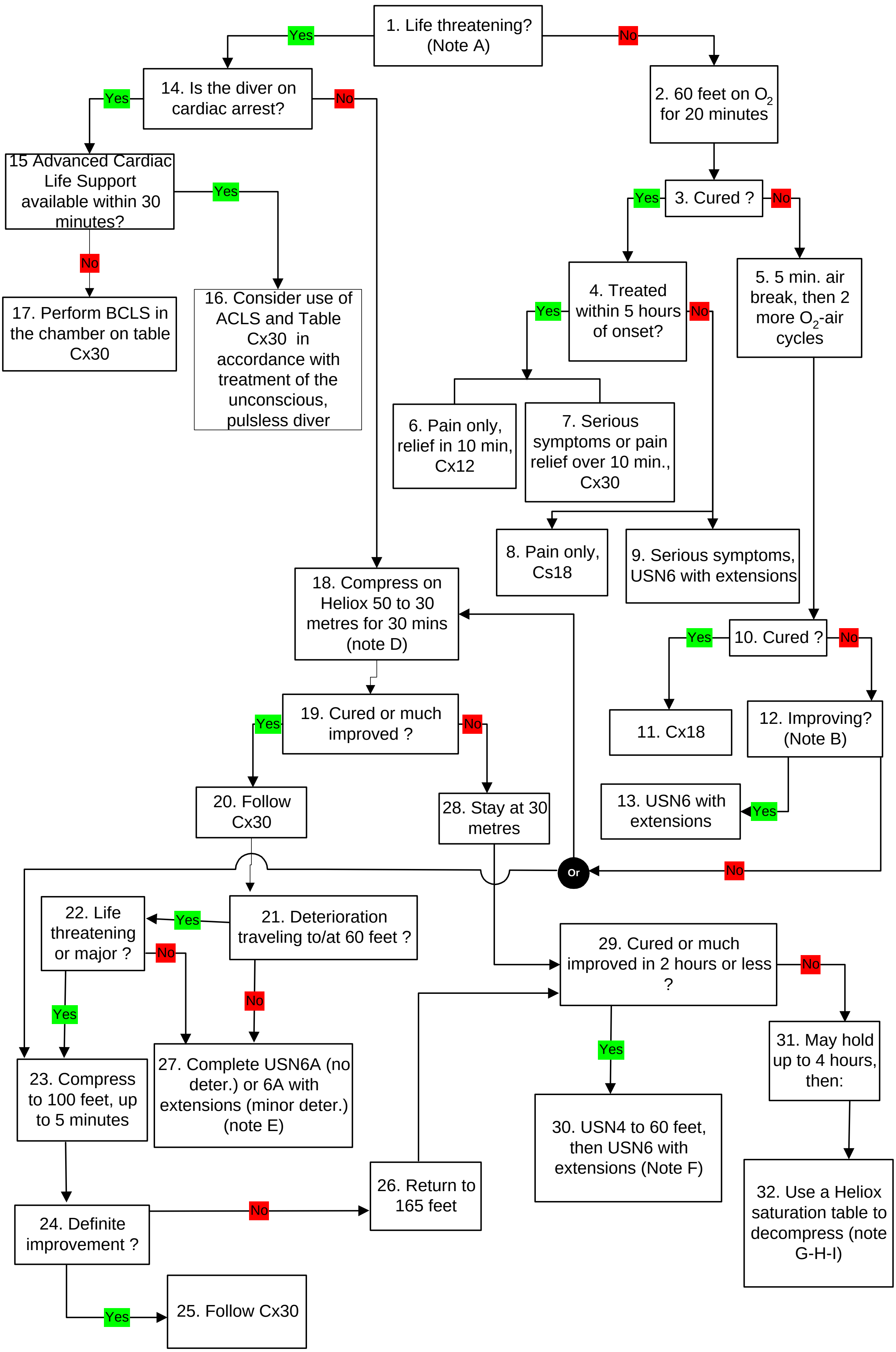
4. Steps are numbered for communication and reference.

5. Tables used are abbreviated below and reproduced in the following section. Notes in explanation of certain steps are listed below.

The chart is intended to be both simple and complete, and to reflect the equipment and resources available in ordinary commercial diving. The intent is to provide a scheme whereby the dose oftreatment can be adjusted in both depth and duration, according to the observed condition of the victim and his response to the early phases of treatment.

NOTES:

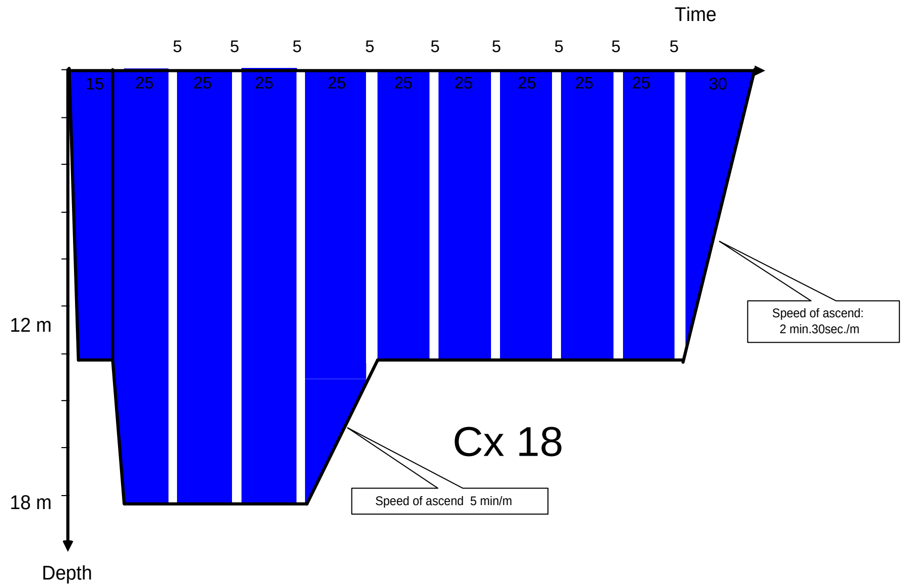
A. Such as unconscious, seizure, shock.
B. When treatment is delayed over 5-6 hours, deeper depth may not help but will add nitrogen to victim. Going deeper here may require the ability to manage saturation decompression.
C. Deeper than 60 feet use treatment mix with p02 Of 1.5-2.5 ATA. Give in cycles as in note H (20-25 minutes of treatment mix, 5 minutes of chamber atmosphere).
D. If not available, start 50-50 nitrox immediately, 5 minute air break every 20-25 minutes.
E. Deterioration occurring later in table is due to brain swelling, will not be helped by deeper depth.
F. At 60 feet put the tender on oxygen, lock in an air-breathing tender if available.
G. A hold of perhaps 1-2 days is usually possible at 100 feet or shallower and may help stabilize the difficult or delayed case.
H. At 60 feet give 3-6 cycles of oxygen for 20-25 minutes with 5 minute air breaks. Repeat every 4-6 hours or as called for by table.
I. When a saturation therapeutic table has been chosen, you need to flush the chamber with 90 m^3 of heliox 20%, then you will need an ECU (Environmental Conditioned Unit) and follow the basic parameters as humidity, temperature, oxygen percentage, carbon dioxide level, etc..



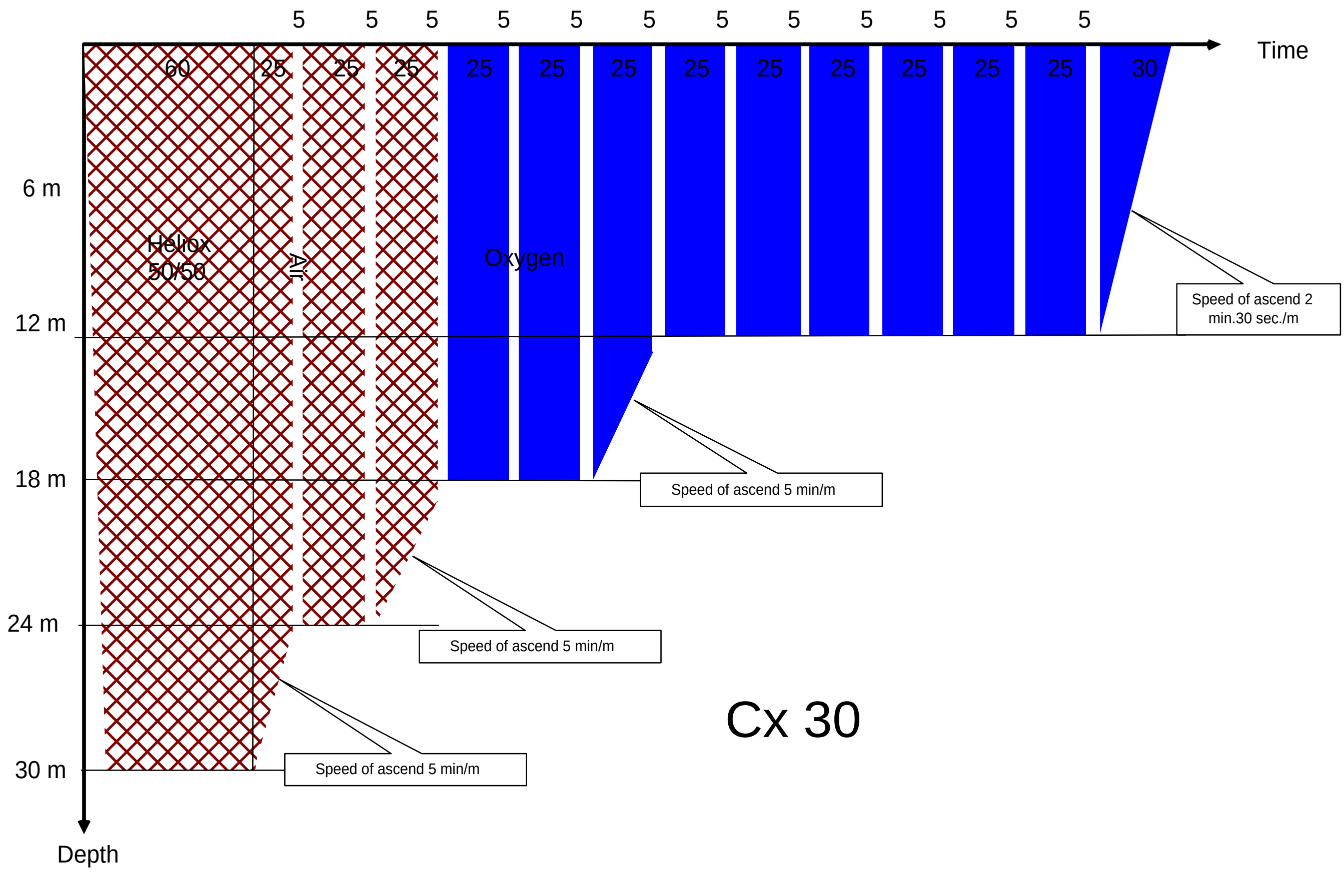
1. Life threatening? (Note A)
Yes
No
14. Is the diver on cardiac arrest?
2. 60 feet on O_2 for 20 minutes
Yes
No
15 Advanced Cardiac Life Support available within 30 minutes?
Yes
3. Cured ?
Yes
No
No
16. Consider use of ACLS and Table Cx30 in accordance with treatment of the unconscious, pulsless diver
17. Perform BCLS in the chamber on table Cx30
4. Treated within 5 hours of onset?
Yes
No
5. 5 min. air break, then 2 more O_2-air cycles
6. Pain only, relief in 10 min, Cx12
7. Serious symptoms or pain relief over 10 min., Cx30
8. Pain only, Cs18
9. Serious symptoms, USN6 with extensions
18. Compress on Heliox 50 to 30 metres for 30 mins (note D)
10. Cured ?
Yes
No
19. Cured or much improved ?
Yes
No
11. Cx18
12. Improving? (Note B)
20. Follow Cx30
28. Stay at 30 metres
13. USN6 with extensions
Yes
Or
No
22. Life threatening or major ?
Yes
21. Deterioration traveling to/at 60 feet ?
No
No
29. Cured or much improved in 2 hours or less ?
No
Yes
Yes
31. May hold up to 4 hours, then:
23. Compress to 100 feet, up to 5 minutes
27. Complete USN6A (no deter.) or 6A with extensions (minor deter.) (note E)
30. USN4 to 60 feet, then USN6 with extensions (Note F)
26. Return to 165 feet
32. Use a Heliox saturation table to decompress (note G-H-I)
24. Definite improvement ?
No
Yes
25. Follow Cx30

