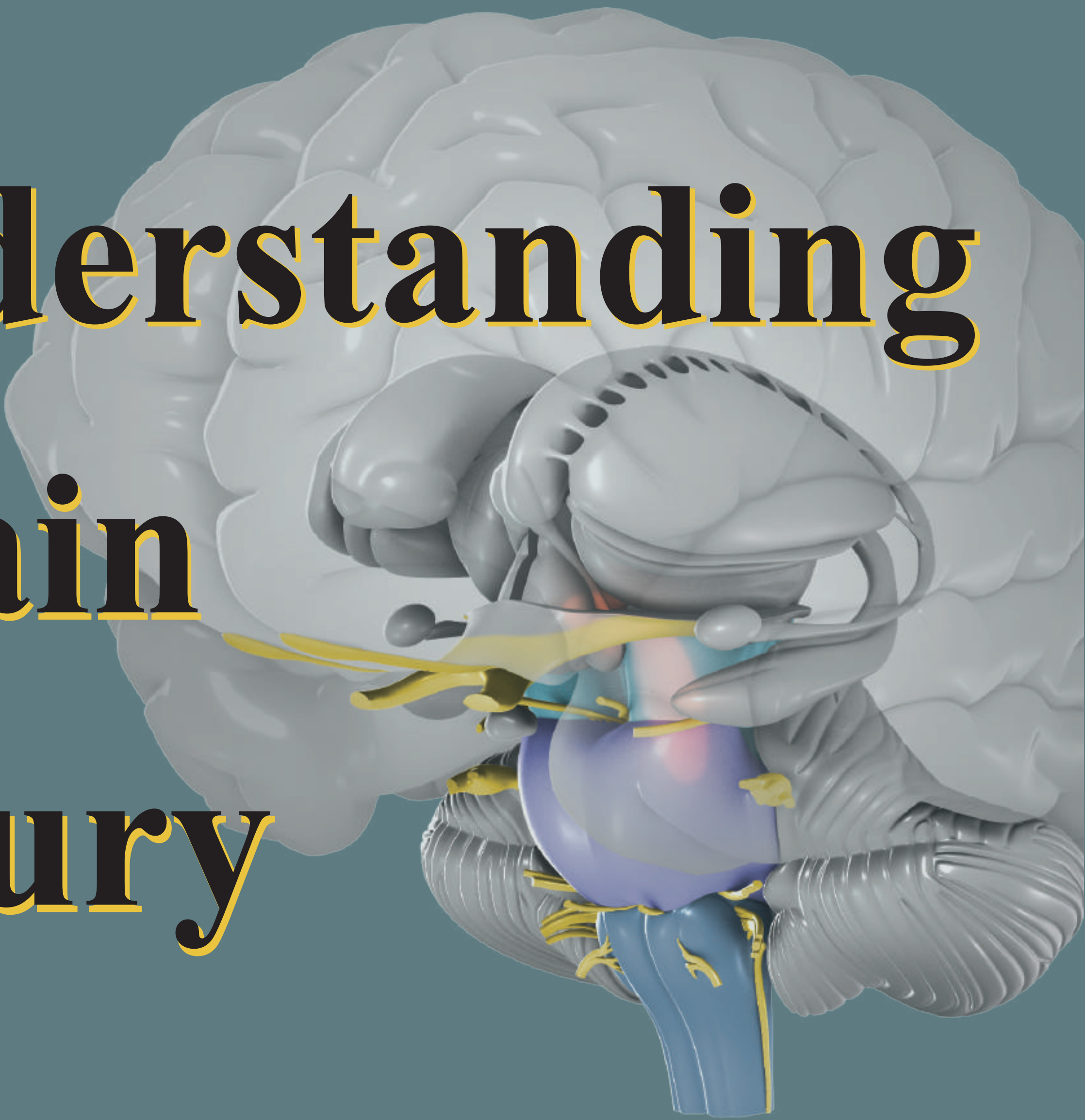
Volume One - Third Edition

Understanding Brain Injury



Acute Hospitalization

an educational guide for family & friends

An Educational Guide for Family & Friends

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Introduction

A family member or close friend experiencing a brain injury can be overwhelming and frightening. The uncertainty associated with the brain injury prognosis and eventual outcome, adds to this stress. It is difficult for a physician or other health care professional to predict the outcome during the first days, weeks, and even months. Along with family members, physicians must “wait and see” how the patient progresses. There is no certain correlation between brain injury severity and the final functional outcome. It is not unusual to feel alone and confused while struggling to understand and cope with this complex condition.

Although each family member or friend may deal with the crisis in his or her own way, all can benefit from certain basic knowledge regarding normal brain function and brain injury. This booklet, and its companion – *Understanding Brain Injury, Neurologic Rehabilitation*, are designed to provide information to assist with this process. The first section describes the structure and function of the brain and explains the effects of injury. Patient assessment, treatment, and care in the intensive care unit and in other hospital settings is also addressed. The second section of the booklet discusses post-traumatic reactions of family members and close friends and answers some common questions. A glossary of hospital terms is included in the back of the booklet.

Although family and friends may be anxious to learn more about brain injury, reading a booklet may be difficult initially following hospitalization, as it may be hard to concentrate and remember explanations. However each individual is different. Some want to learn everything they can as quickly as possible. Others prefer absorbing information a little bit at a time.

This booklet should be read at one’s own pace, perhaps a section at a time. Some individuals begin by reading the question and answer section. Many find it useful to jot down their own questions as they go along. Some may wish to use the blank note pages in the back of this booklet for this purpose. In addition, keeping a journal or diary of events, feelings, concerns and questions may also be helpful.

Plan to use this booklet as a guide while collecting information about brain injury discussing concerns with family, friends, and caregivers. This booklet should provide a foundation of information regarding brain injury; its possible effects on an individual’s physical, cognitive and behavioral function; the acute medical treatment; and information regarding related adjustment issues.

Structures and Functions

The brain is the control center for the entire body and directs all its voluntary and autonomic functions such as circulation, breathing, digestion, elimination, and motion. Signals from the five senses – sight, smell, taste, touch, and hearing, are processed through the brain. In addition, the brain is responsible for higher human functions and attributes including thought, comprehension, memory, speech, emotion, and personality. Understanding the normal structure and function of the brain is the first step in learning about the effects of injury.

This section will cover the structures and functions of the following areas:

- **The Skull**
- **The Cortex (Cerebrum)**
- **The Cerebellum**
- **The Brain Stem**

The Skull

The skull serves as the bony encasement for the delicate tissues that make up the brain. The skull protects the brain from the bumps and bruises of everyday life. Supporting and protecting the brain within the skull are three layers of membranes. These membranes help to separate and protect the lobes or sections of the brain. The outermost membrane is called the dura mater, or dura for short. The middle layer is called the arachnoid membrane, and the membrane in direct contact with the brain's surface is called the pia mater.

CORONAL VIEW OF THE HEAD

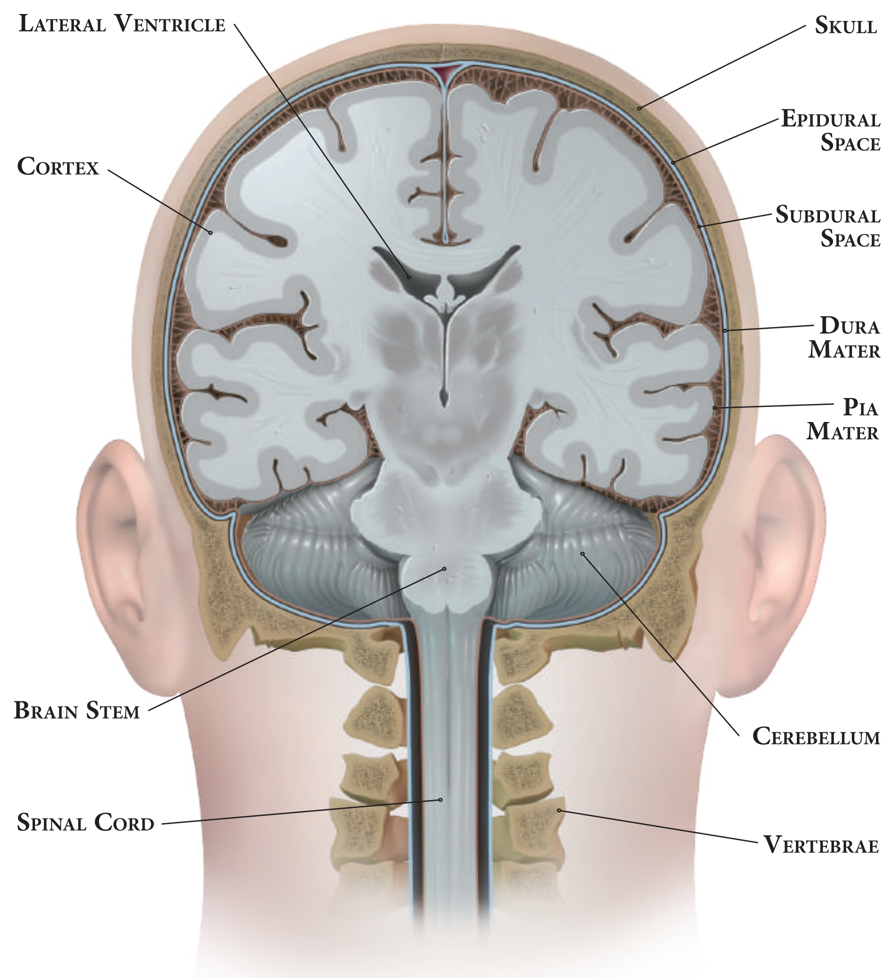


ILLUSTRATION 1.1

Clear cerebrospinal fluid surrounds and cushions the brain and its membranes. Manufactured within small passageways or ventricles inside the brain, this fluid transports certain nutrients between blood vessels and the brain. The ventricles consist of two lateral ventricles and a third and fourth ventricle.