Flow Chart Comments

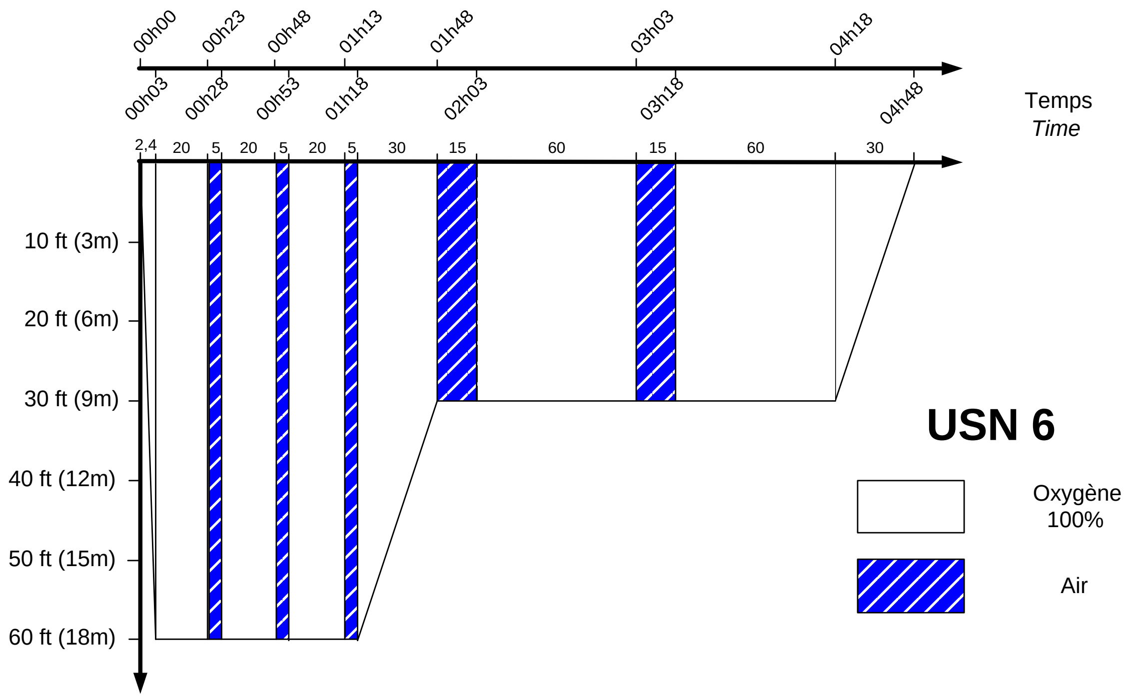
1. The first question is whether the victim's life is in danger due to such things as shock, convulsions, or unconsciousness. If so, the best immediate decision is to go deep, then come up if this wasn't really necessary. Note that spinal symptoms, while serious, are not usually life-threatening.
2. Evaluation after the first oxygen period serves to separate responsive bends from more resistant bends.
3. linked with previous item
4. Fresh cases usually respond to standard treatment; delayed cases usually benefit from longer treatment.
5. This step completes the 60-foot stop on USN Table 6. .
6. This is the standard use for USN Table 5. .
7. This is the standard use for USN Table 6. .
8. In delayed cases joint pains do not always clear completely, some mild soreness often remains. If the neurological exam is normal, Table 6 is probably adequate, but more can be given.
9. This is probably the minimum treatment for a delayed case with serious symptoms.
10. End of the 60-foot stop on Table 6, a good time to estimate the probability of success of the table.
11. The appropriate treatment for a diver who is cured at this point.
12. If there is no improvement, an option is to take the victim to either 100 or 165 feet. The question here is if more depth will offer benefit but this cannot be answered in advance. Long-delayed cases have a lower cure rate with any treatment. Many authorities prefer continued use of oxygen at 60 and 30 feet, even on a daily basis. Going deeper will not hurt, assuming a saturation treatment can be managed, as this is a common outcome.
13. Depending on the original problem and the degree of improvement, the table can be extended at 60 feet, 30 feet, or both. A diver who is improving at 60 feet usually continues to improve at 30 feet. As long as there is no sign of toxicity, the more oxygen the better.
14. No response, no breath, no pulse.
15. The provision of care that Diver Medic or allied health professional renders, including advanced airway management, defibrillation, intravenous therapy and medication administration
16. linked with previous item
17. linked with previous item
18. This step represents either a life-threatening accident from less than 165 feet (an embolism for example) or a serious bends case showing no improvement after the 60-foot stop on USN Table6.
19. As the 30 minute bottom time on USN Table 6-A approaches, the diver's response to depth must be evaluated.
20. The standard use of USN Table 6-A .
21. Self-explanatory. Deterioration travelling to 60 feet is a common dilemma in embolism cases.
22. Important deterioration requires further steps; minor deterioration can be tolerated, as it will go away later in the table.
23. For important deterioration or bends not responding at 60 feet it may not be necessary to return as deep as 165 feet.
24. Evaluate the diver after a short time at 100 feet.
25. If 100 feet is sufficient, the table Cx 30 can be followed entirely.
26. If there is no improvement at 100 feet the only choice is to return to 165 feet.
27. If there was no deterioration, this is the standard use of USN Table 6-A. If there was minor deterioration, the extensions are a wise precaution. Many authorities would use the extensions anyway.
28. At this step, the diver may be unchanged, or improving, after 30 minutes at 165 feet.
29. At this step, the diver either did not make acceptable improvement after 30 minutes at 165 feet or deteriorated traveling to 60 feet and had to return. A bottom time of two hours or less will allow decompression with standard tables.
30. Either the 170/120 table (author's personal preference) or Table 4 will allow travel to 60 feet, where USN Table 6 is substituted with extensions. Deterioration on either table is unlikely. The tender should go on oxygen at 60 feet with the diver.
31. If the decision is not to decompress after two hours, it may be possible to hold for up to four hours, depending on previous oxygen exposure. Many authorities would simply commence saturation decompression after two hours.
32. Continue any standard saturation decompression. While previous oxygen exposure may prevent a hold at 100 feet on air, very long holds are possible in the range of 60-80 feet (many days), limited only by symptoms of lung oxygen toxicity, which are very unlikely.

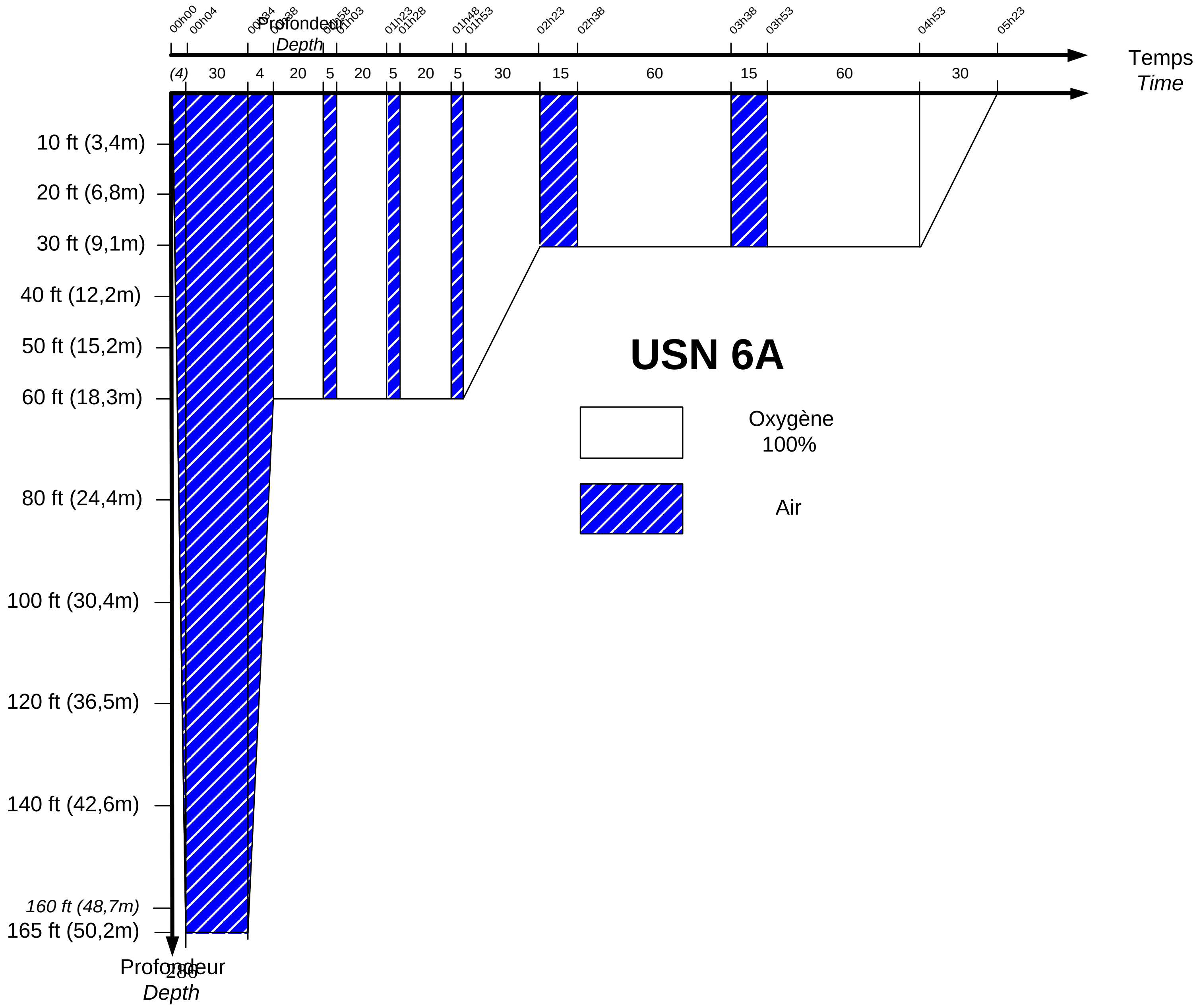


Time
5 5 5 5 5 5 5 5 5
15 25 25 25 25 25 25 25 25 25 30
12 m
18 m
Depth
Speed of ascend:
2 min.30sec./m
Speed of ascend 5 min/m
Cx 18



5 5 5 5 5 5 5 5 5 5 5 5
Time
60 25 25 25 25 25 25 25 25 25 25 25 25 30
6 m
Heliox
50/50
Air
Oxygen
12 m
18 m
24 m
30 m
Depth
Speed of ascend 2
min.30 sec./m
Speed of ascend 5 min/m
Speed of ascend 5 min/m
Speed of ascend 5 min/m
Cx 30


00h00
00h23
00h48
01h13
01h48
03h03
04h18
00h03
00h28
00h53
01h18
02h03
03h18
04h48
Temps
Time
2,4
20
5
20
5
20
5
30
15
60
15
60
30
10 ft (3m)
20 ft (6m)
30 ft (9m)
40 ft (12m)
50 ft (15m)
60 ft (18m)
USN 6
Oxygène 100%
Air


Temps
Time
(4)
30
4
20
5
20
5
20
5
30
15
60
15
60
30
10 ft (3,4m)
20 ft (6,8m)
30 ft (9,1m)
40 ft (12,2m)
50 ft (15,2m)
60 ft (18,3m)
80 ft (24,4m)
100 ft (30,4m)
120 ft (36,5m)
140 ft (42,6m)
160 ft (48,7m)
165 ft (50,2m)
USN 6A
Oxygène 100%
Air
Profondeur
Depth

TABLES

US NAVY TABLE 5

Treatment of pain-only decompression sickness when the neuro exam is normal and symptoms are relieved within 10 minutes at 60 feet.

Descent rate-25 ft/min.

Ascent rate-1 ft/min. Do not compensate for slower ascent rates. Compensate for faster rates by halting the ascent.

Time at 60 feet begins on arrival at 60 feet.

If oxygen breathing must be interrupted, allow 15 minutes after the reaction has entirely subsided and resume schedule at point of interruption.

If oxygen breathing, must be interrupted at 60 feet, switch to Table 6 upon arrival at the 30 foot stop.

Tender breathes air throughout. If treatment is a repetitive dive for the tender or tables are lengthened, tender should breathe oxygen during the last 30 minutes of ascent to the surface.

US Navy Table 5			
Depth (feet)	Time (minutes)	Breathing media	Total elapsed time (hrs:min.)
60	20	oxygen	0:20
60	5	air	0:25
60	20	oxygen	0:45
60 to 30	30	oxygen	1:15
30	5	air	1:20
30	20	oxygen	1:40
30	5	air	1:45
30 to 0	30	oxygen	2:15

US NAVY TABLE 6

Treatment of serious symptoms, or pain-only decompression sickness when symptoms are not relieved within 10 minutes at 60 feet.

Descent rate 25 ftJmin.

Ascent rate-1 ftlmin. Do not compensate for slower ascent rates. Compensate for faster rates by halting the ascent.

Time at 60 feet-begins on arrival at 60 feet.

If oxygen breathing must be interrupted, allow 15 minutes after the reaction has entirely subsided and resume schedule at point of interruption.

Tender breathes air throughout. If treatment is a repetitive dive for the tender or tables are lengthened, tender should breathe oxygen during the last 30 minutes of ascent to the surface.

Table 6 can be lengthened by an extra 25 minutes at 60 feet (20 minutes on oxygen and 5 minutes on air) or an extra 75 minutes at 30 feet (15 minutes on air and 60 minutes on oxygen), or both.

US Navy Table 6			
Depth (feet)	Time (minutes)	Breathing media	Total elapsed time (hrs:min.)
60	20	oxygen	0:20
60	5	air	0:25
60	20	oxygen	0:45
60	5	air	0:50
60	20	oxygen	1:10
60	5	air	1:15
60 to 30	30	oxygen	1:45
30	15	air	2:00
30	60	oxygen	3:00
30	15	air	3:15
30	60	oxygen	4:15
30 to 0	30	oxygen	4:45

US NAVY TABLE 6A

Treatment of gas embolism. Use also when unable to determine whether symptoms are caused by gas embolism or severe decompression sickness.

Descent rate-as fast as possible.

Ascent rate-1 ft/min. Do not compensate for slower ascent rates. Compensate for faster ascent rates by halting the ascent.

Time at 165 feet-includes time from the surface.

If oxygen breathing must be interrupted, allow 15 minutes after the reaction bas entirely subsided and resume schedule at point of interruption.

Tender breathes air throughout. If treatment is a repetitive dive for the tender or tables are lengthened, tender should breathe oxygen during the last 30 minutes of ascent to the surface.

Table 6A can be lengthened by an extra 25 minutes at 60 feet (20 minutes on oxygen and 5 minutes on air) or an extra 75 minutes at 30 feet (15 minutes on air and 60 minutes on oxygen), or both.

US Navy Table 6A			
Depth (feet)	Time (minutes)	Breathing media	Total elapsed time (hrs:min.)
165	30	air*	0:30
165 to 60	4	air*	0:34
60	20	oxygen	0:54
60	5	air	0:59
60	20	oxygen	1:19
60	5	air	1:24
60	20	oxygen	1:44
60	5	air	1:49
60 to 30	30	oxygen	2:19
30	15	air	2:34
30	60	oxygen	3:34
30	15	air	3:49
30	60	oxygen	4:49
30 to 0	30	oxygen	5:19
* use 50/50 nitrox if available, 20-25 min. On / 5 off			

US Navy Table 4			
Depth (feet)	Time (hours)	Breathing media	Total elapsed time (hrs:min.)
165	½ to 2 hr.	air	2:00
140	½ hr.	air	2:31
120	½ hr.	air	3:02
100	½ hr.	air	3:33
80	½ hr.	air	4:04
60	begin USN Table 6		
This table may be used where it is necessary to spend over 30 minutes at 165 feet on U. S. Navy Table 6A, up to a bottom time of 2 hours. At 60 feet, switch to, U. S. Navy Table 6. Tender should go on oxygen at 60 feet.			

US Navy 170/120 Standard Air Table					
Depth (feet)	Bottom Time	Time to first stop (min:sec)	stop (feet)		
			80	70	60
170 feet (or 165)	up to 120 minutes	1:30	2	10	begin USN Table 6
This table may be used where it is necessary to spend over 30 minutes at 165 feet on U. S. Navy Table 6A, up to a bottom time of 2 hours. At 60 feet, switch to, U. S. Navy Table 6. Tender should go on oxygen at 60 feet.					

COMEX TABLE Cx 30

Use treatment of vestibular and general neurological decompression sickness occurring after either a normal or shortened decompression.

Descent rate as quickly as possible, in 2 or 3 minutes.

Ascent rate between 100 and 80 feet-1.5 min/ft. 80 and 60 feet-1.5 min/ft.

Time at 100 feet does not include the compression time.

Comex Table Cx 30			
Depth (feet)	Time (minutes)	Breathing gas	Total elapsed time (hrs:min.)
100	*60	**50-50	1:00
100 to 80	5	Air	1:05
	25	50-50	1:30
80	5	Air	1:35
80	25	50-50	2:00
80 to 60	5	Air	2:05
	25	50-50	2:30
at 60 ft. Begin USN6			
* this period may be broken into 25-5 cycles ** 50-50 helium/oxygen or nitrogen/oxygen			
For use where the embolism victim shows significant deterioration at 60 ft. on U. S. Navy Table 6A but shows good improvement on return to 100 ft., or for the bends victim who is not improving at 60 ft on USN 6. This table is followed to 60 ft., then switched to USN 6. Bends in the tender is possible, consider putting him on oxygen at 30 ft. The full Cx 30 table is quite good, but is not printed here for simplicity.			