Inset View of the Head with Brain

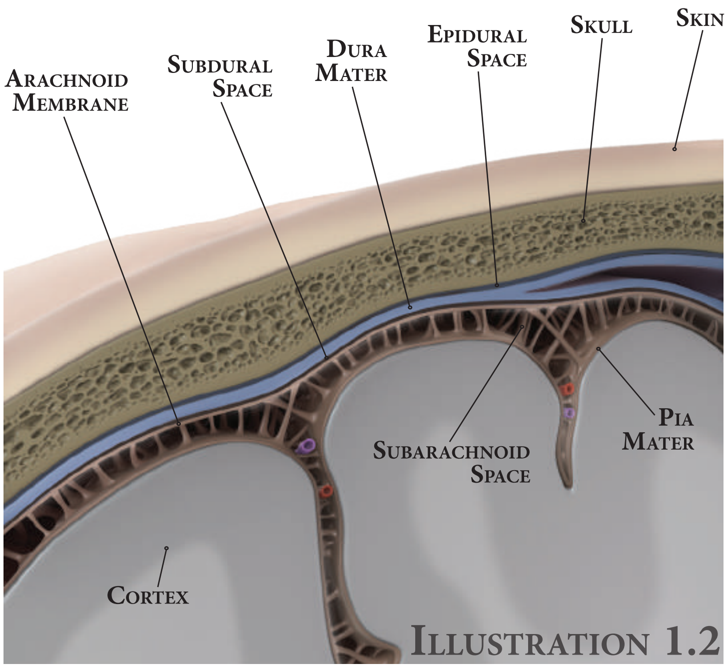


Illustration 1.2

The brain consists of three main sections, namely the cortex (also called the cerebrum or cerebral cortex), the cerebellum, and the brainstem. Although the brain operates in a highly interconnected manner, each section has distinct functions and characteristics. For example, one area controls balance while another regulates emotions. Because the skull is a rigid structure, the space within it remains fixed. Nearly 20 percent of this space is occupied by the membranes and cerebrospinal fluid. The remaining 80 percent consists of the cortex, cerebellum, and brain stem.

The Cortex (Cerebrum)

The largest section of the brain, the cortex, is divided into two connected hemispheres or sides that control important functions, such as speech, perception, and memory. The left side of the brain controls movement and receives sensory messages from the right side of the body. The right side of the brain controls movement and receives sensory messages from the left side of the body. Specific areas within the cerebral cortex regulate separate functions. For example, the speech center governs the ability to form sounds into meaningful words, phrases, and sentences.

Each person has a dominant and a non-dominant cerebral hemisphere. The dominant hemisphere, usually on the left, controls cognitive functions including speech, comprehension, and the ability to perform reading, writing, and arithmetic calculations. The non-dominant hemisphere's functions include spatial perception and creativity such as artistic and musical skills.

Each cerebral hemisphere is subdivided into four distinct lobes: frontal, parietal, temporal, and occipital.

Frontal Lobes

Located in the front of the cerebrum behind the forehead bone, the frontal lobes contribute to a person's judgment, reasoning, personality, motivation, inhibition and concentration. Home of personality, the frontal lobe has a wider range of jobs than any other part of the brain. It controls our ability to make sound decisions, concentrate, plan, and organize. It helps you to have a sense of self in relation to the rest of the world. It allows for available information to be used in planning, prioritizing, sequencing, self-monitoring, self-correcting, inhibiting, initiating, controlling, or altering behavior.

LATERAL VIEW OF THE HEAD WITH FULL BRAIN

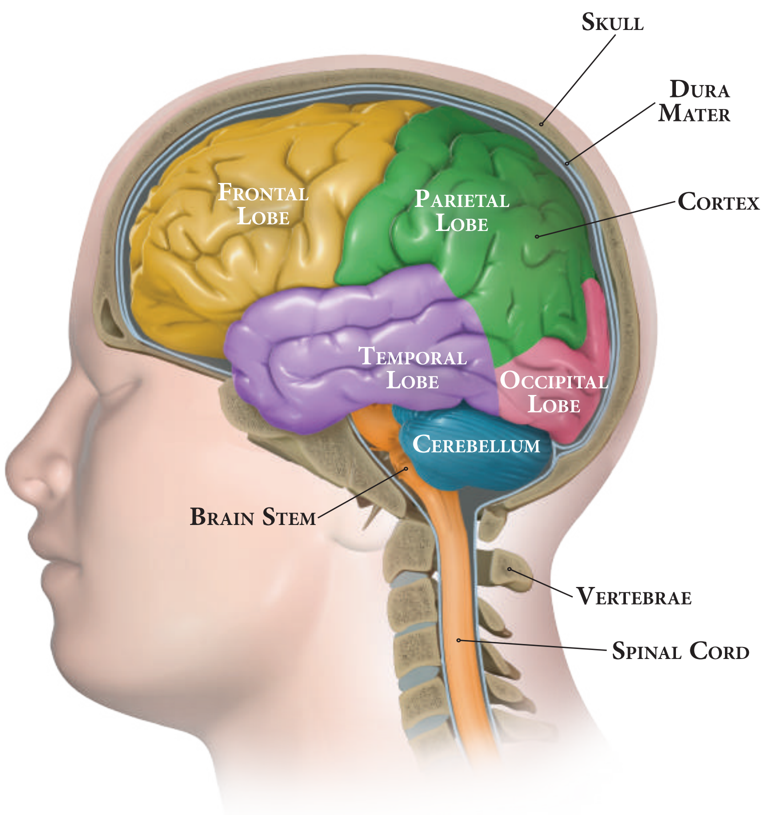


ILLUSTRATION 1.3

Largest of the brain's lobes, the frontal lobe extends from the front of the brain to the central sulcus (furrow). Each hemisphere has a frontal lobe.

The frontal lobes contain the following important areas:

- Premotor cortex
- Broca's area
- Prefrontal cortex
- Primary motor cortex

The frontal lobes are easily damaged by accidental injury. Degenerative brain diseases, stroke, meningitis, encephalitis, oxygen deprivation (hypoxia) due to heart attack, birth defects and brain lesions may impair the frontal lobes.

Damage to the Frontal Lobes

Damage can change a person's personality — they will no longer act like themselves. They may behave differently, even inappropriately. They may lose the ability to plan ahead, lose their drive, and act brashly without realizing it. These changes in behavior and planning may lead to legal complications from inappropriate actions, and/or inappropriate and involuntary psychiatric hospitalizations. Guardianship should be evaluated as an option to protect the interests of survivors of brain injury.

Parietal Lobes

The parietal lobes sit just behind the frontal lobes. The parietal lobes receive and process sensations of touch, including pain, heat, cold, pressure, size, shape, and texture. Combined analysis of information from the various senses also occurs in the parietal lobes. The parietal lobe processes the sensations of touch, pressure, temperature and pain. It helps you to reach, grasp, and know the position of things around you. It even reacts when someone else is touched. The parietal lobe can identify exactly where you're hurt when you get injured.

This lobe reminds the brain how to use tools. It uses "body memory" to respond automatically to actions that are so familiar, you don't have to think about them before you act — like a baseball player swinging a bat. It also governs attention.

The parietal lobe lies between the frontal and occipital lobes in the middle upper brain (cerebrum). Each hemisphere has a parietal lobe with one hemisphere dominant. The dominant hemisphere governs speech, reading, writing, and calculating. It plans complex actions and plays a role in perception and body image.

The other lobe uses visual information to provide a picture of the surrounding world and your body's position in it — how your body is oriented in space. This sense of body position helps you to perform spatial tasks.

The tempero-parietal junction, where the parietal and temporal lobes meet, helps you to figure out what's on someone else's mind. This region is responsible for out-of-body experiences.

Damage to the Parietal Lobes

A person with a brain lesion, stroke, traumatic brain injury, or degenerative damage in this area may not be able to recognize faces, tell left from right, draw, remember words or numbers, speak normally or stay focused. They may misjudge distance and the position of objects. They may get lost going from one room to another in their own home. Their sense of touch, pain or temperature may not work properly. They may become confused and unable to dress themselves or perform simple tasks.

Temporal Lobes

Alongside the frontal and parietal lobes and above the ear sits the temporal lobes. The temporal lobes contain the centers for hearing. In the left hemisphere, the temporal lobe receives and interprets sounds such as words. Both the right and left temporal lobes serve an important role in memory and emotion. The temporal lobe provides the brain with a complete mental picture of what we see, hear and feel. Language, smell and hearing are processed here.

This lobe detects the direction of movement and recognizes objects, particularly faces. It remembers and recalls both facts and general knowledge. It associates memory with emotion and plays a role in making moral judgments.

This is the part of the brain that listens. The temporal lobe plays an important role in understanding words and music. Wernicke's area, which matches words to sounds, is found here. The temporal lobe retrieves the meaning of words from memory, then matches words to concepts to help you express ideas. When children learn to read, the temporal lobe translates word shapes into sound. It stores that information, so it can recognize spoken words.

The temporal lobe is located at the base of the frontal and parietal lobes, just above the ear and in front of the occipital lobe. A large groove called the lateral sulcus (Sylvian fissure) separates it from the two upper lobes. Each hemisphere contains a temporal lobe.

Temporal lobe disturbances, particularly in the temporo-parietal junction, have been linked to seeing ghosts or auras and out-of-body experiences.

Damage to the Temporal Lobes

A stroke or heart attack, traumatic brain injury, infection or degenerative disease, such as Alzheimer's, can damage the temporal lobe — scrambling what a person sees, hears and understands. It may impair the memory of words, shapes and sounds.

Temporal lobe epilepsy — the most common type of epilepsy in adults — dramatically affects personality. Temporal lobe seizures may cause non-stop speech, paranoia, aggressive rages and other personality changes, such religious fanaticism and odd sexual behavior.

Occipital Lobes

The occipital lobes are located in the back of the cortex behind the parietal and temporal lobes. The occipital lobes contain the centers for sight and are responsible for visual recognition. Smallest of the brain's four lobes, the occipital lobe focuses on vision. This region contains the visual cortex and visual association area. These regions work together and with other parts of the brain to process images from the eyes and to interpret the shape, color, depth and angles of what you see.

When you put a hand on the back of your head, you are touching the occipital bone, adjacent to the occipital lobe.

Damage to the Occipital Lobes

Brain injury, lesions, stroke, infection or lack of oxygen (hypoxia) may affect sight and visual perception. A person with an occipital lobe injury may have difficulty reading, identifying colors, locating nearby objects, interpreting drawings, and even recognizing words. Sometimes, the person may not see an object move from one place to another. Distorted vision and visual hallucinations may occur. Extreme damage may cause blindness.

Brain lesions, injury or "cross-wiring" in the junction where the parietal and occipital lobes meet (parietal-occipital junction) may cause synesthesia. People with this condition experience a mixture of the senses. For example, they see colors when they hear music or read numbers. For them, different musical notes may really produce a symphony of colors. When written, the number 5 may look blue and 6 may look green.

The Cerebellum

The cerebellum is a much smaller section of the brain, which lies beneath the cerebral cortex in the back of the skull. It transmits and coordinates signals from the cortex that control the movement of voluntary muscles, such as those in the arms and legs. It also plays an important role in regulating balance, posture, and coordination.

The Brain Stem and Cranial Nerves

The brainstem coordinates the body's automatic or reflex activities — the things we do without conscious thought, such as breathing. The brain stem is located in front of the cerebellum beneath the cerebral cortex. It connects the spinal cord to the cortex and serves as a sort of relay station, passing messages back and forth between various parts of the body and the cerebral cortex.

Brain Stem and Cranial Nerves

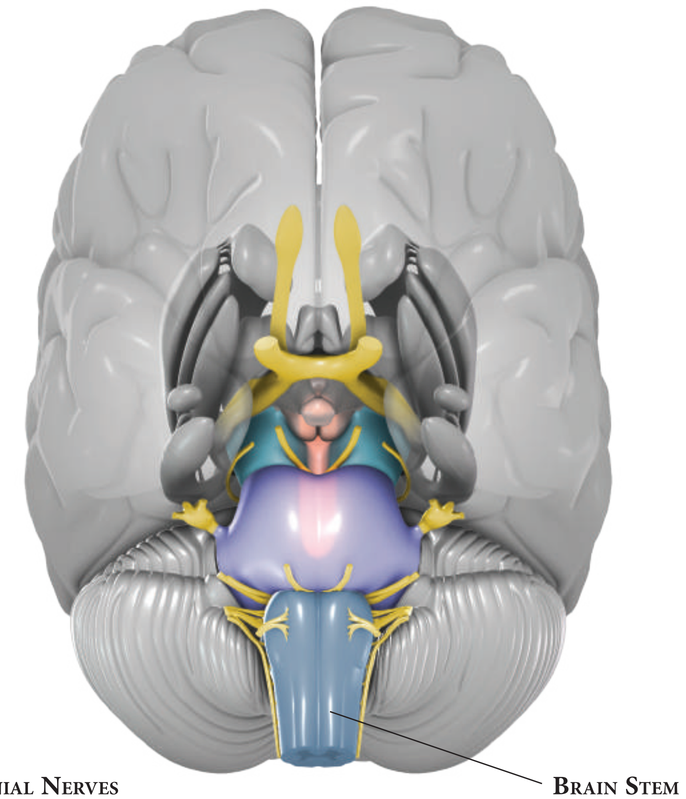
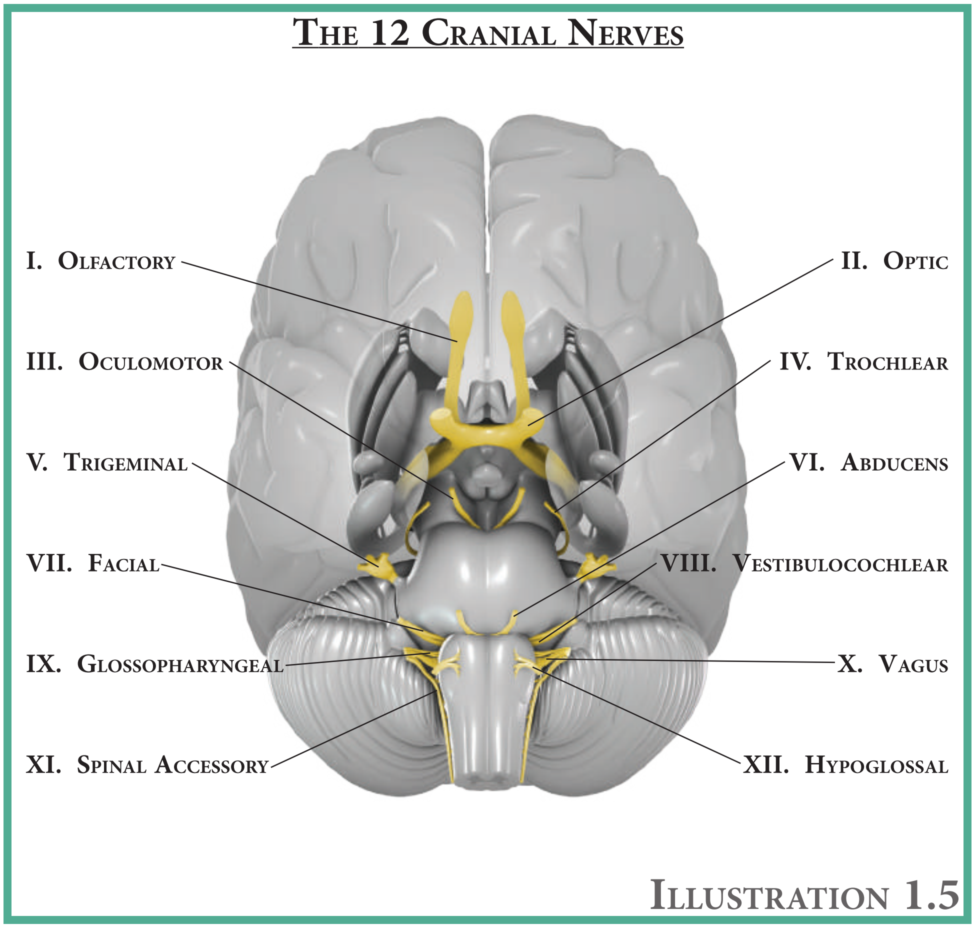


Illustration 1.4

Originating in the brain stem are the twelve cranial nerves that mediate smell, hearing, balance, vision, eye movement, facial sensations, taste, swallowing, and movement of the face, neck, shoulder, and tongue muscles. Also located in the brainstem are vital control centers regulating respiration, pulse (heart rate), and blood pressure. The reticular activating system (RAS) plays a role in mediating the circadian rhythm, which is responsible for the brains' transition from sleep to wakefulness; including the regulation of an individual's ability to maintain a wakeful conscious state.



Cranial nerve		Sensory and motor function
I	Olfactory	Smell
II	Optic	Sight
III	Oculomotor	Moves eye upward, downward and inward; raises eyelids; controls pupils
IV	Trochlear	Moves eye downward and inward (towards nose)
V	Trigeminal	Sensation in eyes, teeth and face, lower jaw; jaw movement; chewing
VI	Abducens	Turns eye outward (away from nose)
VII	Facial	Taste (tip and middle of tongue), facial expression, tear and saliva production
VIII	Vestibulocochlear	Hearing and balance
IX	Glossopharyngeal	Taste (back of tongue), touch, temperature sensation from tongue and throat; tongue and throat movement, swallowing, gag reflex
X	Vagus	Swallowing, breathing, heart rate, stomach acid production
XI	Spinal accessory	Moves head, neck and shoulders, larynx and throat (swallowing)
XII	Hypoglossal	Moves tongue

Brain Injuries

This section will discuss:

- **Concussions**
- **Skull Fractures**
- **Penetrating Head Wound**
- **Arterial Dissections**
- **Diffuse Axonal Injury**
- **Cerebral Infarction / Stroke**
- **Anoxic / Hypoxic Encephalopathy**
- **Increased Intracranial Pressure**
- **Hydrocephalus**
- **Contusions**
- **Hemorrhages & Hematomas**
- **Epidural Hematoma**
- **Intracerebral/Intraparenchymal Hematoma**
- **Subdural Hematoma**
- **Subarachnoid Hemorrhage**
- **Intraventricular Hemorrhage**
- **Aneurysm**
- **Seizures**
- **Coma**

The term brain injury is often used interchangeably with head injury. However, brain injury is a more specific term. Most traumatic brain injuries occur in association with accidents or physical assaults that result in a forceful blow to the head, yet injury to the brain can occur in other ways. A near drowning victim revived through cardiopulmonary resuscitation suffers damage to brain cells because of lack of oxygen. A stroke occurs when a brain blood vessel ruptures or becomes clogged, and the blood supply (carrying oxygen and nutrients) is interrupted, resulting in injury to the brain tissue. Likewise, bleeding from a ruptured artery underneath the skull or within the brain can compress brain tissue and lead to permanent damage and or temporary loss of brain function. Infections, such as meningitis, brain tumors, an overdose of medications, and certain diseases can also result in injury to the brain.

The changes that occur after a brain injury depend on the severity, type and location of the damage. Physical, emotional, mental, and behavioral changes can be temporary or long-lasting. Since no part of the brain operates independently, an injury in one area often affects the functions of many brain areas simultaneously. Interactions between different parts of the brain are essential for almost all body functions. Fortunately when one part of the brain fails to operate properly, other parts may eventually compensate for the loss. Recovery following a brain injury can take a great deal of time and may be partial or complete.

To better understand the effects of brain injury, the causes and types are outlined on the following pages.

Concussions

A concussion is a common term used to describe a mild brain injury. Signs that may briefly follow trauma indicating a concussion include: confusion, amnesia, slurred speech, headache, dizziness, nausea, vomiting, as well as loss of balance or loss of consciousness. A major misconception is that a concussion only occurs when an individual is "knocked out". The majority of concussions do not involve loss of consciousness. Usually the more intense the blow, the more severe the concussion and the resulting symptoms. Lingering symptoms that follow a concussion may include difficulties with headaches, dizziness, vision, hearing, tasting, smelling, balance, coordination, sleep regulation, fatigue, sensation, cognition and emotional regulation.

Skull Fractures

All skull fractures are associated with a risk of underlying brain injury which may include brain bruising or bleeding. Most people realize that a strong blow to the head can cause the skull bones to break. Sometimes the injury results in a crack without displacement of the bone. Physicians may compare this "nondisplaced" fracture to the crack of an eggshell in which the shape of the shell remains unchanged. These fractures usually heal on their own. A more serious fracture, known as a depressed skull fracture, results when pieces of skull bone are displaced and press in against brain tissue. This type of skull fracture usually requires corrective surgery.