Recompression Tables and Their Applications		
Treatment Table	Type of Table	Application
USN 5	oxygen	pain-only DCS (type II) where neuro exam is normal and symptoms are relieved within 10 min at 60 fsw
USN 6	oxygen	serious DCS (type II), pain-only (type 1) where symptoms are not relieved in 10 min, mixed serious and pain-only, or where the diagnosis is not clear
USN 6A	air/oxygen or nitrox/oxygen	cerebral gas embolism, difficult serious DCS, or uncertain diagnosis
USN 4	air or air/oxygen	embolism or DCS needing longer than 30 min at 165 fsw; follow to 60 fsw then start USN 6
Cx 30	nitrox/oxygen	a) serious DCS not responding at 60 fsw or b) cases showing deterioration coming up from 165 fsw but improve at 100 fsw; follow to 60 fsw then start USN 6

TIPS AND PRECAUTIONS

This section offers various suggestions and warnings about practical

procedures in diving cases.

In spinal hits, remember that paralysed extremities will develop pressure sores (bedsores) with surprising quickness, particularly when boney areas press against a hard surface. Good nursing care is important. Heels, ankles, the sides of the knees, the rim of the pelvis above the buttocks, and the elbows may need padding. The time-honoured nurse's procedure is to turn the victim side-back-side every two hours.

IV solutions should be in bags if possible. Bottles must be vented. The drip chamber must be watched as pressure is changing.

Rubber-stopped vials should be vented with a needle prior to compression. If needles are scarce, set the vial upright so the contents will not spill if the stopper is forced into the vial.

If the IV will not bang high enough above the victim to provide a steady drip, put a blood pressure cuff around the IV bag. Inflate to cause the desired rate of drip. **Remember** to decompress the cuff as necessary.

Balloons on endotracheal tubes and Foley catheters must be filled with fluid. If separate vials of sterile water or saline are not available, draw from the IV bag or even use clean drinking water.

Glass ampules will usually tolerate chamber pressure. On opening, hold the ampule with gauze or cloth to protect the bands, as they will implode as they break.

Mercury-containing thermometers and blood pressure cufl's may not be used in chambers.

Stethoscopes and hearing generally are less reliable at depth. Accurate systolic blood pressures can be taken by noting the pressure at which the wrist pulse reappears as the cuff is let down; this is all that is needed for emergencies.

In embolism cases, listen to the lungs regularly, comparing the right and left sides. Some embolism cases will also have a pneumothorax but may have no distress due to treatment with hyperbaric oxygen, which may also shrink the pneumothorax. However, the potential for the pneumothorax to expand-creating a tension pneumothorax-is greatest as the victim nears the surface. This may also be when the medic is becoming less vigilant. The best place to listen for pneumothorax (if the victim is lying on his back) is anteriorly, just under the clavicles.

LESSON 8_03 HIGH PRESSURE NERVOUS SYNDROME (HPNS)

High Pressure Nervous Syndrome is the result of diver exposure to high partial pressures of Helium in breathing gas for commercial and technical diving. It is of no concern for divers using mixed gases above 350 ft (106 metres). However, as divers approach 500 ft (152 meters) on Heliox, HPNS symptoms may begin to appear.

HPNS symptoms include muscle twitching, dizziness, nausea, vomiting, postural and intention tremors, fatigue and somnolence, stomach cramps, and general loss of body control. At deeper depths, extremely serious symptoms leading to death may occur.

The condition is exacerbated by rapid change in pressure during descent. It has been found that HPNS can be abated by descending very slowly, approaching 1 ft per minute. In technical diving, this approach is impractical because of the limited supply of gas.

A better solution has been found to add up to 10% Nitrogen gas to the breathing gas mix. The resulting reduced partial pressure of Helium and the narcotic effect of the added Nitrogen has been found to significantly **reduce** but not eliminate HPNS effect. According to many sources, by using Trimix with up to 10% Nitrogen, divers may approach depths of 600 ft before HPNS again becomes a critical concern.

The onset of symptoms is gradual but timely so that the descent may be slowed or halted. Near the above stated depth boundaries, divers should be keenly aware of the possibility of these symptoms and be ready to take action (stop descent) when the symptoms are observed.

Generally speaking, most technical divers do not use Heliox because of the expense, and therefore, HPNS is usually not a concern. This is because technical diving is rarely performed below 400 fsw (122 msw) and the divers who go there are generally well trained, experienced and have well thought-out dive plans for such dives.

Introduction

As an applied force hydrostatic pressure (HP) has its own biological effects shown on virus, protista and, generally on the whole of the animal genus whose barosensitivity varies with the species and can be characterized by a lethal threshold. In protista, HP can delay (even stop) dividing, cause cellular deformation and the loss of movements of translation. The effects are the same on the eggs and embryos of metazoa : alteration of shape, motion and cellular division. In vertebrates (fish especially), being exposed to HP induces functional and behavioural disorders (excitement, ECG, ventilation, EEG) with alteration of metabolism, neuronal excitability, and neurotransmitters release, synthesis, and binding to their receptors.

Those different physiological and/or physiopathological effects of HP are explained by mechanisms which must be studied at molecular and cellular levels (alteration of intermediary metabolism, oxidizing phosphorylation, enzymatic activities...). Indeed HP has been shown to cause a stiffness (partially reversible) of cellular membranes which can alter its functions (ions transfers, enzymatic activities, receptor proteins...). Exposure to HP also causes alterations of the properties of the microtubules and of the functions of microfilaments, etc.

Those effects of HP can be interpreted in terms of thermodynamics, the physicochemical alterations coming with volumetric, structural, energetic changes ($G = E + P.V. - TS$) whose main cellular targets are the membrane lipids but also the proteins and, generally all the multimacromolecular structures. Thus adapting to high pressures requires metabolic and anatomofunctional specialisations.

Causes

Deep diving deeper than 200 m (656 ft) or a rapid bounce dive compression to 150-180 m (500 – 590 ft).

Symptoms

The symptoms of HPNS include muscle tremors, drowsiness, loss of appetite, nausea, dizziness, vertigo, difficulty in concentrating, and visual disturbances, such as spots or patterns breaking up the diver's field of vision. Some of these symptoms are common to several forms of gas toxicity or physiological stressors (e.g. dizziness, nausea, loss of concentration).

A diver suffering from hyperbaric arthralgia feels a cracking of joints which may even be audible and feels that his joint surfaces are dry (no "joint juice"). Joints sometimes hurt especially on movement. A compression stop may avoid the painful effects of this condition although cracking of the joints may continue.

HPNS occurs when the diver is compressed too rapidly to depths greater than 200 m (656 ft). It varies in severity from one individual to another, and manifests itself as a tremor which, in some men, may be so severe that they are incapacitated. Other symptoms may include uncontrolled muscle jerks, sleepiness, visual disturbances, dizziness, nausea and vomiting.

Treatment

In commercial diving, the effects of HPNS are reduced by slow and staged pressurization, and by adding small amounts of nitrogen to "relax" tissues. Divers are pressurized to approximately 10-11 bars (90-100 meters) and held there for several hours for tissue saturation to take place, and the gas gradient to equilibrate. Pressurization is then resumed, and the dive halted again after a further increase in pressure, for the process to repeat itself. The transit to the "bottom" may thus take many hours, far longer than is possible on open or closed circuit SCUBA, with an attendant decompression lasting several days due to the complete saturation of the divers' tissues with the inert gas mixtures involved.

To reduce the effects of HPNS, small amounts of nitrogen may be used in the mixture to "relax" different tissues compartments and so reduce certain of the side effects, notably the muscle tremors that are typically the earliest and least controllable of the effects. The tremors are postulated to be caused by differential dissolution of gases into the tissues of the myelin sheath surrounding the nerves, causing the nerves to locally spasm.

LESSON 8_04 REVIEW OF MEDICAL PROBLEMS

The illness and injury statistics for four years on one major operators' installation in the North Sea are shown in the tables opposite. The incidence of serious accidents by occupational groups over a period of time is shown in the diagram below.

1. Respiratory
2. Gastrointestinal(e.g. stomach ulcer)
3. Muscles and joints
4. Skin
5. Central nervous system (e.g. stroke)
6. Ear, nose and throat
7. Eyes
8. Dental
9. Genitourinary (e.g. kidney stones)
10. Cardiovascular (e.g. heart attack)

Bronchitis

Bronchitis is an inflammation of the bronchi, which are the branches of the windpipe inside the lungs. There are two forms, acute (of recent origin) and chronic (of long standing).

Acute bronchitis

This may occasionally occur as a complication of some infectious fever (for instance, measles) or other acute disease. More usually, however, it is an illness in itself. It usually commences as a severe cold or sore throat for a day or two, and then the patient develops a hard dry cough, with a feeling of soreness and tightness in the chest which is made worse by coughing. Headache and a general feeling of being unwell are usually present. In mild cases there is little fever, but in severe cases the temperature is raised to about 38-39 °C and the pulse rate to about 100, while the respiration rate is usually not more than 24.

In a day or two the cough becomes looser, phlegm (sputum) is coughed up (at first sticky, white, and difficult to bring up, later greenish yellow, thicker, and more copious), and the temperature falls to normal. The patient is usually well in about a week to 10 days, but this period may often be shortened if antibiotic treatment is given.

Note.

- The rise in temperature is only moderate.
- The increase in the pulse and respiration rates is not very large.
- There is no sharp pain in the chest.

These symptoms distinguish bronchitis from pneumonia (see page 221), which gives rise to much greater increases in temperature and pulse rate, with obviously rapid breathing and a blue tinge to the lips and sometimes the face. The absence of pain distinguishes bronchitis from pleurisy (page 220), for in pleurisy there is severe sharp pain in the chest, which is increased on breathing deeply or on coughing.

General treatment

The patient should be put to bed and propped up with pillows, because the cough will be frequent and painful during the first few days. A container should be provided for the sputum, which should be inspected. Frequent hot drinks will be comforting. Smoking should be discouraged.

Specific treatment

Give 2 tablets of acetylsalicylic acid every 4 hours. This is sufficient treatment for milder cases with a temperature of up to 38 °C which can be expected to return to normal within 2-3 days. If the temperature is higher than 38 °C,

give phenoxymethyl penicillin potassium tablets (500 mg) at once, followed by 250 mg of the same drug every 6 hours for the next 5 days. If the patient is allergic to penicillin, sulfamethoxazole + trimethoprim tablets (400+80 mg), 2 tablets every 12 hours for 5 days, should be given instead.

Should there be no satisfactory response to treatment after 3 days, seek RADIO MEDICAL ADVICE.

Subsequent management

The patient should remain in bed until his temperature has been normal for 48 hours.

Examination by a doctor should be arranged at the next port.

Chronic bronchitis

This is usually found in people past middle age who are aware of the diagnosis. Exposure to dust and fumes and inhalation of tobacco smoke predispose to the development of chronic bronchitis. Sufferers usually have a cough of long standing. If the cough is troublesome, give codeine sulfate, 15 mg (half a tablet), repeated after 4 hours if necessary.

Superimposed on his chronic condition, a patient may also have an attack of acute bronchitis, for which treatment (as above) should be given. If this occurs, the body temperature is usually raised and there is a sudden change from a clear, sticky or watery sputum to a thick yellow sputum. Anyone with chronic bronchitis should seek medical advice on reaching his home port.

Cough

Coughing is a sudden forceful expulsion of air from the lungs, usually in a series of efforts. Although annoying, a cough helps to get rid of phlegm (sputum) that builds up in air passages.

Coughs may be productive (of sputum) or nonproductive (dry). The sputum may be purulent (with pus), copious or scanty, thick or thin and fluid, clear or frothy, odourless or foul-smelling, blood-streaked or manifestly bloody. A cough may be acute or chronic, occasional or persistent, slight or severe, painful or painless.

Coughing is not a disease in itself but a symptom. An acute cough is usually caused by an infection of the upper respiratory system. A productive cough that lasts for more than 3 months frequently means that the patient is suffering from chronic bronchitis, even though he does not recognize that he is ill until he becomes short of breath. Because of cigarette-smoking and air pollution, thousands of people become victims of chronic bronchitis and eventually of emphysema. Chronic cough with fever suggests a more serious condition, such as tuberculosis, pneumonia, or even carcinoma of the lung. Chronic cough without fever may indicate heart disease, bronchial asthma, or bronchiectasis (infection and degeneration of the air passages). In all cases of chronic cough, a doctor on shore should be consulted.

The following general observations may be helpful.

- Simple bronchitis usually follows a viral infection or "cold" that is accompanied sometimes by a sore throat, a raw heavy feeling behind the breastbone, and a dry cough that changes into a productive cough.
- Pleurisy is manifested by a severe pain in the chest wall that is aggravated by deep breathing.
- With pneumonia, there is usually fever, often a productive cough with pus or sputum, and pain in the chest.
- Tuberculosis of the lungs may be associated with a slight but prolonged cough.
- Cancer of the lung has become alarmingly frequent in persons who have been heavy smokers. Early diagnosis of cancer is difcult but cough, spitting blood, persistent fever, and loss of weight may be early warnings.

When a cough accompanies an acute illness, especially when there is fever, a full history should be obtained from the patient. After examining the patient and his sputum, the most likely cause of the illness should be determined. Prepare a request to obtain RADIO MEDICAL ADVICE.

Treatment

Coughs due to colds and viral bronchitis are treated symptomatically with acetylsalicylic acid, as described under Bronchitis.

For persistent and severe coughing accompanying respiratory infections, give half of a 30-mg tablet of codeine, several times a day, if necessary.

Specific treatment should be directed to the cause of the illness. The patients pulse, temperature, and rate and depth of respiration should be noted.

Asthma

Asthma is a disease in which the patient suffers from periodic attacks of difficulty in breathing out and a feeling of tightness in the chest, during which time he wheezes and feels as if he were suffocating.

The causes of asthma are usually:

• exposure to irritants to which the sufferer is sensitive-these may be either inhaled (e.g., dust, acrid fumes, or simply cold air) or ingested (e.g., shellfish or eggs);

• mental stress in highly strung and over conscientious persons;

• certain chest diseases, such as chronic bronchitis.

Asthma may begin at any age. There is often a previous history of attacks from time to time in the patients life.

The onset of an attack may be slow and preceded by a feeling of tightness in the chest, or it may occur suddenly. Sometimes the attack occurs at night when the patient has been lying flat.

In the event of a severe attack, the patient is in a state of alarm and distress, unable to breathe properly, and with a sense of weight and tightness around the chest. He can fill up his chest with air but finds great difculty in breathing out, and his efforts are accompanied by coughing and wheezing noises due to narrowing of the air tubes within his lungs. His distress increases rapidly in severe cases, and he sits or stands as near as possible to a source of fresh air, with his head thrown back and his whole body heaving with desperate efforts to breathe. His lips and face, at first pale, may take on a blue tinge and be covered with sweat, while his hands and feet become cold. His pulse is rapid and weak, and may be irregular. Fortunately, less severe attacks, without such great distress, are more common.

An attack may last only a short while, but it may be prolonged for many hours. Eventually, however, the breathing gradually becomes easier, and coughing may then produce some sputum. After an attack, the patient may be exhausted, but very often he appears to be, and feels, comparatively well. Unfortunately this relief may only be temporary and attacks may recur at varying intervals.

Asthma must not be confused with choking due to a patient having inhaled something, for instance food, into his windpipe. In choking symptoms occur immediately.

Treatment General treatment

The patient should be put to bed in a position he finds most comfortable, which is usually half sitting up. If he is emotionally distressed, try to calm him.

In severe cases of asthma, RADIO MEDICAL ADVICE should be obtained.

Specific treatment

A person who knows that he is liable to attacks has usually had medical advice and been supplied with a remedy. In such cases the patient probably knows what suits him best, and it is then wise merely to help him as he desires and to interfere as little as possible. He should be allowed to select the position easiest for himself.

A bedside vaporizer or turned-on hot shower should be used to humidify the air that is inhaled by the patient with asthma. To offset possible dehydration, the patient should be encouraged to drink plenty of fluids, especially water. More palatable liquids such as fruit juices and hot tea may be helpful.

Medicaments to enlarge the air passageways (bronchodilators), such as ephedrine sulfate, 25 mg, should be given by mouth every 4-6 hours. If the patient is unduly nervous or unable to sleep, 15-30 mg of phenobarbital should be given by mouth every 4-6 hours.

For acute asthmatic episodes, 0.3 ml to 0.5 ml of aqueous epinephrine hydrochloride injection 1:1000 should be given subcutaneously and, if necessary, repeated after 60 minutes.

After obtaining RADIO MEDICAL ADVICE on treatment, a 500-mg aminophylline suppository may be used. The use of a suppository should be restricted to only one or two occasions because repeated usage might cause severe rectal irritation.

Antibiotics may be given in acute asthma, because most adult asthma patients will have a bronchial infection that may or may not be apparent. RADIO MEDICAL ADVICE should be obtained as to whether antibiotics are indicated.

If all or some of the above procedures are used, most acute asthma attacks can be treated adequately.

Pneumonia-lobar pneumonia

Lobar pneumonia is an inflammation of one or more lobes of the lung. It may have a rapid onset over a period of a few hours in a previously fit person, or it may occur as a complication during the course of a severe cold or an attack of bronchitis.

The patient is seriously ill from the onset, with fever, shivering attacks, cough, and a stabbing pain in the chest made worse by breathing movements or the effort of coughing. The breathing soon becomes rapid and shallow, and there is often a grunt on breathing out. The rapidity of the shallow breathing leads to deficient oxygenation of the blood with consequent blueness of the lips. The cough is at first dry, persistent, and unproductive, but within a day or two thick, sticky sputum is coughed up; this is often tinged with blood, giving it a "rusty" appearance. The temperature is usually as high as 39-40.5 °C, the pulse rate 110-130, and the respiration rate is always increased to at least 30 and sometimes even higher.

Treatment General treatment

Put the patient to bed at once and follow the instructions for bed patients (page 98). The patient is usually most comfortable and breathes most easily if propped up on pillows at 45°. Provide a beaker for sputum, and measure and examine the appearance of the sputum.

Encourage the patient to drink (water, tea, fruit juice) because he will be losing a lot of fluid both from breathing quickly and from sweating. Encourage him to eat whatever he fancies.

Specific treatment

RADIO MEDICAL ADVICE should be obtained on the medication suggested below.

Give two 250-mg ampicillin capsules every 6 hours for the first 2 days, and then one capsule every 6 hours for the next 5 days.

If the patient is allergic to ampicillin, give 2 tablets of sulfamethoxazole + trimethoprim every 12 hours for 5 days. Acetylsalicylic acid or paracetamol tablets can be given to relieve pain (2 tablets of either of these drugs, repeated every 6 hours, if necessary).

Subsequent management

The patient should be encouraged to breathe deeply as soon as he is able to do so and be told not to smoke. Patients who have had pneumonia should be kept in bed until they are feeling better and their temperature, pulse, and respiration are normal. Increasing activity and deep breathing exercises are helpful in getting the lungs functioning normally after the illness. Patients who have had pneumonia should not be allowed back on duty until they have seen a doctor.

Pleurisy

Pleurisy is inflammation of the pleural membranes that line the chest cavity and surround the lungs. Often it is associated with bronchitis, pneumonia, and tuberculosis.

The onset of pleurisy is usually sudden with a cough and a sharp stabbing pain in the chest. The pain is made worse by breathing or coughing and relieved by preventing movement of the affected side.

If a pleurisy occurs without the other signs of pneumonia (see page 221), get RADIO MEDICAL ADVICE. All cases of pleurisy, even if recovered, should be seen by a doctor at the first opportunity.

Shingles, severe bruising, or the fracture of a rib, or muscular rheumatism in the chest wall may cause similar pain, but the other features of pleurisy will not be present and the patient will not be generally ill.

Pleural effusion (fluid round the lung)

In a few cases of pleurisy the inflammation causes fluid to accumulate between the pleural membranes at the base of a lung. This complication should be suspected if the patient remains ill but the chest pain becomes less and chest movement is diminished on the affected side by comparison with the unaffected side.

General treatment

If pneumonia is present follow the instructions on page 221. Otherwise, confine the patient to bed. If there is difficulty in breathing, put the patient in the half sitting-up position or in the leaning forward position with elbows on a table. Get RADIO MEDICAL ADVICE.

Abdominal pain Minor abdominal conditions

This group of conditions includes indigestion, "wind", flatulence, mild abdominal colic (spasmodic abdominal pain without diarrhoea and fever), and the effects of overindulgence in food or alcohol. The patient can often tell quite a lot about the possible causes of his minor abdominal conditions or upsets, so always encourage him to tell you all he can. Ask about intolerance to certain foods, such as fried foods, onions, sauces, and other spicy foods, any tendency to looseness, diarrhoea, or constipation, and any regularly felt type of indigestion and any known reasons for it. Mild abdominal pain will usually cure itself if the causes) can be understood and removed.

Guard against total acceptance of the patients explanation of the causes of his pain until you have satisfied yourself, by examining his abdomen, that he is not suffering from a serious condition. Note that a peptic ulcer may sometimes start with symptoms of slight pain.

General management

The patient should be put on a simple diet for 1-2 days, and given 2 aluminium hydroxide tablets three times a day. Repeat these at night, if the patient is in pain. If the condition does not resolve itself within two days of starting this regime, get RADIO MEDICAL ADVICE. Anyone who has persistent or unexplained mild abdominal symptoms should be seen by a doctor at the next port.

Abdominal emergencies

Abdominal emergencies such as appendicitis and perforated gastric or duodenal ulcer are high on the list of conditions that, ashore, would be sent to hospital for surgical treatment. While there is no doubt that early surgical treatment is usually best, this does not mean that other forms of treatment are unsuitable or ineffective. In most abdominal emergencies on board a ship at sea, surgical treatment is usually neither advisable nor possible, Note that in the very early stages of abdominal conditions such as appendicitis or perforated ulcers, diarrhoea, vomiting, headaches, or fevers are seldom present other than in a mild form. If these symptoms are present, the illness is much more likely to be a diarrhoea and vomiting type of illness.

Examination of the abdomen

The abdomen should be thoroughly examined. The first thing to do is to lay the patient down comfortably in a warm, well-lit place. He should be uncovered from his nipples to the thigh and the groin should be inspected (see Hernia, page 207). Look at the abdomen and watch if it moves with the patients breathing. Get the patient to take a deep breath and to cough; ask him if either action causes him pain and, if so, where he felt it and what it was like. Probably, if the pain is sharp he will point with his finger to the spot, but if it is dull he will indicate the area with the flat of his hand.

Look for any movement of the abdominal contents and note if these movements are accompanied by pain and/or by loud gurgling noises. Note if the patient lies very still and appears to be afraid to move or cough on account of pain or if he writhes about and cries out when the pain is at its height. Spasmodic pain accompanied by loud gurgling noises usually indicates abdominal colic or bowel obstruction. When the patient lies still with the abdomen rigid, think in terms of perforated appendix or perforation of a peptic ulcer.

Bowel sounds

When you have completed your inspection, listen to the bowel sounds for at least two minutes by placing your ear on the abdomen just to the right of the navel.

- Normal bowel sounds occur as the process of normal digestion proceeds. Gurgling sounds will be heard at intervals, often accompanied by watery noises. There will be short intervals of silence and then more sounds will be heard -at least one gurgle should be heard every minute.
- Frequent loud sounds with little or no interval occur when the bowels are "working overtime", as in food poisoning and diarrhoea to try to get rid of the "poison", and in intestinal obstruction (total or partial, page 210) to try move the bowel contents.

The sounds will be loud and frequent and there may be no quiet intervals. The general impression may be one of churning and activity. At the height of the noise and churning, the patient will usually experience colicky pain which, if severe, may cause him to move and groan.

- Absence of bowel sounds means that the bowel is paralysed. This condition is found with peritonitis following perforation of an ulcer or of the appendix, or serious abdominal injuries. The outlook is always serious. RADIO MEDICAL ADVICE is required, and the patient should go to a hospital ashore as soon as possible.

When you have learned all that you can by looking and listening-and this takes time-you should then feel the abdomen with a warm hand. Before you start, ask the patient not to speak, but to relax, to rest quietly, and to breathe gently through his open mouth so that his abdominal muscles will be as relaxed as possible. Then begin your examination by laying your hand flat on the abdomen away from the areas where the patient feels pain or complains of discomfort. If you examine the pain-free areas first, you will get a better idea of what the patients abdomen feels like in a part that is normal. Then, with your palm flat and your fingers straightened and kept together, press lightly downwards by bending at the knuckle joints. Never prod with the fingertips. Feel systematically all over the abdomen, leaving until last those areas that may be "bad" ones. Watch the patients face as you feel. His expression is likely to tell you at once if you are touching a tender area. In addition you may feel the abdominal musclés tensing as he tries to protect the tender part. When you have finished your examination, ask him about the pain and tenderness he may have felt. Then make a written note of all that you have discovered.

The urine of any patient suffering from abdominal pain or discomfort should always be examined and tested.

Peptic ulcer

A peptic ulcer is an open sore, usually benign, that occurs in the mucous membrane of the inner wall of the digestive tract in or near the stomach. Peptic ulcers are of two types: (1) gastric ulcers, which occur in the stomach, and (2) duodenal ulcers, which form in the duodenum, the first section of the small intestine. Although the cause of these ulcers is obscure, excessive secretion of hydrochloric acid and gastric juice in the stomach is an important factor in their production.

In normal digestion, both the stomach and duodenum are exposed to the action of the gastric juice. Oversecretion of the acidic gastric juice is a prime factor in the production of duodenal ulcers and the reactivation of healed ulcers. Emotional strain, due to suppressed anger or other psychological problems, is a contributing factor to ulcer formation. Certain medicaments (such as acetylsalicylic acid) or excessive use of alcoholic beverages may cause ulcers.

A shallow ulcer may heal within a short time, but more often it becomes deep-seated and causes recurring bouts of indigestion and pain.

At first, discomfort is noticed about three hours after meals at a point half-way between the navel and the breastbone in the mid-line or slightly towards the right side. Within days or weeks, the discomfort develops into a gnawing pain associated with a feeling of hunger occurring 1-3 hours after meals. Sleep is often disturbed by similar pain in the early part of the night. The pain is relieved temporarily by taking food or indigestion medicine. Vomiting is uncommon, but acidic stomach fluid is sometimes regurgitated into the mouth ("heartburn"). The appetite is only slightly diminished, and weight loss is not marked. Bouts of indigestion lasting weeks or months alternate with symptom-free periods of variable length. With gastric ulcers, pain tends to come on sooner after a meal and vomiting is more common than with duodenal ulcers.

On examination of the abdomen, tenderness localized to the area mentioned above will be found by gentle hand pressure.

The symptoms of the peptic ulcer may be similar to those of other disorders of the digestive tract, such as indigestion (see page 209), and diseases of the liver, gallbladder, and right kidney.

Treatment

The patient should rest in bed but may be allowed up for washing and meals. Frequent small meals of bland food should be provided, with milk drinks in between. Tobacco and alcohol should not be allowed. One aluminium hydroxide tablet should be given half way between meals. Pain relief tablets are not necessary, and acetylsalicylic acid, which often irritates the gut, should never be given. The patient should be sent to a doctor at the next port for full investigation.

Complications

The ulcer may extend through the thickness of the gut wall, causing a hole (perforation), or it may erode the wall of a blood vessel, causing serious internal bleeding.

Bleeding peptic ulcers

Most peptic ulcers, gastric or duodenal, have a tendency to bleed, especially if they are longstanding. The bleeding may vary from a slight oozing to a profuse blood loss which may endanger life. The blood always appears in the faeces.

Small amounts may not be detected but larger amounts of digested blood turn the faeces, which may be solid or fluid, black and tarry. In some cases fresh, bright red blood may be vomited, but when there is partially digested blood, the vomit looks like coffee grounds.

The patient usually has a history of indigestion, and sometimes the symptoms may have increased shortly before haemorrhage takes place.

General treatment

The patient must be put to bed at once and should be kept at rest to assist clot formation (see Internal bleeding, page 40). Obtain RADIO MEDICAL ADVICE, and get the patient to hospital as soon as possible.

A pulse chart should be started, since a rising pulse rate would be an indication for urgent hospital treatment. The patient should be given nothing by mouth during the first 24 hours, except sips of iced or cold water. After the first 24 hours, small amounts of milk or milky fluids can be given with 15-30 ml of milk each hour for the first 12 hours. This amount can then be doubled, provided that the patients condition is not getting worse.

Specific treatment

Give 15 mg of morphine (l'/z 10-mg ampoules) intramuscularly at once, then give 10-15 mg every 4-6 hours, depending on the response to treatment, which aims at keeping the patient quiet, at rest, and free from worry.

If bleeding continues at a worrying rate, which will be indicated by a rising pulse rate and a deterioration in the patients condition, all that can be done is to try to get the patient to hospital as quickly as possible and to attempt to meet fluid requirements by giving fluids intravenously. Get RADIO MEDICAL ADVICE. A fluid input/output chart (page 102) should be started.

Perforated ulcer

When perforation occurs, there is a sudden onset of agonizing abdominal pain, felt at once in the upper central part before spreading rapidly all over and accompanied by some degree of general collapse and sometimes vomiting. The patient is very pale and apprehensive and breaks out in a profuse cold sweat. The temperature usually falls, but the pulse rate is at first normal or slow, although weak. The patient lies completely still either on his back or side, with his knees drawn up, and he is afraid to make any movement which might increase his agony-even talking or breathing movements are feared, and questioning is often resented.

Large perforations produce such dramatic symptoms that the condition is unlikely to be mistaken for others causing abdominal pain, in which the patient is likely to move about in bed and cry out or complain when pain increases. The pain is most severe just after perforation has occurred, when the digestive juices have escaped from the gut into the abdominal cavity. However, after several hours, the pain may become less severe and the state . of collapse be less marked but this apparent recovery is often short-lived.

On feeling the abdomen with a flat hand, the abdominal muscles will be found to be completely rigid-like feeling a board. Even light hand pressure will increase the pain and be resented by the patient, especially when the upper abdomen is felt. It will be seen that the abdomen does not take part in breathing movements. The patient cannot relax the abdominal muscles, which have been involuntarily contracted by pain.