PENETRATING HEAD WOUND

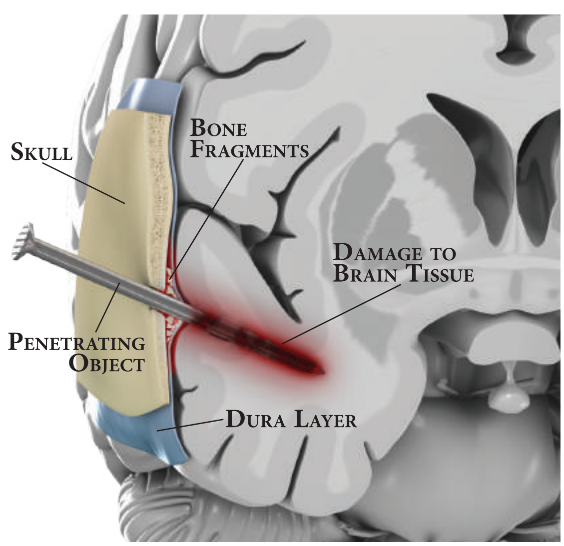


ILLUSTRATION 2.1

Penetrating Head Wound

A penetrating head wound occurs when something forcefully enters the skull and penetrates the brain. Injury occurs along the path that the object travels into the brain and where it comes to rest. The extent of brain injury depends on the object's size and force of entry. Penetrating head wounds always damage the skull, and bone fragments in the wound may worsen the injury. As the object travels through the brain, it disrupts blood vessels, causing bleeding. This bleeding may increase pressure inside the skull, leading to coma and, in serious cases, death.

Intentional and accidental events cause penetrating head wounds. Examples are stab wounds, car accidents and workplace accidents (nails, screwdrivers). During natural disasters, such as hurricanes or tornadoes, flying objects can penetrate the skull. About 35% of penetrating head wounds are gunshot wounds.

Every penetrating head wound is different, so the consequences are unpredictable. Anything can happen – from no lingering deficits after a minor injury to death from a serious injury. Deep wounds are more damaging than shallow ones.

Arterial Dissections

Blunt or penetrating trauma to the head or neck may cause the arteries in the neck to tear. These tears are also referred to as "dissections" and are a common cause of stroke after brain injury. The carotid or vertebral arteries may be involved. Treatment may involve the use of blood thinners, placement of a stent to keep the blood vessel open or bypass surgery.

Diffuse Axonal Injury

Nerve cells, or neurons, have long branches called axons. Axons transmit signals to other neurons throughout the brain, spinal cord, and body. Many axons running parallel make up the white matter of the brain and spinal cord — so called for the whitish color of their protective myelin sheaths. Axons are somewhat flexible but will tear when stretched suddenly by a traumatic event. This type of injury, known as shearing, damages the axons and myelin sheaths. It prevents them from working properly — disrupting communication among neurons. Without this communication, the brain cannot function properly.

DIFFUSE AXONAL INJURY

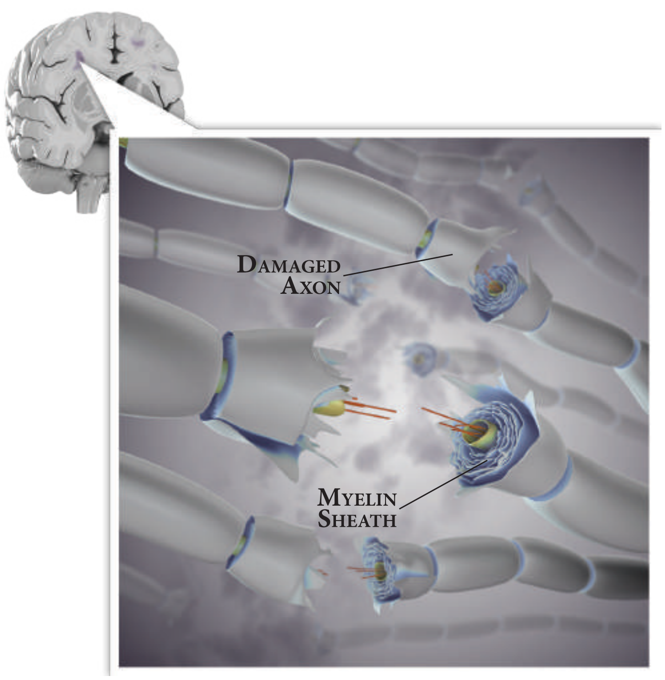


ILLUSTRATION 2.2

A diffuse injury is widespread or scattered — an extensive injury to axons throughout a part of the brain. Hitting your head in a car accident, fall from a bicycle, slip on icy pavement, or other accident can lead to diffuse axonal injury. Violently shaking or throwing a person can cause this type of injury. In babies, this condition is called shaken baby syndrome.

A diffuse axonal injury can temporarily or permanently disrupt how the brain works. Since some parts of the brain are more vulnerable to injury than others, it is difficult to predict how a person will be affected. This type of injury can increase pressure inside the skull, leading to coma and sometimes death.

Cerebral Infarction / Stroke

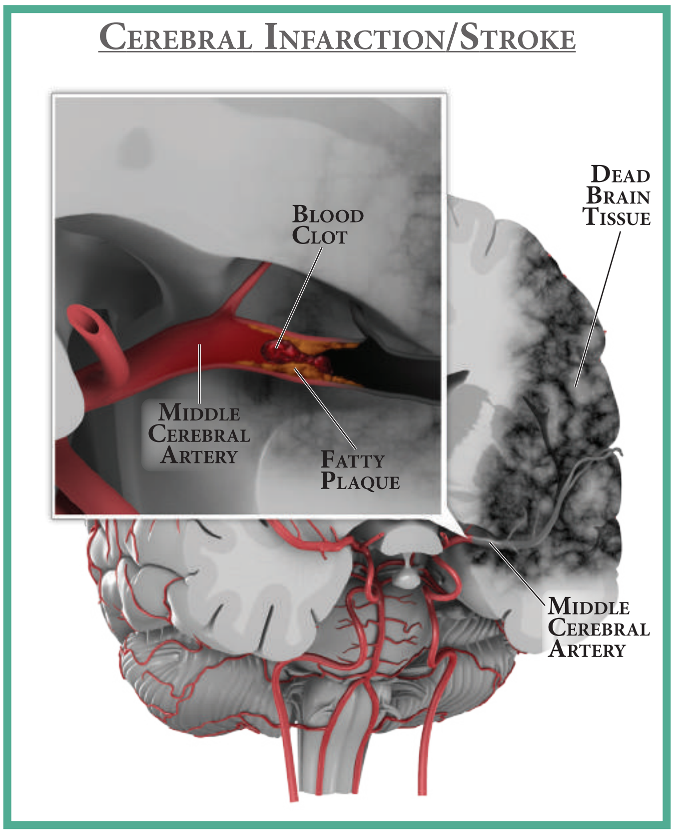


Illustration 2.3

When a blood clot blocks the blood flow to the brain, a person has an ischemic stroke. This type of stroke is also called a cerebral infarction or brain attack. During the stroke, the brain cannot receive new supplies of oxygen and other vital nutrients from the blood. Within minutes, starving brain cells die. A stroke is a medical emergency that needs immediate treatment to prevent brain damage and death.

Blood clots cause about 80% of all strokes. A clot, or thrombus, may form within brain or neck arteries or travel to the brain as an embolus from elsewhere in the body.

Blood clots generally lodge in clogged arteries. Over time, bad cholesterol and other fatty substances (plaques) build up on the artery walls, narrowing the passageways. This condition is called atherosclerosis. Blood clots can get snagged on the fatty plaques or trapped in narrowed arteries. Blood clots from the heart or legs may get stuck in the small arteries of the brain.

Other conditions cause blood clots. They include:
- Heart problems, i.e., a defective heart valve or abnormal heartbeat
- Blood disorders
- Certain drugs, e.g., birth control pills

The effects of stroke vary. The extent of damage depends on where the clotting occurs and how long the brain survives without oxygen.

A stroke may cause temporary or permanent injury, coma or death. After stroke, common disabilities are difficulty speaking or swallowing, paralysis on one or both sides of the body and problems with concentration, attention, learning, memory and judgment. A person may find it hard to control emotions. Their personality may change. They may feel sad or experience numbness, strange sensations or nerve pain in their hands and feet.

Anoxic/Hypoxic Encephalopathy

The total absence of oxygen in the brain is called anoxia. Hypoxia is a shortage of oxygen. In both conditions, the brain is starved of oxygen — only to different degrees. Often these terms are confused, and used interchangeably. Widespread brain damage that changes the way the brain works or alters its structure is known as encephalopathy.

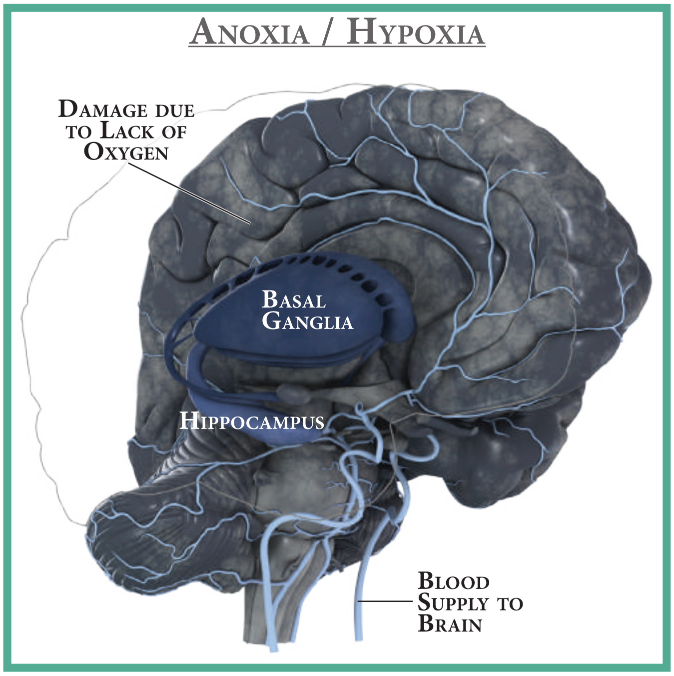


Illustration 2.4

Anoxia quickly leads to brain injury. Since the blood carries oxygen throughout the body, any interference in circulation means a decrease in the oxygen supply to vital organs. Thus, when the heart stops pumping during a cardiac arrest, the oxygen supply to the brain also stops. Unlike stroke, a heart attack cuts off oxygen to the whole brain – resulting in global injury. Near drownings or various accidents that cause severe blood loss can result in anoxia.