As the size of a perforation can vary from a pinhole to something much larger in diameter, a small perforation may be confused with appendicitis because the pain begins centrally. But:

- with a perforated ulcer, the pain is usually in the upper middle abdomen at first and not around the navel as in appendicitis;
- with a perforated ulcer, the central upper pain remains as the main source when the pain starts to be experienced elsewhere, whereas in appendicitis the pain moves, the central colicky pain becoming a sharp pain in the right lower quarter of the abdomen; and
- a patient with a perforation usually has a history of previous indigestion, but this does not apply to patients with appendicitis.

General treatment

It is essential that the patient should be transferred to hospital as quickly as possible. Get RADIO MEDICAL ADVICE. The patient should be strictly confined to bed. A temperature, pulse, and respiration chart should be started with readings every hour for the first 24 hours and then every 4 hours. The perforation may close naturally if nothing is given by mouth for the first 24 hours.

Specific treatment

It is essential to achieve adequate pain relief, so give 15 mg of morphine (11/2 10-mg ampoules) intramuscularly at once. In a case of severe pain not satisfactorily controlled by such an injection, a further injection may be given within the first hour. Thereafter, the injection should not be repeated more frequently than every 4 hours. Acetylsalicylic acid tablets must never be given.

All patients, unless sensitive to penicillin, should be given procaine benzylpenicillin, 600 000 units intramuscularly, at once, followed by the same dose every 12 hours until the patient is seen by a doctor. 1f the patient is sensitive to penicillin, wait for 24 hours before commencing standard antibiotic treatment with erythromycin.

Subsequent management

After the first 24 hours, if progress is satisfactory, a small amount of milk or of milk and water in equal proportions can be given. Start with 15-30 ml of fluid each hour for the first 12 hours. The amount can then be doubled, provided the pain does not become worse. If milk is well tolerated, increasing amounts can be given frequently. Apart from milk and water, the patient should consume nothing until he is in hospital ashore.

Peritonitis

Peritonitis is an inflammation of the thin layer of tissue (the peritoneum) that covers the intestines and lines the inside of the abdomen. It may occur as a complication of appendicitis after about 24-48 hours or of certain other serious conditions (e.g., perforation of a peptic ulcer).

The onset of peritonitis may be assumed when there is a general worsening of the condition of a patient already seriously ill with some abdominal disease. It commences with severe pain all over the abdomen-pain which is made worse by the slightest movement. The abdomen becomes hard and extremely tender, and the patient draws up his knees to relax the abdominal muscle. Vomiting occurs and becomes progressively more frequent, large quantities of brown fluid being brought up without any effort. The temperature is raised (up to 39 °C or above) and the pulse is feeble and rapid (110-120), gradually increasing in rate. The pallid anxious face, the sunken eyes, and extreme general weakness all confirm the gravely ill state of the patient. If hiccoughs begin, this must be regarded as a very serious sign.

Treatment

Peritonitis is a very serious complication of abdominal disease, so get RADIO MEDICAL ADVICE and deliver the patient to hospital as soon as possible, Until this can be done, manage the illness as follows.

- Treat the infection. Give procaine benzylpenicillin, 1 200 000 units intramuscularly, and metronidazole, 200 mg, at once; then give procaine benzylpenicillin, 600 000 units intramuscularly, every 12 hours and metronidazole, 100 mg, every 8 hours. If the patient is sensitive to penicillin, give erythromycin, 500 mg, and metronidazole, 200 mg, at once, and then erythromycin, 250 mg, every 6 hours and metronidazole, 100 mg, every 8 hours. If the patient was being treated for appendicitis, this means changing to intramuscular injections of penicillin but continuing with the metronidazole.

- Correct dehydration. Following RADIO MEDICAL ADVICE, intravenous fluid may be given, if necessary. Keep a fluid input/ output chart (page 102). If thirst continues, cautiously allow sips of water.
- Keep regular records. Make notes of the patients temperature, pulse, and respiration every hour, and of any change for better or worse in his condition

Skin and Eye

See specific Lesson 7_01 INJURIES TO SKIN AND EYES

Stroke and paralysis (cerebrovascular accident)

Stroke

A stroke occurs when the blood supply to some part of the brain is interrupted. This is generally caused by:

- a blood clot forming in the blood vessel (cerebral thrombosis)
- a rupture of the blood vessel wall (cerebral haemorrhage)
- obstruction of a cerebral blood vessel by a clot or other material from another part of the vascular system (cerebral embolism)
- pressure on a blood vessel, e.g., by a tumour.

A stroke can be a complication of high blood pressure.

A stroke generally occurs suddenly, usually in middle-aged or old people, without warning signs. In more severe cases, there is a rapidly developing loss of consciousness and a flabby, relaxed paralysis of the affected side of the body. Headache, nausea, vomiting, and convulsions may be present. The face is usually flushed, but may become pale or ashen. The pupils of the eyes are often unequal in size. The pulse is usually full and rapid, and breathing is laboured and irregular. The mouth may be drawn to one side and often there is difficulty in speaking and swallowing.

The specific symptoms will vary with the site of the lesion and the extent of brain damage. In mild cases, there may be no loss of consciousness and paralysis may be limited to weakness on one side of the body.

In a severe stroke there is loss of consciousness, the breathing is heavy and laboured, and the patient may lapse into a coma and die.

The outcome of a stroke will depend upon the degree of brain compression or damage. When it is fatal, death usually occurs in 2-14 days and seldom at the time of the attack. Most patients with first or second attacks recover, but recurrent attacks are likely. The extent of permanent paralysis will not be determined for at least 6 months.

Treatment

Good nursing care is essential after a stroke. The patient should be undressed as gently as possible and placed in bed with the trunk of the body, shoulders, and head elevated slightly on pillows. An attendant should be assigned to stay with the patient. Extra care should be taken to prevent the patient from choking on saliva or vomit. The patient's head should be turned to one side so that fluids can flow out of the mouth. Mucus and food debris should be removed from the mouth with a piece of cloth wrapped round a finger. If there is fever, cold compresses should be applied to the forehead. If the patient is conscious and able to swallow, liquid and soft foods may be given. To prevent bedsores the patient should be kept clean and turned to a different position in bed every 3-1 hours. Bowel regularity should be maintained.

RADIO MEDICAL ADVICE must be obtained, and early evacuation to hospital should be anticipated.

Colds (common cold, coryza, rhinitis)

The symptoms of the common cold are: temperature, runny nose, red and watery eyes, malaise, aching muscles, chilliness, and often a sore scratchy throat and cough. A cold lowers a person's resistance to other diseases and permits secondary infections. Symptoms of a cold may precede many communicable diseases, so the patient should be watched carefully for other symptoms of these diseases. A septic sore throat may start as a cold. A cold may lead to bronchitis, pneumonia, and middle-ear disease.

Treatment

Unless symptoms develop that indicate a more serious disease, the treatment for a cold should be symptomatic. The patient should be kept in bed until the temperature is normal and he feels reasonably able to function. Acetylsalicylic acid, 600 mg, should be given by mouth every 3-4 hours to help relieve the symptoms. If it is not well tolerated by the patient, paracetamol, 500 mg, may be tried at the same frequency.

Antibiotics should NOT be given.

The patient should drink plenty of fluids such as water, tea, and fruit juices. He should be advised to blow his nose gently to avoid forcing infectious material into the sinuses and middle ear. When symptoms subside for 24 hours, the patient should get out of bed but restrict activities for a day or two before returning to full duty. This will also help to stop the spread of the cold to other crew members.

Warning. Anyone who is deaf or slightly deaf as the result of a cold, should not travel by air or go skin-diving.

Sore throat

A common complaint, sore throat may be local or it may be part of a serious illness. Tonsillitis (inflammation of the tonsils) and abscesses in the tissues of the tonsillar area are examples of localized throat conditions. Laryngitis is the inflammation of the voice box. Diphtheretic and streptococcal sore throat are conditions with marked systemic effects. Streptococcal sore throat resembles scarlet fever, but differs from it clinically in the absence of a skin rash.

Most sore throats are associated with the winter ailments of coughs and colds. Some are caused by the inhalation of irritants or the consumption of too much tobacco. Most are relatively mild, though in some the tonsils or larynx may be inflamed.

Tonsillitis

This is the inflammation of the tonsils, the fleshy lumps on either side of the back of the throat. The symptoms are soreness of the throat, difficulty and pain in swallowing, and a general feeling of being ill with headache, chilliness, and aches all over, all of which come on fairly suddenly. The patient may find it difcult to open his mouth. He also looks ill and has a flushed face. The tonsils will be swollen, red, and covered with many yellow spots or streaks containing pus. The tonsillar lymph glands become enlarged and can be felt as tender swellings behind the angles of the jaw on one or both sides.

The temperature and pulse rate are normally raised. If treatment does not appear to be helping after 2-3 days, glandular fever should be considered as an alternative diagnosis. Feel in the armpits and groin for enlarged glands indicating glandular fever.

Laryngitis

This is inflammation of the voice box, or larynx, the area that includes the Adam's apple. In addition to the more general causes mentioned for sore throat, the inflammation may be caused by overuse of the voice. There is generally a sense of soreness of the throat, pain on swallowing, and a constant dry irritating cough, while the voice is usually hoarse and may be lost altogether. Usually the temperature is found to be normal, and the patient does not feel ill. Occasionally, however, there is a slight fever, and in other cases bronchitis may be present.

General treatment for sore throats

Take the patients temperature, and feel for tender enlarged glands in the neck.

Patients with sore throats should not smoke.

For simple tonsillitis or sore throat, gargling with warm salt water (a teaspoonful of salt to half a litre of water) every 3 hours may be all that is needed.

Give patients with only a mild sore throat, and no general symptoms of illness and fever, acetylsalicylic acid or paracetamol to relieve the pain.

Mild sore throats should NOT be treated with antibiotics.

Patients with tonsillitis, or a sore throat accompanied by fever, whose glands are swollen and who feel generally unwell should be put to bed and can be given paracetamol and a gargle as above.

Give patients not allergic to penicillin one injection of 600 000 units of procaine benzylpenicillin intramuscularly, and follow this after 12 hours with the standard antibiotic treatment.

Subsequent management

Keep a check on the general condition of the patient and keep a record of his temperature, pulse, and respiration. Recovery will usually begin within 48 hours, and the patient can be allowed up when his temperature is down and he feels better.

Peritonsillar abscess (see below) can be a complication following tonsillitis.

Peritonsillar abscess (quinsy)

This is an abscess that can follow tonsillitis. It forms normally round one tonsil, and the swelling pushes the tonsil downwards into the mouth. The patient may find it so difcult and painful to swallow that he may refuse to eat. He may have earache on the aflected side. The swelling on the tonsil will be extremely tender, and a finger pressing gently inwards just below and behind the angle of the jaw will cause pain. There is usually fever, sometimes quite high (up to 40 °C). The throat will be red and a swelling will be seen above the tonsil on the affected side.

General treatment

The patient should be put to bed and his temperature, pulse, and respiration taken and recorded every 4 hours. Give a liquid diet or minced food in a sauce, as solids are usually painful to swallow. Ice-cold drinks are much appreciated as they dull the pain and thus allow some fluid and nourishment to be taken.

Specific treatment

Give the patient one intramuscular injection of 600 000 units of procaine benzylpenicillin unless the patient is allergic to penicillin, and immediately start the standard antibiotic treatment.

If the patient cannot swallow whole tablets he may be able to take them ground up in water or in a teaspoonful of honey. If swallowing is impossible and the patient is not allergic to penicillin, give procaine benzylpenicillin, 600 000 units intramuscularly, every day for 5 days.

Give 2 acetylsalicylic acid or paracetamol tablets every 6 hours to relieve the pain.

Subsequent management

A peritonsillar abscess may settle down with treatment, or it may burst. The patient should be told that the abscess will be very painful before it bursts, and that when the abscess does break there will be severe pain, followed by a discharge of pus which should be spat out. The patient should be given a mouthwash of water to gargle with after the abscess breaks. Soon after the abscess has broken, the patient will feel much better and he can be allowed up when his temperature has remained normal for 24 hours.

Sinusitis

Sinusitis is the inflammation of the accessory sinuses (hollows) of the skull. These communicate with the nose through small openings. The larger sinuses in both cheek bones (maxillary) and in the forehead (frontal) are most commonly affected Sinusitis usually begins suddenly, often during or just after a common cold. The small opening of one or more sinuses becomes blocked and pus will be trapped in the cavity, causing local tenderness, pain, and fever. The condition is often worse on waking and gradually diminishes throughout the day.

Maxillary sinusitis

The pain is felt in the cheek bone and is increased by pressing firmly on the bone or by tapping with a finger on the bone. The pain is usually made worse when the patient bends forward. There is often a foul-tasting and -smelling discharge into the back of the mouth and nose. Sometimes the eye on the affected side is bloodshot.

Frontal sinusitis

The pain is felt round the bony ridge which lies under the eyebrow, and firm pressure there, and sometimes inward pressure on the corner of the eye socket next to the nose, will cause tenderness. There may be an intermittent nasal discharge of pus from the infected sinus. The patient is usually feverish and feels unwell. Sometimes the eye on the affected side is bloodshot.

Treatment

The patient should be put to bed and kept there until his temperature has been normal for 24 hours. He should be told not to blow his nose but to wipe it. Apart from being painful, blowing the nose may force the infection further back and make the disease worse.

Hot, moist compresses or a hot-water bag may be applied over the forehead, nose, and cheeks to help relieve discomfort or pain.

For pain relief, see section on analgesics.

The patient should be told not to travel by air or to skin-dive until allowed to do so by a doctor.

If the sinusitis continues for more than a few days or recurs frequently, the patient should be advised to consult a doctor at the next port of call.

Dental emergencies

The following dental first aid procedures are intended to relieve pain and discomfort until professional care is available.

Bleeding

Bleeding normally occurs following removal of a tooth. However, prolonged or profuse bleeding from a tooth socket must be treated.

Treatment

To treat bleeding, excessive blood and saliva should be cleared from the mouth. Then, a piece of gauze 5 cm x 5 cm, should be placed over the extraction site and biting pressure applied by the patient. It is important to fold the gauze to a proper size well adapted to the extraction site. The pad should be left undisturbed for 3-5 minutes, then replaced as necessary. Once bleeding has stopped, the area should be left undisturbed. If bleeding is difficult to control, a piece of gauze, 5 cm x 5 cm twisted into a thin cone shape or rolled (see Fig. 126) should be packed into the site and a second gauze pressure pack placed over it. The patient should apply biting pressure for 30 minutes to 1 hour and continue biting if necessary. The mouth should not be rinsed for 24 hours. A soft diet should be maintained for two days.

Lost fillings

Fillings may come out of teeth because of recurrent decay around them, or a fracture of the filling or tooth structure.

Treatment

If pain is absent, no treatment will be required for a lost filling and the patient should be advised to see a dentist when in port. If the tooth is sensitive to cold, a temporary dressing should be put into the cavity. First, the tooth is isolated by placing a 5 cm x 5 cm piece of gauze on each side. A cotton pellet can be used to dry the cavity. A drop of oil of cloves should be placed on cotton and gently pressed into the cavity; this will usually control the pain and may be repeated 2 or 3 times daily as necessary.