Some brain regions, such as the hippocampus and basal ganglia, are more vulnerable to damage from a lack of oxygen. They become injured faster than other parts of the brain when deprived of oxygen.

The brainstem, which controls breathing and basic body functions, is better protected against oxygen starvation than the cerebrum. This is why a person can survive a heart attack but still suffer from physical, behavioral and mental problems.

The most common causes of anoxia/hypoxia are:

- Strangulation
- Severe asthma attack
- Blood clots in the lung
- A crushing injury to the chest
- Near drowning
- Shock from massive blood loss
- Cardiac Arrest / Irregular heartbeat (ventricular fibrillation)
- Carbon monoxide poisoning

After anoxic/hypoxic encephalopathy, a person may be unable to move their limbs, have slurred speech, difficulty swallowing, seizures, tremors or other movement problems. Concentration, attention, problem-solving skills, judgment and memory may be affected. Personality may change. A person may be moody and anger easily or feel sad and disinterested in life. In severe cases, a person may fall into a coma or suffer brain death.

Increased Intracranial Pressure

Patients' symptoms following a brain injury are often a direct result of a build-up of pressure within the skull. The brain, its membranes, and the cerebrospinal fluid are encased within rigid skull bones; there is no leeway to accommodate the swelling or accumulation of blood (hematomas) caused by injury. Increased intracranial pressure compresses delicate brain tissue and leads to further brain injury.

To help reduce this increased intracranial pressure, surgeons remove hematomas in the operating room or use other methods of control. They carefully monitor for signs and symptoms of increasing pressure in the brain, including: decreased alertness, drowsiness, coma, severe headache, forceful vomiting, development of weakness or paralysis of arms and/or legs, irregular breathing patterns, and changes in the pupils' reaction to light. In addition, surgeons often insert a special device beneath the skull to monitor pressure so they can detect abnormally elevated pressures early on and respond quickly.

Physicians may use other methods besides surgery to manage increased intracranial pressure. These include certain medications and controlled hyperventilation using a respirator to increase the breathing rate, thus reducing carbon dioxide in the blood.

Hydrocephalus

Hydrocephalus may develop in individual's following a brain injury. Hydrocephalus occurs when there is obstruction of the normal flow of cerebrospinal fluid between the fluid filled spaces of the brain. Blockage of the flow of cerebrospinal fluid will result in dilation of the brains ventricles (fluid filled spaces) which can be seen on CT or MRI Scans. Symptoms of hydrocephalus may include the deterioration of a patient's physical, cognitive and emotional condition, as well as the failure of a patient to improve despite aggressive therapies and treatments. Most commonly, a triad of dementia, ataxia, and incontinence develops. Treatment includes the neurosurgical placement of a "shunt". A "shunt" is a surgically placed tube connected to a brain ventricle for the purpose of diverting excessive fluid to the abdominal cavity, heart or a large vein in the neck. (See ICP Monitor/Ventriculostomy, in the Intensive Care section later is this booklet for more information on shunts.)

Contusions

CONTUSION

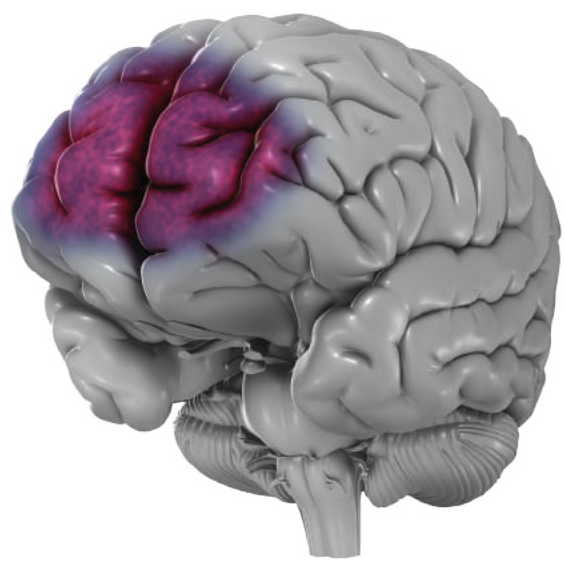


ILLUSTRATION 2.5

A contusion is bruising of brain tissue. It can form anywhere blood leaking from broken blood vessels pools in brain tissue, causing swelling.

Strong, direct blows to the head cause brain contusions. They also happen when a moving head strikes an object at high speed — for example, when a head hits the windshield during a car crash. The head often suffers structural damage, such as broken skull bones (skull fracture). Contusions can occur beneath a skull fracture or in response to an impact in which the brain shifts and rebounds against the skull. A contusion may occur at two points: where the head hits an object (the point of impact); and where the recoiling brain strikes the opposite side of the skull. This is known as a coup-contrecoup injury. A severe blow to one side of the head can cause even greater damage on the opposite side.

Contusions can temporarily or permanently disrupt brain activity — depending on their size and location. Minor damage from hits or blows causes small contusions and mild symptoms. A person may blackout for only a few seconds or may not lose consciousness at all. They may feel dazed for a few days or weeks after the injury. Other symptoms are headache, dizziness, blurred vision, ringing in the ears, tiredness, sleep problems, mood changes, and having trouble remembering, concentrating, paying attention or thinking.

Moderate and severe contusions cause longer blackouts — lasting minutes or longer. Over time, a person may develop worsening headaches, nausea and vomiting, seizures, dilation of the pupils, slurred speech, loss of coordination, inability to awaken from sleep, weakness or numbness in arms or legs, worsening confusion, restlessness and feeling upset.

The tissue damage and bleeding associated with contusions may lead to coma and even death. Multiple contusions may result in widespread bleeding and swelling which increases pressure on the brain. Moderate to severe contusions are life threatening and need emergency medical attention. This may include neurosurgery to open the skull to reduce pressure and/or for removal of necrotic tissue.

Hemorrhages & Hematomas

A strong blow to the head may damage or rupture one of the blood vessels surrounding the brain, or within the brain, leading to heavy bleeding (hemorrhage) or to the slow leakage of blood from the torn vessel. Other causes of bleeding are brain lacerations (tearing of brain tissue) and penetrating wounds from bullets, knives, or other sharp instruments. The accumulation of blood from these injuries is called a hematoma. Hematoma means "a mass of blood". Frequently, the neurosurgeon can remove subdural and epidural hematomas and stop the bleeding. However, a blood clot or bleeding deep within the brain tissue itself may not be treatable with surgery.

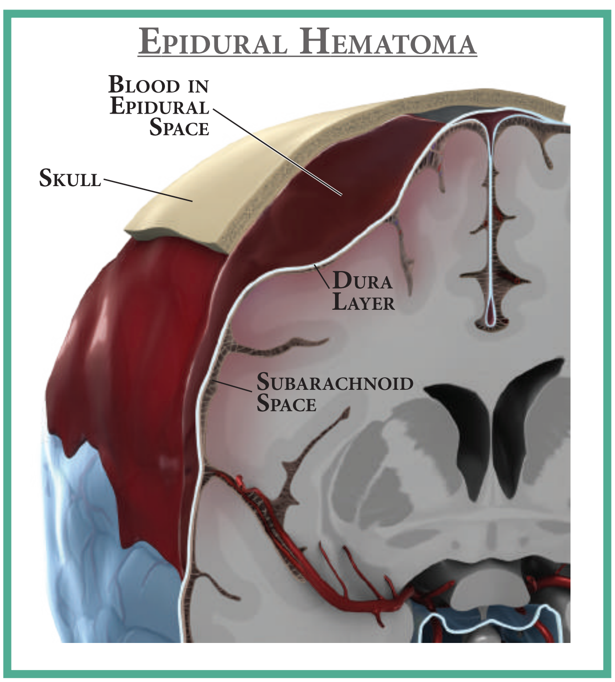


Illustration 2.6

Epidural Hematoma

In an epidural hematoma, bleeding occurs between the skull and the dura mater, the outermost membrane covering the brain. Epidural hematomas occur most frequently in conjunction with a skull fracture on the side of the head over the temporal lobe and originate from an artery. Although the underlying brain may not have been damaged initially, pressure from the hematoma can lead to brain injury.

Intracerebral / Intraparenchymal Hematoma

Bleeding that occurs directly within brain tissue may lead to a build-up of a blood clot within the brain itself, called an intracerebral/intraparenchymal hematoma. These hematomas usually result from penetrating wounds or blood vessels that rupture.

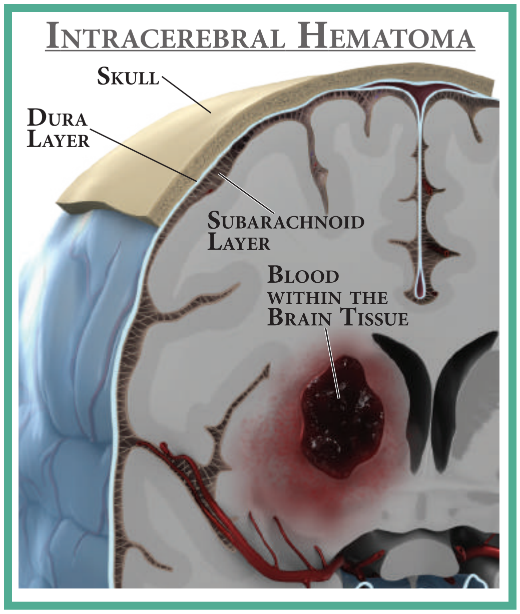


ILLUSTRATION 2.7

Subdural Hematoma

When bleeding occurs between the dura mater and the underlying membranes covering the brain itself, the term subdural hematoma is used. Subdural hematomas often occur in association with damage to the veins overlying the brain which rupture and leak into the space between the two outermost membranes (meninges) surrounding the brain. They may produce symptoms immediately or gradually as blood seeps out of torn vessels.

The hematoma compresses the brain. Trapped blood may clot, increasing pressure on brain tissue even more. Blood leaks into tissues of the brain, causing swelling. Brain cells begin to die as they are deprived of oxygen and nutrition. As the mass of blood grows, brain damage occurs. Large, rapid bleeds may lead to loss of consciousness and death.

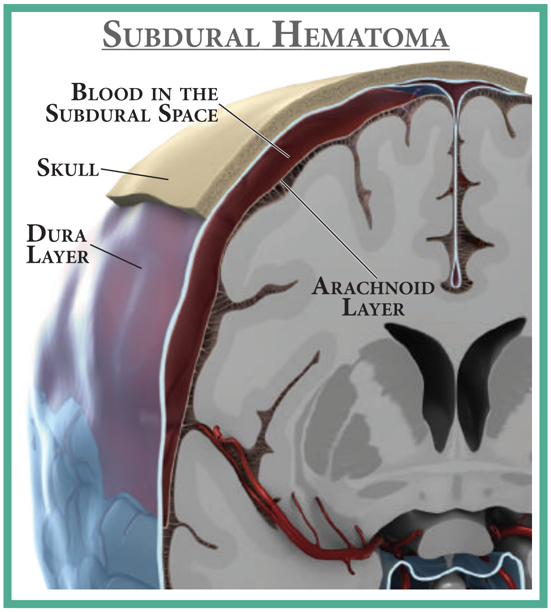


ILLUSTRATION 2.8

There are three types of subdural hematomas:

- **Acute:** After a severe brain injury; causes immediate, life-threatening symptoms
- **Subacute:** After major brain injuries; symptoms appear after days but may take longer
- **Chronic:** After minor brain injuries; symptoms may not be noticed for weeks

All subdural hematomas are medical emergencies and need medical attention as soon as possible to prevent permanent brain damage and death.

The most common cause is brain injury from a traumatic event, such as accidental blow or fall, particularly in the elderly. As the brain shrinks with age, tiny veins between the brain's surface and dura are stretched and more easily injured.

The effects vary, depending on which area of the brain suffers the hematoma. A person may have difficulty speaking or swallowing, memory loss, pain or numbness, paralysis on one or both sides and changes in behavior.

Subarachnoid Hemorrhage

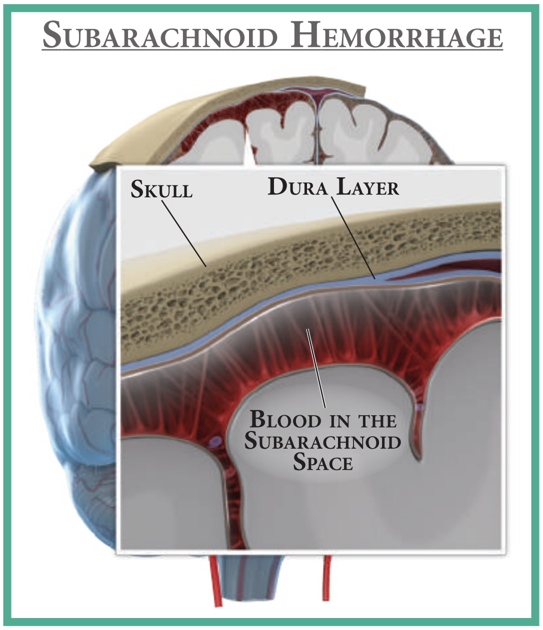


Illustration 2.9

Uncontrolled bleeding into the space between the middle and innermost membranes (meninges) surrounding the brain is a subarachnoid hemorrhage. The middle membrane is the arachnoid mater — hence subarachnoid or "under the arachnoid".

Vasospasm, or constriction of the blood vessels, restricts blood flow. It is a common complication of subarachnoid hemorrhage. It can cause stroke. The blood within the arachnoid space displaces the cerebrospinal fluid (CSF) and blocks the delivery of nutrients to the brain cells. The blood can block the flow of CSF in the ventricles causing a rise in pressure, or hydrocephalus. In both stroke and hydrocephalus, brain cells starve and die.

The most common cause of bleeding is rupture of a bulge in an artery (aneurysm). Subarachnoid hemorrhage occurs in 10–15 out of 100,000 people. It is most common in people from 20 to 60 years of age. It happens more often in women than men.

Sometimes the cause is unknown. Bleeding may occur in abnormal knots of blood vessels (arteriovenous malformations) present on the brain's surface at birth. A subarachnoid hemorrhage may be caused by brain injuries, bleeding disorders, and the use of blood thinners. You are more likely to have a subarachnoid hemorrhage if others in your family have suffered one. In the elderly, brain injury resulting from a fall is often responsible. Car accidents are the leading cause in young people.

Subarachnoid hemorrhage is a medical emergency. Without treatment, the person may die. What happens after treatment depends on the location and extent of bleeding. Some people recover completely. Others are left with permanent disabilities, while some die. Common disabilities are paralysis, difficulty talking or swallowing, memory loss, pain or numbness and changes in behavior.

Intraventricular Hemorrhage

Uncontrolled bleeding into one or more of the brain's ventricles is called an intraventricular hemorrhage. The ventricles are spaces within the brain that make and store cerebrospinal fluid (CSF), which nourishes the brain.

This type of hemorrhage occurs most often in premature babies. In infants born before 32 weeks of pregnancy, the veins next to the ventricles are often weak, because they are not yet fully developed. In premature babies, other complications can increase pressure in the veins, causing them to rupture and bleed easily — usually in the first few days after birth.

Intraventricular Hemorrhage

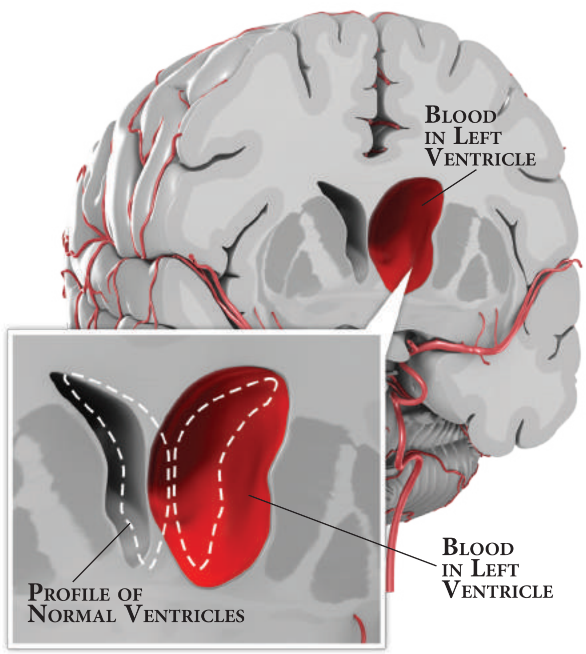


Illustration 2.10

The bleeding causes swelling in nearby brain tissues. Blood in the ventricles can block the flow of CSF, causing a build-up of fluid that increases pressure within the brain. This condition is called hydrocephalus or "water on the brain." About 1 in 500 newborns develop hydrocephalus.

In adults, intraventricular hemorrhage occurs in about 35% of people with moderate to severe brain injuries. Most often, blood leaks into the ventricles after a traumatic brain injury, such as a blow to the head during a fall or car accident.

The swelling and rise in pressure injures brain tissues, sometimes permanently. How much damage occurs depends on the location and extent of bleeding. Outcomes range from little or no permanent brain damage to death.

Aneurysm

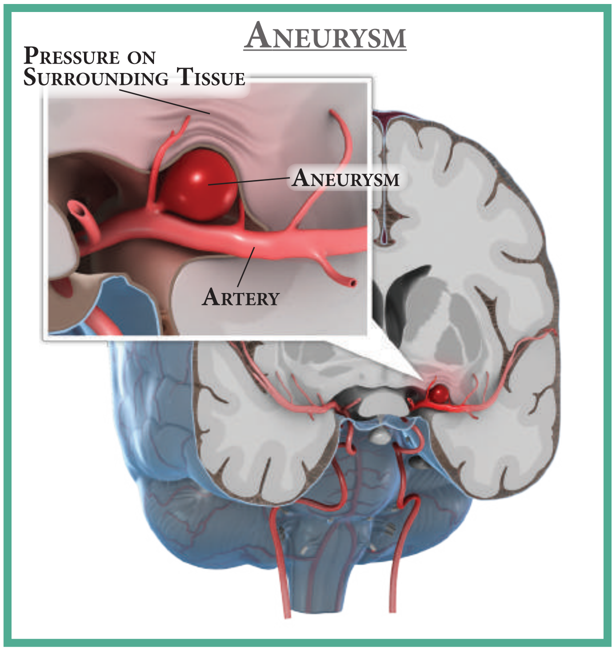


Illustration 2.11

An aneurysm is a weak spot in a blood vessel (artery) that bulges out and fills with blood. This bulge puts pressure on surrounding tissue and nerves. It may leak or rupture, spilling blood into the brain.

This weakness often occurs where arteries branch, but aneurysms can occur anywhere in the brain. They are common along the Circle of Willis, a ring of arteries at the base of the brain.

The causes of aneurysm are unclear. They may occur after a brain injury or infection. With age, vessel walls weaken and aneurysms may form. You can be born with an aneurysm. They can run in families and are more common in women than men. Most aneurysms happen in people between 40 and 60 years old.

Some aneurysms are very small and cause no problems. Aneurysms that leak or rupture can be deadly. Leaking blood damages or kills nearby brain cells and increases pressure inside the skull. A ruptured aneurysm is a life-threatening medical emergency. In 50% of cases, it leads to death.

What happens to a person after treatment depends on how much bleeding occurs and which area of the brain suffers. A person may have difficulty speaking or swallowing, memory loss, pain or numbness, paralysis on one or both sides and changes in behavior.

Seizures

Five to 10 percent of all patients with brain injury will have seizures or convulsions soon after a brain injury or even years later. Seizures indicate irritation or injury to certain areas of the brain which interferes with the normal pattern of communication and transmission of information between brain cells (neurons). During the seizures, patients often lose consciousness and their bodies shake and writhe. Since prolonged uncontrolled seizures can cause further damage to the brain, medications are often used to prevent or control them.