Toothache without swelling

This condition is usually caused by irritation or infection of the dental pulp from a cavity, lost filling, or a recurrent problem in a tooth that has a filling in place.

Treatment

The patient who has a toothache without swelling of the gums or face should be advised to chew on the other side of his mouth. Foods should not be too hot or too cold. Pain may be relieved with acetylsalicylic acid, 600 mg by mouth. If the patient does not tolerate this drug, a 500-mg paracetamol tablet should be given. The patient with a toothache should be told to swallow the acetylsalicylic acid and never to hold the tablets in the mouth as this will burn the soft tissues. If the aching tooth has a large cavity, the instructions for placing a sedative cotton dressing, described on page 184, under Lost fillings, should be followed.

Toothache with swelling

Toothache with swollen gums or facial tissue is often the result of infection by tooth decay that involves the dental pulp and spreads into the tissues of the jaws through the root canals. The condition is also common as a result of infections associated with diseases of the gums, periodontal membrane, and the bone that supports the teeth. In all cases, there is frequently pain, swelling, and the development of an abscess with pus formation.

Treatment

The patient with mouth and facial swelling should be observed closely and the following data noted: (1) the exact area of the swelling, initially and during the illness; (2) the type of swelling, whether soft, firm, or fluctuant (movable tissue containing a pus-filled cavity); (3) degree of difficulty in opening and closing the mouth; and (4) the oral temperature, morning and night. These data are important for following the patient's progress and evaluating the effectiveness of the treatment.

The pain should be controlled with acetylsalicylic acid as described above under Toothache without swelling.

For infection, an initial dose of 500 mg of phenoxymethyl penicillin potassium should be given by mouth, followed by 250 mg every six hours. If the patient is allergic, or suspected of being allergic, to penicillin, oral erythromycin should be used in the same dosage and frequency. The patient should be kept on the antibiotic for at least 4 days after he becomes a febrile (without fever). He should be instructed to see a dentist at the earliest opportunity.

The patient should be advised to rinse the mouth with warm saline solution (a quarter teaspoonful of table salt in 200 ml of warm water) for 5 minutes of each waking hour. This will cleanse the mouth and help to localize the infection in the mouth. Also, saline solution may produce earlier drainage and relief from pain. After the pain and swelling subside, the oral rinsing should be continued until the patient is seen by a dentist.

Dental infection

Dental infection usually occurs when decay extends into the pulp of the teeth. Bacteria from the mouth will enter the tissues of the jaws via the canal in the tooth's root. The infection may remain mild or may progress to a swelling in the mouth or face, after producing fever, weakness, and loss of appetite.

Treatment

Discomfort from a dental infection may be controlled with acetylsalicylic acid, 600 mg by mouth. If the patient does not tolerate acetylsalicylic acid, a 500-mg paracetamol tablet should be given. Antibiotics are used as described in the section Toothache with swelling, but RADIO MEDICAL ADVICE should be obtained beforehand.

Painful wisdom tooth (pericoronitis)

Pericoronitis is an infection and swelling of the tissues surrounding a partially erupted tooth, usually a wisdom tooth (third molar). Often a small portion of the crown or a cusp of the offending tooth can be seen through the soft tissues. The soft tissues appear swollen and the degree of inflammation or redness may vary considerably. When the infection is severe, the patient may complain of difficulty in opening the mouth. When the area is examined carefully, pus may be found coming from underneath the soft tissues in the area of the partially erupted tooth.

Treatment

For a painful wisdom tooth, the area between the crown of the tooth and the soft tissues should be flushed with warm saline solution (a quarter teaspoonful of table salt in 200 ml of warm water). In addition, the patient should be treated as directed under Toothache with swelling.

Trench mouth (Vincent's infection)

Vincent's infection is a generalized infection of the gums. During the acute stage it is characterized by redness and bleeding of the gums. Usually there is a film of greyish tissue around the teeth. There is usually a very disagreeable odour and a foul metallic taste in the mouth. The acute stage may be accompanied by a moderately high fever. Lymph glands in the neck may be swollen.

Treatment

The patient should be advised to eat an adequate diet but avoid hot or spicy foods. The fluid intake should be increased.

For pain, 600 mg of acetylsalicylic acid should be given by mouth every 3-4 hours as needed. If it is not well tolerated by the patient, try 500 mg of paracetamol at the same frequency.

For infection, an initial dose of 500 mg of phenoxymethyl penicillin potassium should be given by mouth, followed by 250 mg every 6 hours. If the patient is allergic, or suspected of being allergic, to penicillin, oral erythromycin should be given at the same dosage. The patient should be kept on the antibiotic until at least 4 days after the fever has gone. He should be instructed to see a dentist at the earliest opportunity.

Denture irritation

Generalized inflammation in the denture area is usually due to poor oral hygiene. Inflammation in localized areas usually requires some alteration or adjustment of the denture by a dentist. These localized areas are usually located where the border of the denture rests against the tissues.

Treatment

The patient should avoid using the denture until the soft tissues have healed. The denture should be cleaned carefully with mild soap and water and stored in a water-filled container to avoid dehydration of the base material. The patient should be referred to a dentist for appropriate adjustment of the denture.

Urinary problems

Urinary system

The urinary system produces urine to rid the body of certain wastes that result form cellular action. Urine is normally composed of water and salts, but in certain illnesses, sugar, albumin (a protein), cells, and cellular debris also may be present. Identifying the composition of urine is helpful in the diagnosis of some illnesses.

The urinary system includes two kidneys (where the urine is formed); two ureters (tubes to carry urine from the kidneys to the bladder); the bladder (a reservoir for urine until discharged); and the urethra (the tube that carries the urine from the bladder to the outside of the body) (see Fig. 140).

Kidneys

The kidneys, bean-shaped organs weighing about 200 g each, are on either side of the spinal column in the upper quadrants of the abdominal cavity, at about the level of the last lower rib. The kidneys are deeply embedded in fatty tissue, well protected by the heavy muscles of the back, and are seldom injured except by severe trauma.

The kidneys purify blood and maintain a proper fluid and chemical balance for the body. About 96% of urine is water. The quantity of urine excreted (over one litre daily) and the analysis of its composition (urinalysis) inform the physician whether the kidneys are working properly. When the kidneys fail, the body is poisoned by wastes that cannot be excreted. This uraemia, if not treated properly, may lead to death.

Bladder and urethra

The bladder is a muscular sac. When empty, it lies entirely within the pelvis, behind and beneath the pubis. Because of its vulnerable location, especially when distended, the bladder may be punctured, ruptured, or otherwise injured when the abdomen is struck heavily or the pubis is broken.

The urethra is the canal that empties the urine from the bladder. It also carries male seminal fluid (semen) on ejaculation. Through the external opening of the urethra, bacteria and other organisms may travel to the bladder, to the kidneys by way of the ureters, or to the testicles through the seminal ducts, causing infection of these organs.

Renal colic (kidney-stone colic)

Stones composed of crystals of various salts and other solid particles may form in the kidneys. A stone may remain in the kidney without causing any trouble, but often it causes a dull pain in the loin, accompanied on occasion by passing of blood in the urine. Acute pain (renal colic) does not arise until a stone enters the tube (the ureter) leading from the kidney to the bladder.

The pain, which is agonizing, comes on suddenly. It starts in the loin below the ribs then shoots down to the groin and testicle. Each bout may last up to 10 minutes with a similar interval between bouts. The patient is unable to keep still and rolls about, calling out with each paroxysm of pain. Vomiting and sweating are common. The pulse is rapid and weak but the temperature usually remains normal. An attack usually lasts for several hours before ending, often abruptly, when the stone moves downwards to the bladder

General treatment

The patient should be put to bed.

The first objective for treatment of renal colic is relief of pain. Changes in position may help pass the stone.

Always examine a specimen of urine, when it is available, for clots or frank blood. Test also for protein.

Specific treatment

As soon as possible, mix 15 mg of morphine (l'/z 10-mg ampoules) with 0.5 mg of atropine in the same syringe and inject intramuscularly. The acute pain may not recur, once relieved, but renewed paroxysms of pain are an indication to repeat the injection at intervals of not less than 4 hours.

RADIO MEDICAL ADVICE on further treatment should be obtained.

The patient should be encouraged to drink a glass of water every half hour, or hour, to increase the flow of urine. The urine may be filtered through gauze to see if the stone or stones have been passed.

When the stone is passed, the patient should continue to drink fluids freely. The diet should be liquid or soft for a day or two, or longer if the patient continues to feel ill. If chills and fever occur, indicating infection of the genitourinary tract, sulfamethoxazole + trimethoprim may be indicated (see Inflammation of the bladder and kidneys, below). RADIO MEDICAL ADVICE should be obtained again. The patient should be advised to see a doctor at the next port. The stone, if passed, should be given to the doctor.

Inflammation of the bladder and kidneys (cystitis and pyelitis)

This relatively common inflammation, which may affect the bladder alone (cystitis) or the bladder together with the kidneys (pyelitis), occurs more often in women than men. Predisposing factors are poor hygiene, co-existing disease of the urinary system or genitalia (kidney or bladder stones, urethritis, vaginal discharge), or partial obstruction of the outflow of urine (enlarged prostate gland).

The usual symptoms of cystitis are dull pain in the pit of the abdomen and in the crotch, with a frequent or constant need to pass small quantities of urine, which causes a burning sensation when passed. The temperature is moderately raised and the patient feels generally unwell.

A specimen of the infected urine may contain matter or small amounts of blood. A cloudy appearance and an unusual odour may be noticed.

In contrast to this usual pattern of disease, cystitis can occur without temperature change or general symptoms so that, apart from frequent urination, the patient may not realise that infection is present.

When the kidneys are also inflamed, there will in addition be pain in one or both loins with a high temperature (38-40 °C). The patient will feel very ill with widespread aching, shivering attacks, and even vomiting.

General treatment

In all save the mildest cases, the patient should be put to bed. The temperature, pulse, and respiration should be recorded, and the urine examined daily and tested for protein

Two to four litres of bland fluid should be drunk each 24 hours. Hot baths and heat applied to the lower abdomen will ease the bladder discomfort.

Specific treatment

Give two tablets of sulfamethoxazole + trimethoprim every 12 hours for 7 days. If the response to treatment is unsatisfactory, get RADIO MEDICAL ADVICE.

Acute stoppage or retention of urine

A stoppage is present when a person is unable to urinate even though the bladder is full. Much pain and suffering are caused as the bladder becomes increasingly distended. It can be felt in the lower abdomen as a rounded, tender swelling above the pubic bone and, in severe cases, can extend upwards as far as the navel.

In these cases, there is always some degree of blockage somewhere in the tube (urethra) between the bladder and the external opening. Common causes include localized injury, a scar within the tube (stricture), urinary stone stuck in the tube, holding the water too long (particularly during or after heavy drinking), and, most common in men past middle age, an enlargement of the prostate gland. This enlargement may previously have caused difficulty with urination such as a poor stream, trouble in starting and stopping, dribbling, and a frequent, urgent need to urinate during both day and night.

Acute retention of urine is rare in women.

Treatment

The patient should lie in a hot bath, where he should try to relax and to pass urine. If he has severe discomfort, give 1 S mg of morphine intramuscularly before he gets into the bath. Give him nothing to drink. Keep the bath water really hot. If urination has not occurred within halfan-hour, the penis and genital area should be washed thoroughly in preparation for catheterization.

Nephritis (glomerulonephritis)

This inflammation or degeneration of the kidneys may occur in acute or chronic forms.

Acute nephritis

The acute inflammation interferes with the removal of waste products from the bloodstream. Suddenly the amount of urine passed may markedly decrease, there may be swelling (oedema) of the ankles, and the skin may turn pale and pasty. Also the usual symptoms of acute diseases may occur, such as malaise, pain in the small of the back, headache, fever (usually slight), shortness of breath, nausea, and vomiting.

With reasonable care, acute nephritis may clear up in a few weeks to a few months. However, the disease is always serious. Aggravated cases may terminate fatally in a relatively short time, or they may go on to chronic nephritis despite the best treatment.

Prolonged exposure to cold temperatures (without proper clothing or other protection) or overindulgence in alcohol may also be associated with kidney damage. Other common causes of kidney damage and acute nephritis are: toxins from such focal infections as abscessed teeth or paradental purulent inflammation; toxins from acute infectious diseases, such as tonsillitis, meningitis, typhoid fever, and gastrointestinal disorders; chemical poisoning, e.g., mercury poisoning;' and extensive burns.

Treatment.

In a suspected case of this disease on board ship, obtain RADIO MEDICAL ADVICE.

The diet should be soft and easily digested. Both salt and water intake should be kept low, especially if there is swelling of the ankles (see Oedema, page 216).

Chronic nephritis

Symptoms include swelling of the ankles, puffiness around the eyes, pale pasty skin, malaise, headache, nausea, vomiting, and a decrease in the amount of urine.

Medical assistance regarding treatment should be sought early. An accurate measure of the urine over 24-hour periods will help the doctor giving medical advice by radio.

Heart pain and heart failure

When the calibre of the coronary arteries becomes narrowed by degenerative change, insufficient blood is supplied to the heart and consequently it works less efficiently. The heart may then be unable to meet demands for extra work beyond a certain level and, whenever that level is exceeded, attacks of heart pain (angina pectoris) occur. Between episodes of angina, the patient may feel well.

Any diseased coronary artery is liable to get blocked by a blood clot. If such a blockage occurs, the blood supply to a localized part of the heart muscle is shut off and a heart attack (coronary thrombosis) occurs.

Angina pectoris (pain in the chest)

Angina usually affects those of middle age and upwards. The pain varies from patient to patient in frequency of occurrence, type, and severity. It is most often brought on by physical exertion (angina of effort), although strong emotion, a large meal, or exposure to cold may also be precipitating factors. The pain appears suddenly and reaches maximum intensity rapidly before ending after 2 or 3 minutes. During an attack, the sufferer has an anxious expression, his face is pale or grey, and he may break out in a cold sweat. He is immobile and will not walk about. Bending forward with a hand pressed to the chest is a frequent posture. Breathing is constrained by pain, but there is no true shortness of breath.

When the attack ends (and never during it), the patient will describe a crushing or constricting pain or sensation felt behind the breastbone. The sensation may feel as if the chest were compressed in a vice, and it may spread to the throat, to the lower jaw, down the inside of one or both arms-usually the left one-and maybe downwards to the upper part of the abdomen.

Once the disease is established, attacks usually occur with gradually increasing frequency and severity.

General treatment

During an attack, the patient should remain in whatever position he finds most comfortable. Afterwards he should rest. He should take light meals and avoid alcohol; tobacco, and exposure to cold. He should limit physical exertion and attempt to maintain a calm state of mind.

Specific treatment

Pain can be relieved by sucking (not swallowing) a tablet of glyceryl trinitrate (0.5 mg). The tablet should be allowed to dissolve slowly under the tongue. These tablets can be used as often as necessary and are best taken when the patient gets any symptoms indicating a possible attack of angina. Tell the patient to remove any piece of the tablet that may be left when the pain has subsided, since glyceryl trinitrate can cause a throbbing headache.