Coma

Brain injury can also result in coma. This condition is a state of unconsciousness in which the patient is unresponsive to and unaware of surroundings. The length of a coma varies with each brain injury and can last from a few days to several months and in rare cases years. Family members should not expect a patient to suddenly wake up from a coma as they do after a night's sleep. Emergence from a coma is usually a very gradual process of increasing responsiveness and awareness. Physicians and nurses cannot predict how an individual will progress and often must be patient along with the family.

Family members and friends often wonder if comatose patients can hear. Sometimes patients seem to show signs that they may understand when they appear to follow a simple request, like squeezing a hand. Occasionally, they seem to be calmed by a familiar voice or music. Since patients rarely remember these events later, it is impossible to know what they actually experience. Nevertheless, health care professionals recommend people approach comatose patients as if they could hear and understand.

Assessment and Treatment

This section will discuss:

- **Early Assessment**
- **Diagnostic Tests**
- **Glasgow Coma Scale**
- **Vital Signs and Reflexes**
- **Early Treatment**

Early Assessment

Quick and efficient assessment and treatment of patients with brain injuries are the keys to preventing further damage and related complications. Advances in emergency medicine, more sensitive diagnostic tests, surgical procedures, and life support systems have helped increase the survival rate over the past 10 to 15 years. Paramedics and emergency medical technicians are specially trained to respond at-the-scene to brain injuries and cardiac arrests. The paramedics often begin to stabilize patients before transferring them to an emergency department or trauma center. Ambulances are equipped with two-way radios, computers, and advance life support equipment, enabling paramedics to communicate with physicians and alert the hospital of the patient's condition.

The primary goal of emergency personnel is to maintain a proper oxygen supply to the brain and other vital organs by sustaining adequate blood pressure. Thus, they assess and treat other injuries that cause loss of blood, which may lead to shock and cardiac arrest.

At the scene of an injury and in the emergency department, trauma personnel try to obtain information about the accident or sudden illness from observers and family members. Properly assessing the cause of an injury frequently helps physicians diagnose the extent and type of damage and decide on treatment.

The first minutes and hours after an acute injury are very difficult for families and close friends, but physicians and nurses must stabilize and assess the patient and begin treatment before they can offer information and answer questions.

Diagnostic Tests

Physicians often request a number of tests to determine the extent and nature of injury. Tests used for the assessment of patients with brain injuries may include:

- X-ray / Evaluation of the Cervical Spine
- CT Scans
- MRI
- Catheter Angiography / CTA / MRA
- EEG (Electroencephalogram) / QEEG (Qualitative Electroencephalogram)
- PET Scan (Positron Emission Tomography)
- SPECT scan (Single Photon Emission Computed Tomography)
- Other Tests

X-ray / Evaluation of the Cervical Spine

X-rays can identify the presence and extent of a fracture of the skull or cervical spine.

CT Scan

Patients with skull fractures, those who show changes in their level of alertness or function, and those who may have suffered a brain injury, usually undergo CT scans. Thin sections of the brain can be examined; showing areas of hemorrhage, fluid collection, contusions, stroke, and special types of skull fractures. The scan, a painless procedure, also helps determine the presence and amount of brain swelling. Most commonly used in acute situations, CT scans are an excellent way for physicians to determine if there is brain injury that may require emergency neurosurgical intervention. CT scans may initially be negative, but reveal abnormalities when repeated several days later.

MRI

MRI uses magnetic fields instead of x-rays to produce a picture of the brain tissue. MRIs can pick up slight changes not seen on a regular x-ray or CT scan, making this test especially important in the evaluation of symptomatic individuals having mild brain injuries (concussions) and to evaluate damage to the brain structures. MRIs may be used in the evaluation of patients demonstrating chronic cognitive or behavioral symptoms despite negative CT scans.

Catheter Angiography / CTA / MRA

Catheter Angiography, CTA, and MRA are tests that enable the blood vessels of the brain to be seen after the vessels have been injected with contrast medium (a substance opaque to the testing method). They are used to detect an altered appearance of the blood vessel channel. They are a useful way for physicians to diagnose dissections (tears) of the carotid or vertebral arteries, aneurysm, or traumatic vascular injury.

EEG / QEEG

An EEG (electroencephalogram) is a recording of the electrical activity of the brain. This painless procedure is similar to an electrocardiogram that records the electrical activity of the heart. Specially trained technicians paste electrodes, which look like small flat sponges with wires attached, onto the scalp and connect the wires to a machine that measures brain activity. Patients with seizures often require EEGs to locate the area of abnormal electrical activity in the brain. EEG's are also used to confirm the diagnosis of epilepsy, a seizure disorder, which can result from brain trauma.

A QEEG (quantitative electroencephalogram) is a more complex version of the traditional EEG. The QEEG is intended to aid in evaluating brainwave patterns throughout the brain and comparing them to standard samples and those with neurologic impairment to identify areas of significant deviation which may indicate injury.

PET / SPECT Scan

A PET scan (Positron Emission Tomography) uses a radionuclide tracer to produce positrons that emit two gamma rays that are detected. The tracer tends to be a glucose analog which allows the PET scan to detect the active uptake of glucose and image the actual function of the brain. This shows what areas of the brain remain active following an injury.

The SPECT scan (Single Photon Emission Computed Tomography) is similar to a PET scan with the exception that only one gamma ray is detected. It is a functional scan of the brain and will show areas of the brain that are actively using glucose demonstrating an increased level of activity.

Other Tests

Tests that examine specific responses of the senses and the potential for further recovery are also used in some cases. For example, specialized EEG's, known as visual evoked potentials (VEP), brainstem auditory evoked potentials (BAEP), or somatosensory evoked potentials (SEP), may be performed if there is uncertainty regarding an individual's ability to see, hear, or feel following a brain injury.

In addition, patients undergo frequent blood and urine tests to check the concentration of body chemicals, gases, and cells. If the patient shows signs of infection, nurses send samples of blood, urine, mucus, wound drainage, and other body fluids to the laboratory to be examined for the presence of bacteria (germs) / infection.

Glasgow Coma Scale

Once the patient is partially stabilized in the emergency department, he or she is usually transferred to an intensive care unit where assessment and treatment continue. Physicians commonly use a clinical test, the Glasgow Coma Scale, to evaluate brain injuries. It rates three categories of patient responses: eye opening, best verbal response, and best motor response. Levels of responses indicate the degree of functional brain impairment.

- ***Eye opening*** tests indicate the function of the brain's activating centers. The patient's eyes may open spontaneously, only on verbal request, or only with painful stimulation.
- ***Best verbal response*** indicates the condition of the central nervous system within the cerebral cortex. The patient may be able to speak normally and be oriented to time and place, or he or she may be disoriented and use inappropriate words. At the other end of the scale, the patient may only make incomprehensible sounds or no sound at all.
- ***Best motor response*** tests examine a patient's ability to move arms and legs. Responses may vary from the ability to move about on command to the ability to move reflexively only in response to pain or not at all.

Each category of the Glasgow Coma Scale is rated using "1" as the lowest possible score. The worst possible Glasgow Coma Scale score is "3", while the best possible score is "15". Physicians classify brain injuries as severe, moderate, or mild (concussion), using these scores. A score of 3-8 denotes a severe brain injury, 9-12 a moderate brain injury, and 13-15 a mild brain injury. Other determinants of brain injury severity include the duration of the loss of consciousness or coma, and the length of time a patient experiences confusion or amnesia.

Vital Signs and Reflexes

Constant and frequent assessment is the hallmark of intensive care, as changes in vital signs, responsiveness, and reflexes often indicate problems that need immediate attention or close observation. These can include fever, increasing intracranial pressure, and bleeding. Nurses carefully monitor vital signs, such as temperature, pulse rate, breathing rate, and blood pressure. They also assess the status of the nervous system by checking the pupils' response to light, a patient's response to commands, the strength of a hand grip, and the movement and strength of arms and legs. Physicians check the function of the 12 cranial nerves and other reflexes to determine the extent and nature of the injury.

Early Treatment

Treatment of brain injury varies according to the severity and type of injury. In the first hours and days after an injury, treatment plans may change rapidly in response to the patient's condition. Family members and friends may find it difficult to follow the constant changes. Writing down explanations, preparing written questions ahead of time, and asking doctors and nurses to repeat or thoroughly explain information can help in understanding early treatments.

Basic treatment goals include: preventing or controlling increased intracranial pressure and edema with surgery and other methods, controlling bleeding, maintaining adequate blood pressure, maintaining an adequate supply of oxygen to the brain and other vital organs, preventing or controlling seizures, maintaining fluid balance, preventing infection, and supporting all the systems of the body in the best way possible.

Many hospitals state that rehabilitation begins the moment the patient arrives in the emergency department. Thus, issues as good nutrition, proper positioning of arms and legs, and proper skin care are also part of the treatment that comatose and immobilized patients receive in the intensive care unit.

Most people have never been inside an intensive care unit, where the sights and sounds can be somewhat overwhelming.

This section presents a brief explanation of the common equipment used in the care of patients with brain injuries.

- **Intravenous Line**
- **Arterial Line**
- **Monitoring Equipment**
- **Foley Catheter**
- **Chest Tube Drainage System**
- **Nasogastric Tube**
- **Cooling (Hypothermia) Therapies**
- **Endotracheal Tubes and Tracheostomy**
- **Ventilator (Respirator)**
- **Suction Catheter**
- **ICP Monitor**

Intensive care treatment may last from several hours to several weeks, depending on the extent of the individual's injury.

Intravenous Line

To insert an intravenous (IV) line, a small plastic tube called an intravenous catheter, is threaded into the vein (blood vessel) using a needle. Once the catheter is in place, the needle is removed. The intravenous catheter is connected to a longer piece of tubing that is attached to a bag or syringe of fluid. IVs are used to deliver fluid, nutrients, and medication to the body. They can be inserted into veins in almost any part of the body, including the arms, legs, neck, and chest.