If the patient is emotional or tense and anxious, give him 5 mg of diazepam at equal intervals, three times daily during waking hours, and, if he is sleepless, 10 mg at bedtime. The patient should continue to rest and take the above drugs as needed until he sees a doctor at the next port.

Warning. Sometimes angina pectoris appears abruptly and without exertion or emotion, even when the person is resting. This form of angina is often due to a threatened or very small coronary thrombosis (see next page) and should be treated as such, as should any attack of anginal pain lasting for longer than 10 minutes.

Frequent easily provoked attacks often precede a myocardial infarction. RADIO MEDICAL ADVICE should always be obtained in such cases. Evacuation of the patient should be arranged as soon as possible.

Coronary thrombosis (myocardial infarction)

A heart attack happens suddenly and while the patient is at rest more frequently than during activity. The four main features are pain of similar distribution to that in angina (page 203), shortness of breath, vomiting, and a degree of collapse that may be severe. Sweating, nausea, and a sense of impending death are often associated features.

The pain varies in degree from mild to agonizing, but it is usually severe. The patient is often very restless and tries unsuccessfully to find a position that might ease the pain. Shortness of breath may be severe, and the skin is often grey with a blue tinge, cold, and covered in sweat. Vomiting is common in the early stage and may increase the state of collapse.

In mild attacks, the only symptom may be a continuing anginal type of pain with perhaps slight nausea. It is not unusual for the patient to believe mistakenly that he is suffering from a sudden attack of severe indigestion.

General treatment

The patient must rest at once, preferably in bed, in whatever position is most comfortable until he can be taken to hospital. Exertion of any kind must be forbidden and the nursing attention for complete bed rest (page 98) provided. Restlessness, often a prominent feature, is usually manageable if adequate pain relief is given. Most patients prefer to lie back propped up by pillows, but some prefer to lean forward in a sitting position to assist breathing (see Fig. 31, page 33). An hourly record of temperature, pulse, and respiration should be kept. Smoking and alcohol should be forbidden.

Specific treatment

Whatever the severity of the attack, it is best to give all cases an initial dose of morphine, 15 mg intramuscularly, at once. If the patient is anxious or tense, give diazepam, 5 mg three times a day, until he can be placed under medical supervision. In serious or moderate attacks, give a further 15 mg of morphine, intramuscularly, 3-4 hours after the initial injection. The injection may be repeated every 4-6 hours as required for pain relief. Get RADIO MEDICAL ADVICE.

Specific problems in heart attacks

If the pulse rate is less than 60 per minute, give the patient atropine, 1 mg intramuscularly, and raise the legs. The dose should be repeated after 4 hours, if the pulse rate remains less than 60 per minute. However, should a repeat dose become necessary, get RADIO MEDICAL ADVICE.

If the heart stops beating, get the patient on to a hard flat surface and give heart compression and artificial respiration (page 6) at once.

If there is obvious breathlessness the patient should sit up. If this problem is associated with noisy, wet breathing and coughing give one 40-mg furosemide tablet, restrict fluids, start a fluid balance chart (page 102), and get RADIO MEDICAL ADVICE.

Paroxysmal tachycardia

Tachycardia is excessively rapid heart action, with a pulse rate above 100. This condition comes in bouts (paroxysms). The patient will complain of a palpitating, fluttering, or pounding feeling in the chest or throat. He may look pale and anxious, and he may feel sick, lightheaded, or faint. The attack starts suddenly and passes off, after several minutes or several hours, just as suddenly. If the attack lasts for a few hours, the patient may pass large amounts of urine. The pulse will be diflicult to feel because of the palpitations, so listen over the left side of the chest between the nipple and the breastbone and count the heart rate in this way. The rate may sometimes reach 160-180 beats or more per minute.

General treatment

The patient should rest in the position he finds most comfortable. Reassure him that the attack will pass. Sometimes an attack will pass if the patient takes and holds a few very deep breaths, or if he makes a few deep grunting exhalations. If this fails, give him a glass of ice-cold water to drink.

Specific treatment

If these measures do not stop an attack, give diazepam, 5 mg. Check the heart rate every quarter of an hour. If the attack is still continuing after 2 hours, get RADIO MEDICAL ADVICE.

Note. Heart rate irregularities are likely to occur when a person has consumed too much food, alcohol, or coffee; smoked to excess; or is emotionally excited. Unless they are associated with symptoms of heart disease (pain), there is usually no cause for alarm. However, the patient should be advised to consult a physician.

Congestive heart failure

Congestive heart failure occurs when the heart is unable to perform its usual functions adequately. This results in a reduced supply of blood to the tissues and in congestion of the lungs. In acute failure, the heart muscle fails quickly and the lungs become congested rapidly. In chronic failure, the heart muscle fails gradually and the body has time to compensate. However, when compensation is no longer adequate, fluid will begin to accumulate in the lower parts of the body. Swelling most often appears in the legs and feet, but it may occur in other parts of the body. Although there are many underlying causes of congestive heart failure, the most common are chronic coronary, hypertensive, and arteriosclerotic heart disease.

The signs and symptoms of the disease depend on whether the onset of failure was sudden or gradual. Generally, a gradual loss of energy and a shortness of breath (dyspnoea) occur upon exertion. In more acute cases, the patient may cough up frothy, bloodstained, or pink sputum. Later, shortness of breath may appear during periods of lesser activity, and the patient may need to sit up in bed, or sleep on several pillows at night, to breathe more easily. Ankle swelling may occur owing to the accumulation of fluid in the tissues and, as failure progresses, the swelling may involve the hands, legs, and abdomen. The liver may become enlarged owing to congestion, resulting in discomfort and tenderness. In more advanced cases, there may be blueness of the skin, especially at the lips, ears, and fingernails.

Treatment

In severe cases of chronic failure, the patient should be confined to bed in a sitting or semisitting position. Heavy meals should be avoided, and the food kept as salt-free as possible. Smoking should be prohibited. RADIO MEDICAL ADVICE must be obtained. A patient with chronic heart failure should receive medicaments only upon medical advice.

Oedema

Oedema is the name given to the presence of an abnormal collection of fluid in the tissues under the skin. It is not a disease in itself but a sign that there is some underlying condition that causes the fluid to gather.

Its presence can be confirmed by gently pressing the tip of one finger on the affected part for 10 seconds. When the finger is taken away, a dent will be seen in the skin.

Generalized oedema

Generalized oedema occurs in chronic heart failure (see page 205) when the heart's efficiency as a pump is grossly impaired. This condition is not often found on board ship. Oedema can also be found in long-standing disease of certain structures within the kidney. This condition is extremely rare at sea and is beyond the scope of this book.

In all cases of generalized oedema, test the urine for protein (page 107). If protein is present in the specimen, give no treatment and get RADIO MEDICAL ADVICE.

Oedema caused by heart disease

In heart disease, the swelling first appears in the feet and ankles and spreads up the legs. If the patient is in bed, the oedema will collect under the skin overlying the lower part of the spine. The swelling is worse in the evenings or after exertion. In addition, fluid will collect in the lungs, causing a cough and breathlessness.

General treatment

The patient should be put to bed and a fluid balance chart started. Fluid intake should be restricted, as advised in the section on fluid balance (page 101).

Specific treatment

If fluid restriction is insuflicient to cause a decrease in the amount of oedema, give one 40-mg furosemide tablet each morning for 2 or 3 days each week, followed by a drug-free period, until the patient can be put under medical care. Get RADIO MEDICAL ADVICE on the possible cause of generalized oedema in your patient. The patient should be warned that he will pass large volumes of urine at frequent intervals, beginning soon after the tablet has been taken, and provision should be made for this.

Localized oedema

This condition is much more common on board ships. It can be found:

- in one or both legs where venous return is sluggish because of varicose veins (page 238) . in one leg where venous return is obstructed because of inflammation of varicose veins
- at any site in association with boils, abscesses, or carbuncles

It can occur temporarily in the ankles and feet (a) as a result of standing for a long time in a hot climate or sitting in one place, as in a lifeboat; or (b) in females just before starting a period.

An examination will reveal the cause of the oedema. The treatment is that of the cause, and the appropriate sections of this guide should be consulted. Relief will be obtained by elevating the affected part.

LESSON 8_05 CARE OF THE PATIENT IN THE HYPERBARIC ENVIRONMENT

Coping with divers' injuries

When a diver becomes injured or ill he must be removed from the water and put either into a decompression chamber or aboard the vessel which supports his diving activity.

It is not easy to recover an injured diver into a bell and it is extremely difficult if he is unconscious. The problems are caused by the long narrow entrance port, the heavy equipment worn and physical strength required of the co-diver in the hyperbaric environment. These difficulties have been partially overcome by installing a system of pulleys, rather like a block and tackle, inside the rescue bell which can be used to wind the diver into the bell.

When the injured diver has been recovered into the diving bell and the entrance sealed, the time taken to move the bell from the worksite to the deck decompression chamber is generally fifteen to twenty minutes.

The size of the diving bell and the equipment worn by the divers makes it very difficult to perform external heart compression. The best the co-diver can do is to make sure the injured man has a clear airway and is breathing properly. If the casualty is not breathing, artificial respiration should be given if possible. Attempts to compress the heart are not likely to be successful.

In saturation diving the casualty may not be accessible to the doctors for days or weeks because of the long decompression time required. Other injuries such as burst lung and pneumothorax, or mediastinal emphysema (see pages 169-70) have to be treated before decompression can begin. In some cases the diver may have reached the surface but has to undergo recompression before the doctor arrives - with cerebral air embolism, for example. It is essential therefore that divers should be adequately trained in first aid. Emergency procedures and basic first aid are given in Chapters 3 and 4 of this book, and advice for coping with specific diving-related injuries is included later in this chapter. It is also very important to be able to describe the injured diver's conditions in a way which will be helpful to medical personnel on the rig and onshore. They can then give co-divers appropriate instructions for treating the casualty.

Assessing priorities

The commonest mistake when managing an injured diver in a pressure chamber is trying to decompress him too quickly. If there is doubt about what action to take with a casualty it is always best to stop decompression and do nothing until a decision can be taken, with external advice if necessary. A man suffering from pneumothorax will come to no harm unless the pressure is changed. Thoughtlessly continuing the decompression of an injured man may cause additional decompression problems to compound his original injury.

A case which illustrates this point occurred in the mid-1970s in the North Sea when a saturation diver was badly burned by his hot water supply. The attendant was told what treatment to give for the burned area. It was emphasized by the onshore doctor that decompression should be extremely slow because normal decompression tables are designed for healthy divers. The advice was not followed precisely. In order to get the burned patient to medical attention rapidly the decompression was speeded up. The following day the burn had responded to treatment and the patient was very well. But the change in the decompression schedule caused decompression sickness, not in the burned casualty, but in his attendant! The attendant then had to be recompressed and then slowly decompressed. Because of the rapid decompression the attendant had become much more seriously ill than the diver who had been burned.

Diagnosing the injury

A number of devices have been developed over the years to aid diagnosis across the hull of a pressure chamber. It is now possible to take X-ray photographs across the portholes of pressure chambers using portable machines. Flexible X-ray plates have been developed which can be passed through the medical locks of saturation chambers. It is also possible to listen to the chest or the abdomen of a patient using an electric stethoscope which is passed across the hull of a pressure chamber through an electrically insulated penetrator. The doctor tells the diver or co-diver on which part of the body to press the stethoscope so that he can listen from the outside.

A number of other investigations are also possible using suitably insulated penetrators. It is now possible to measure blood pressure, count the pulse rate and even take an electrocardiogram (ECG), showing the patients heart activity, from outside the pressure chamber. Because of these new developments it is not always necessary for a doctor or nurse to enter the chamber to make a diagnosis. If the codiver is trained in first aid he should be able to treat the injured diver following instructions from the doctor or specialist at a distance.

Transfer under pressure

Systems have been designed which allow the patient to be transferred from a small offshore chamber to a large operating chamber close to a hospital onshore. The necessary treatment can then be given under close specialist supervision and with the back-up services of the hospital.

A system like this operates for the North Sea region in Aberdeen. It consists of a specially designed titanium capsule which acts as a highpressure, or hyperbaric, stretcher. It is attached to the offshore pressure chamber and then transferred with the patient to the helicopter. In ~he helicopter a second chamber with a medical attendant inside has already been compressed to the pressure of the offshore chamber. When the hyperbaric stretcher is attached to the second chamber in the helicopter the doors connecting them are opened and the medical attendant can then help the patient. Both chambers are flown together to the onshore operating chamber and connected to it. The patient and the attendant can then be transferred to the large chamber onshore. The appropriate staff and equipment are already present in the large onshore chamber and are ready to undertake the necessary treatment.

This system has been in existence in Aberdeen for some time. It has been called out on several occasions but at the time of writing has only

been used once. It was used for the management of a patient who sustained a burst lung with mediastmal emphysema at a depth of 400 ft (120 m). After his lung leak had sealed he required a long and slow decompression taking nearly a month, under careful X-ray control.

Surgical treatment at pressure

In the North Sea there has been no need to undertake surgical treatment at pressure, even though there were two cases of acute appendicitis in the 1970s. Both were treated without operating using gut sedation and antibiotics. Perforated peptic ulcers can also be managed in this way. When acute surgical illness occurs in a remote place it is best to try and treat it without operating.

Lesson 9_01 UNDERWATER BLAST WATER JETTING

Injury from Underwater blast

CAUSES

Underwater blast injury is caused by the shockwave generated by an underwater explosion. It causes internal damage.

SYMPTOMS

- Pain due to perforated ear drums. - Pain due to injuries to internal organs. Internal injury may be extensive in spite of no visible injury. - Difficulty in breathing because of lung damage.

TREATMENT

- Allow the patient to adopt the most comfortable position.
- Treat for shock.
- Oxygenotherapy : at surface apply Table Cx 12, page 5 in chamber apply Table Cx B, page 17

Contact Medical/Safety Network for assistance.

Accidents from H.P. Water Jetting

The following comments about the management of accidents with high pressure water jets have been made by the Diving Medical Advisory Committee (D.M.A.C.)

SYMPTOMS

The wound caused may appear insignificant and give little indication of the extent of the injury beneath and the damage to deeper tissue. Large quantities of water may have punctured the skin, flesh and organs through a very small hole that not even bleed. Initial mild damage to the wall of an organ may result in subsequent rupture, particularly if infection has been introduced.

The development of subsequent infection is particularly important in abdominal injuries.

TREATMENT

The outcome depends upon the extent of initial injury and the presence or absence of infection, and even though the injury seems trivial on the surface and the patient has no complaints, it is of great importance to arrange for medical examination as quickly as possible.

Where surgical examination is not immediately possible in a remote situation, first aid measures are confined to dressing the wound and observing the patient closely for the development of further complaints over four or five days. The development of fever and a rising pulse rate suggest that the injury is serious together with persistance or occurrence of pain.

On evacuation, the diver should carry the following card which outlines the possible nature of the injury

"This man has been involved with high pressure water jetting at pressures up to 14,500 Iblin2 (100 MPa, 1000 Barr,1019 kglcm2) with a jet velocity of 900 miles (1.440 km) per hour.

Please take this into account when making your diagnosis.

LESSON 9_02 MANAGEMENT OF A MEDICAL EMERGENCY WITHIN A DIVING BELL

LESSON 9_03 METHOD OF CARE FOR A CASUALTY WHEN TRANSFERRING FROM DIVING BELL TO MAIN CHAMBER

LESSON 9_04 PERSONAL HYGIENE

INTRODUCTION

Infection is the most frequent medical problem encountered during saturation diving. The closed environment, temperature, humidity, hyperoxia and helium environment contribute to enhanced microbial growth. Superficial infections, especially of the external ear canal and of soft tissues following minor wounds, are particularly common. The sources of microbial contamination of the chamber include the divers themselves, equipment, food, materials introduced into the chamber, the fresh water supply, and seawater. Control of microbial growth within the chamber is important in minimising episodes of infection.

This Guidance Note considers those few microbes of particular relevance to saturation diving (certain bacteria, and, to a lesser extent, some fungi and viruses) and describes measures to prevent/discourage infection by them.

This Guidance Note will be updated as indicated by the rapid increase in knowledge concerning microbes.

MICROBES AND SATURATION DIVING

Bacteria

Predominant among the many microbes present in a saturation system environment are Gram-negative bacteria principally the pseudomonas and the coliform (e.g. proteus, klebsiella and E. coli) groups. The pseudomonas group is a natural inhabitant of fresh and seawater, and can thus readily enter a saturation system. The main source of coliforms is faecal excretion, therefore the organisms are an inevitable contaminant of chambers.

Skin and other superficial infections from Gram-negative bacteria are more common in the hyperbaric environment than in normobaric conditions. Notwithstanding the wide range of microbes in the chamber complex, the majority of superficial infections (including that of the external ear canal - otitis externa) in divers are caused by one single species Pseudomonas aeruginosa (formerly known as Pseudomonas pyocyaneus, hence „pyo").

Fungi

Fungi and their spores are widespread, and, like Gram-negative bacteria, grow well in warm and humid conditions. Some fungi are normally present on human skin, and in saturation conditions these are more likely to cause superficial infections, e.g. "Athlete's Foot". (Fungi can cause a variety of other infections, but there is no predisposition to them in the hyperbaric environment).

Viruses

Viruses, which spread from human to human by a variety of routes, cause several of the most common infectious illnesses. Viruses causing respiratory infection are most frequently transferred by airborne droplets produced by e.g. coughing, sneezing. Droplet spread in the confined chamber community can result in transmission of unwelcome but not serious infection, e.g. the common cold.

The HIV and Hepatitis B viruses are spread by direct contact with the body fluids of an infected individual (principally blood to blood). Though sensible and normal hygiene practices (summarised below), ensure risk of infection no greater in hyperbaric than normobaric conditions, these two viruses receive this mention as they necessarily have received considerations specific to diving.

MEASURES TO SAFEGUARD AGAINST INFECTION

Consideration is given to personal hygiene, both general (common to normobaric and hyperbaric conditions) and specific to saturation diving, to prevention of infection of the external ear canal, and to chamber and equipment cleansing routines and environmental control.

Personal Hygiene Measures

A high standard of personal hygiene is important.

Divers should be free from infection before being committed to saturation.

Regular showers are advisable throughout saturation - at least once daily and increasing to before and after each dive lock out. The diver should use a neutral or slightly acid soap to prevent destruction of the protective bacteria on the skin. The ears should be kept dry during showering to reduce the possibility of bacterial growth and soap remnants in the external ear - readily achieved by, e.g., occluding the entrance of the canal with clean gauze smeared with vaseline. Regular changes to clean, non-restrictive and comfortable clothing protect the skin.

Lock-out of used clothes and towelling, etc, should not be delayed. Such items should be laundered at a high temperature of minimum 85°C.

Bedding should be changed regularly.

Persistently wet or abraded skin and minor wounds and burns greatly increase the risk of infection. Even minor wounds need regular meticulous cleaning and covering. (The attendant should wear disposable gloves). Waste associated with cleaning and dressing should be put into plastic bags for early lock-out.

Nails should be cut at right angles to fingers and toes. Attempts to cut at ingrowing toe-mils or corns risk sores and infections.

Armpits and crotch need a clean and dry regularly.

Shaving should be avoided or limited if the skin of the beard area is irritated.

Regular visits to the dentist and good brushing of teeth (thorough brushing of all surfaces of all teeth takes a few minutes dedicated to the task) at least twice a day are the cornerstones of avoiding most, inclûding infection, dental problems. Dental floss is a valuable aid.

Sharing of razor, toothbrush, comb or towel is ill-advised. There is no need for personalised eating and drinking utensils, though a drink should not be shared from the same cup. Unused food and drink should be locked-out without delay.

With particular reference to blood spillage, but applying also to vomit, diarrhoea, etc, the principles are to clean up thoroughly using disposable gloves and paper cloths, soiled materials into plastic bag for early lock-out and to treat the wiped surface with washing followed by chamber cleanser (considered below).

As far as is possible, divers should retain diving equipment as personal, e.g. undersuit, suit, headliner. - It is not practicable to personalise helmets, and all that can be done between dives is a wipe and rinse. The oro-nasal mask and nose block pads, however, clearly a significant potential source of infection, can be removed from the helmet after each bell run and surfaced (to be washed, treated with chamber cleanser, rinsed and dried). The practical constraints likely preclude personalising the oro-nasal by means of changing it between dives during one bell run. Neck dams may require to be cleaned in the bell. Particular care should be taken with items which will be in close contact with the divers skin to ensure that any cleanser (which may irritate the skin) is washed off adequately before re-use. Suits, etc, should be cleaned and dried on the surface between dives.

There is no need to go beyond these simple, personal and routine measures unless circumstances have required guidance on further actions.

Prevention of Infection of the External Ear Canal

Prophylactic ear drops containing acetic acid and aluminium acetate (Domeboro otic) are designed to minimise the chance of infection by maintaining the external ear canal acidic. With the head leaning to one side, and without allowing the nozzle of the dropper bottle to touch anything, 3-4 drops are placed into the external canal of the ear. The drops should be used for a timed minute in each ear twice daily and following each dive/shower. Divers should retain two bottles for personal use, one for each ear and labelled accordingly.

Chamber Cleansing and Environmental Control

Chamber cleansing is designed to limit microbial growth (particularly the predominant Gram-negative bacteria) and, therefore, to protect against infection.

Cleansing (with liquid anti-microbial - specific agents considered below) is started at the top of the chamber and is continued downwards, with excess cleanser ultimately drained from the bilges. Relays of fresh cloths/sponges should be used on each occasion and discarded after limited use.

Before a saturation dive, the entire chamber (including e.g. service locks, "rims" of toilets, bunk brackets) is most thoroughly cleansed (with the deck plates lifted), and allowed to dry. The parts of the chamber which will be in direct or indirect contact with the skin (e.g. shower-deck, sink, tables and BIBS masks) and other personal equipment e.g. headsets, should be disinfected using chamber cleanser, left for a minimum of 10 minutes, then rinsed and dried thoroughly. Shower-heads should be removed, cleansed, rinsed after 10 minutes, and dried. The chamber should be ventilated and clean bedding and towels provided.

During saturation, the toilet, sink and shower areas, service-locks and their immediate areas, and table surfaces should be cleansed daily. Twice weekiy, chamber walls and bulkheads and BIBS masks, etc, should be cleansed, and shower-heads removed for cleansing on the surface.

Bilges or floor areas beneath deck plates should be drained of cleanser, but should not be actively cleansed or otherwise disturbed.

Shower areas should be drained quickly after showering and the floor retained dry.

Chamber Disinfectant Cleansers

Several agents are in use or recommended. These include "Panacide M", "Tego 1036", "Tego 2000" and "Trigene" . Various other products may also be suitable.

The prime requirements of the disinfectant agents is that they should be very effective against the microbes known to flourish in the chamber environment and be non-toxic to man. Additionally, the disinfectants should be odourless, non-volatile, and be free from irritant and sensitising properties.

"Panacide M" is now less used than formerly because of its undesirable properties of strong odour and skin irritation. The Tego products are increasingly being used, and combine good anti-microbial properties with relatively few disadvantages, e.g. they are odourless and less likely to be irritant to the skin.

All chamber disinfectants should be used at the appropriate dilution, skin contact should be minimised by the use of personal protective equipment, and they should be applied by cloth or sponge to avoid the formation of an airborne aerosol.

Environmental Control

Safeguarding against infection within chambers involves control of humidity (which should be maintained at the dry end of the range of comfort), the use of hot water at no less than 60°C for cleaning and meticulous conduct of the onboard procedures to ensure the purity of the fresh water supplies. Samples of potable water should be tested by a laboratory before committmg to, and at regular intervals dunng, saturation.

FURTHER MEASURES

Routine swabs for microbe analysis from the ear canals of divers are not advisable. Rather, such swabs should be reserved for use in divers with clinical features of otitis externa, such as pain, itch, discharge. However, routine swabs from chamber surfaces both pre-dive and during saturation are helpful as guides to efficacy of cleansing regimes.

It is essential to use the correct swabbing technique - the swab bud on the end of the stick should touch only the part to be sampled, and nothing (including fingers) should touch the swab stick.

As a generalisation, the extent of chamber contamination and risk of episodes of infection increase with the duration of the dive, particularly when chamber complexes remain at pressure for long periods. When such operations are planned, intermittent surfacing of individual chambers for cleansing and drying is beneficial in controlling chamber contamination.

LESSON 9_05 DANGEROUS MARINE LIFE

Jelly fish sting

Stings follow contact with the tentacles of some jelly fish. The most dangerous types of jelly fish are the Portuguese Man- of-War and the Sea Wasp.

SYMPTOMS

- Pain at site of sting. May be mild like a nettle sting or severe enough to cause unconsciousness - Redness, swelling or blistering of the skin. Loss of the body sensation - Muscle cramps - Admominal pain - Paralysis of limbs - Nausea and vomiting - Severe backache.

TREATMENT

- Get out of the water, - Remove any remaining tentacle and sting fluid with a stick or cloth, - Wash copiously with water, - Apply weak alkali (saturated solution of baking powder), or vinegar. - Treat for shock. - Give Steroid (Decadron) intramuscular. - Contact Medical/Safety Network for assistance.

Cone shell stings

Injection of venom from certain species of conical shells found in sand and under rocks. Clothing does not afford full protection so that contact must be avoided if at all possible.

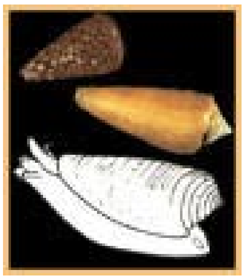
SYMPTOMS

Sting site painful and surrounded by white or blue area

Numbness spreading rapidly from sting area

Paralysis may follow

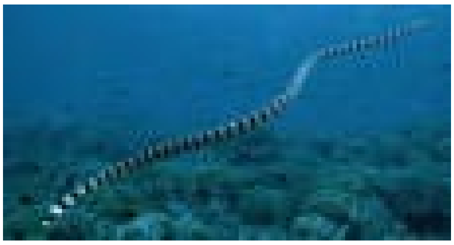
Unconsciousness. `



TREATMENT

Keep patient quiet, - Apply a tourniquet above the bite and keep injured area as cold as possible (immerse in ice cold fresh water), - Treat for shock (see page 59), - Give Steroid (Decadron) intramuscular, - Contact Medical/Safety Network for assistance.

Venomous fish and sea snakes stings



In some areas venomous sea snakes and fishes are prolific, and local information should be sought to indicate which ones may be encountered.

Note that clothing does not afford full protection so that contact must be avoided if at all possible.

Poison is injected into the diver's skin from hollow fangs in the snake's upper jaws or via venom apparatus carried in the tips of spines.

SYMPTOMS

Early onset

- A vague feeling of being unwell

- Muscle stiffness

- Aching pain on movement

Late onset - Spreading paralysis involving the whole body - Shock - Convulsions - Unconsciousness.

TREATMENT

Immediate treatment is imperative.

- Keep the patient quiet,

- Apply a tourniquet above the bite and keep the injured area as cold as possible (immerse in ice cold fresh water),

Anti-serum must be given intravenously. A doctor should be called to give a polyvalent anti-serum containing Krait (Elapidae) fraction. This should be given by slow intravenous injection, - Treat for shock.

Stingrays

The stingrays are Australia's largest venomous fish. The sting from some species can cause excruciating pain and is sometimes lethal. More than often, the penetration of the poisonous spine is more dangerous than the venom.

Stingrays usually are bottom feeders and prefer to lay on the sand in wait or feed on molluscs. They will usually try to avoid humans and only defend themselve if trodden on or handled.

Stonefish.

Few fish can match the sinister reputation of the stonefish, but then not many species have as potent a venom as these grotesque gargoyles of tropical seas.

These fish are among the deadliest of all Australian animals. The venom is contained in glands below the skin on the creature's back, connected to thirteen sharp spines. The spines usually remain folded, but at the slightest disturbance they are immediately raised and protude verticaly.

Fire coral

Hazard to Humans: MODERATE TO SEVERE. Contact may cause a severe burning sensation. Skin may remain tender and inflamed for several days and blistering may occur sensitive individuals. A very few divers have reported to Diver's Alert Network (DAN) severe allergic reactions after contact

Treatment and care:

Prompt cleansing of the wound , removal of foreign particles and application of antiseptic agents are recommended. A brief rinse of acetic acid 5% (vinegar) or isopropyl alcohol (mixed 40 to 70% usually diminishes discomfort.

Hazard	**Symptom**	**First Aid**
Anemone Stings	Painful Blisters	Rinse, use ICE for pain relief
Box Jellyfish	Painful	Vinegar Rinse, pick off tentacles; then ICE
Hydroid Stings (Fire Coral)	Painful Rash	Rinse, apply ICE
Portuguese Man-of-War	Painful	Pick off stingers, wash with water, then ICE
Coral cuts	Frequent infections	Scrub well; apply antibiotic ointment
Ray stings	Painful, slow healing wound	Scrub; rinse; remove stinger; apply HEAT
Sea Urchins	Painful	Pull out large spines; let small spines dissolve
Puffer fish	Fatal	
Crown of Thorns Starfish	Painful punctures	Pull out spines; seek medical attention
Cone Shells	Potentially fatal	Pressure bandage; seek immediate medical care
Scorpion fish; Lionfish	Painful	Scrub; rinse; apply HEAT
Stonefish	Painful up to Fatal	Effective antivenin exists; immediately soak in hot water; seek medical treatment
Oriental Catfish	Pain and stinging	Promptly flush wound; soak in hot water water 30 min.
Sharks	1/3 shark bites are fatal	Use direct pressure; call 911
Barracuda	Lacerations	Direct pressure for bleeding; scrub
Snakes	Infrequent envenomations; usually fatal	Good news: there is antivenin. Seek immediate medical treatment
Moray Eels	Lacerations	Clean wound; Direct pressure for bleeding
Blue Ring Octopus (Avoid this animal)	Fatal	Direct pressure with heat applied while immediately seeking medical care
Octopus	Painful bites	Thoroughly clean wound; scrub; and treat with antibiotics