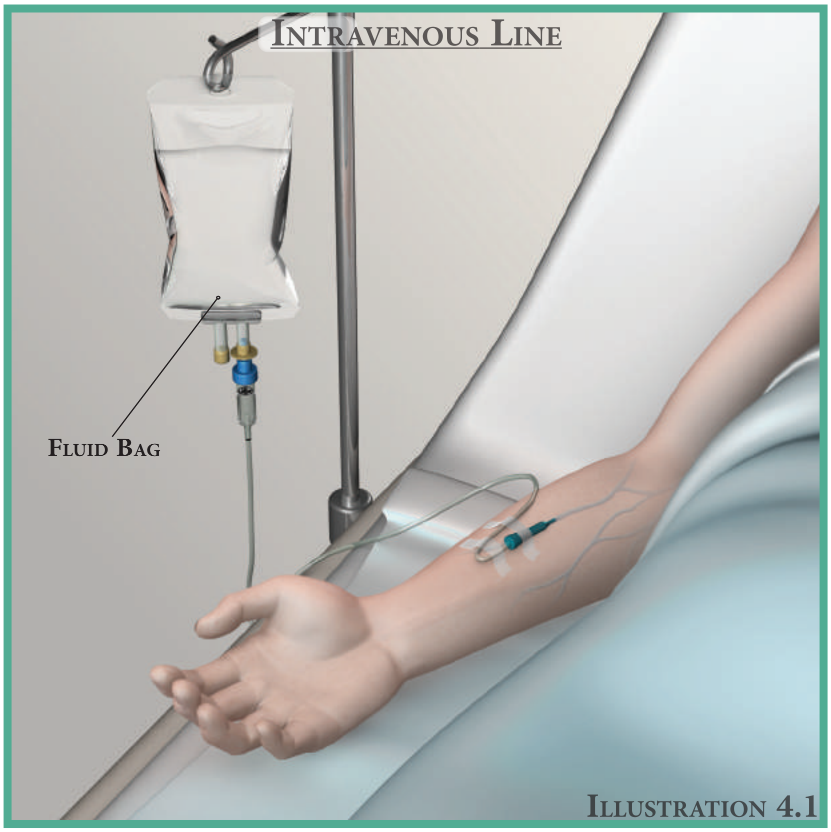


ILLUSTRATION 4.1

Arterial Line

Similar to an IV, an arterial or A-line is a catheter placed in one of the arteries (blood vessels), usually in the wrist. Arteries carry oxygen and nutrient-rich blood from the heart to the tissues and organs throughout the body. Veins carry blood that is higher in content of carbon dioxide back to the heart and lungs. Physicians and nurses draw small amounts of blood from the arterial line at regular intervals to measure the oxygen and carbon dioxide content of the blood and many of the body's chemicals (electrolytes). Therefore, each time a blood sample is required, the patient need not receive a needle stick.

CARDIOVASCULAR MONITOR, FOLEY CATHETER, AND CHEST TUBE

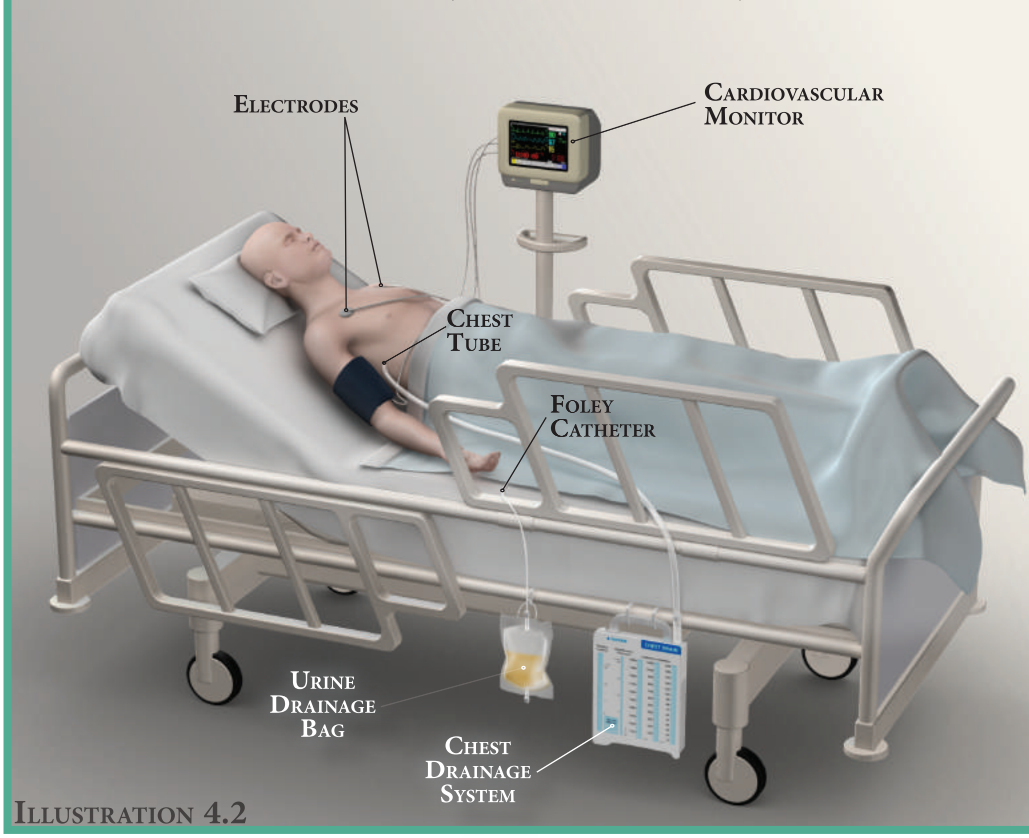


ILLUSTRATION 4.2

Monitoring Equipment

A monitor looks like a small computer display and can usually be found at the head of the patient's bed. Electrodes attached to the patient's body are connected to the monitor to measure heart rate, heart rhythm, blood pressure, and pulse oximetry. An arterial line or ICP monitor may also be connected and provides constant readings. If any of these parameters goes above or below a certain point, an alarm sounds to alert the nurse. However, alarm signals do not necessarily mean that anything is wrong. Often, the alarm sounds when the patient moves around in bed or when an electrode becomes loose. Interpreting the information displayed on the monitor requires considerable medical training and experience.

Foley Catheter

The Foley catheter is a small tube inserted into the bladder to drain urine. It is connected to a urine drainage bag that hangs on the side of the bed. Measuring and testing the body's output of urine helps to monitor the patient's fluid status and kidney function.

Chest Drainage System

Patients with brain trauma often experience other types of injuries. Those with chest trauma may need a tube inserted into their chest wall to drain air, fluid, and blood into an airtight plastic container attached to a suction catheter. This treatment promotes the re-expansion of a collapsed or partially collapsed lung. Patients with chest tubes who are alert and awake may require pain medication. Nurses may also monitor a comatose patient for non-verbal signs of pain.

Nasogastric Tube

A nasogastric (NG) tube is usually inserted when a patient is in the hospital unit and unable to swallow or has gastrointestinal issues. It is a clear plastic tube about the size of a small straw that is inserted through the nose down the back of the throat through the esophagus (the tube-like passage between the throat and the stomach) and into the stomach. Initially, this tube is used to remove air and digestive juices from the stomach. When the patient becomes more stable, it may also be used as a feeding tube.

Nasogastric Tube

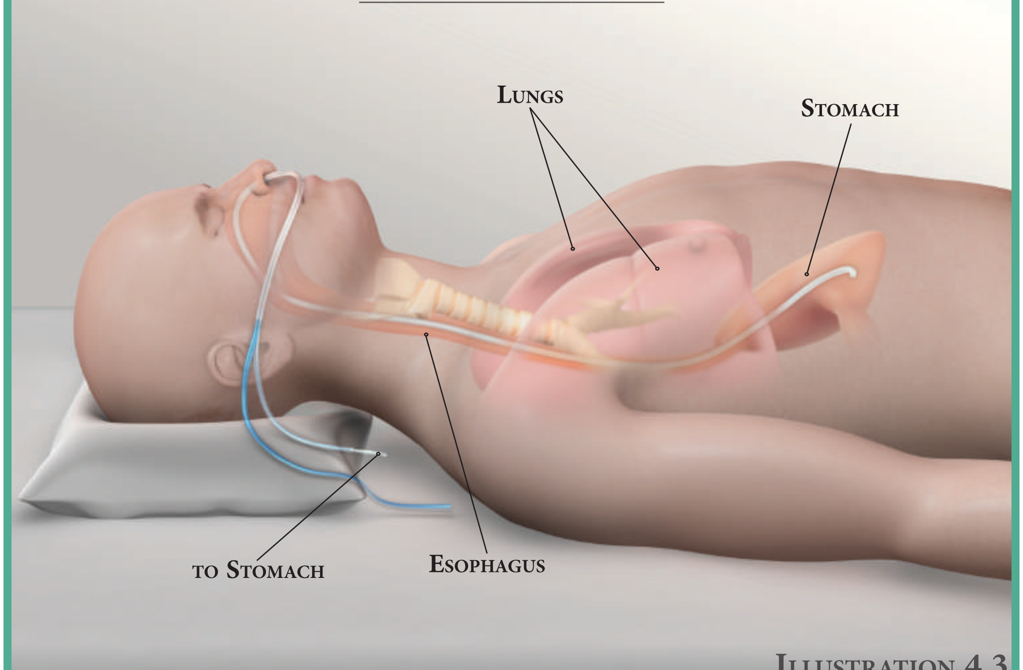


Illustration 4.3

Cooling (Hypothermia) Therapies

Because of injury to the temperature control center of the brain, a patient may run a very high temperature. Cooled liquid pumped through an external or endovascular cooling device help to keep the patient's temperature as close to a normal range as possible. More recently, therapeutic hypothermia has been studied as a means of reducing further neurologic complications and increasing the chances of a more favorable outcome.

Endotracheal and Tracheal Tubes

Patients with severe brain injury may not breathe deeply and regularly and may experience problems clearing their air passages. This condition may be caused by injury or swelling in the area of the brain that controls breathing. Such patients usually require a breathing (endotracheal) tube to keep their airways open. The tube passes through the mouth and into the windpipe or trachea through which it delivers oxygen to the lungs. Mechanical ventilation (artificial respiration) may be required which can control breathing rate and depth.

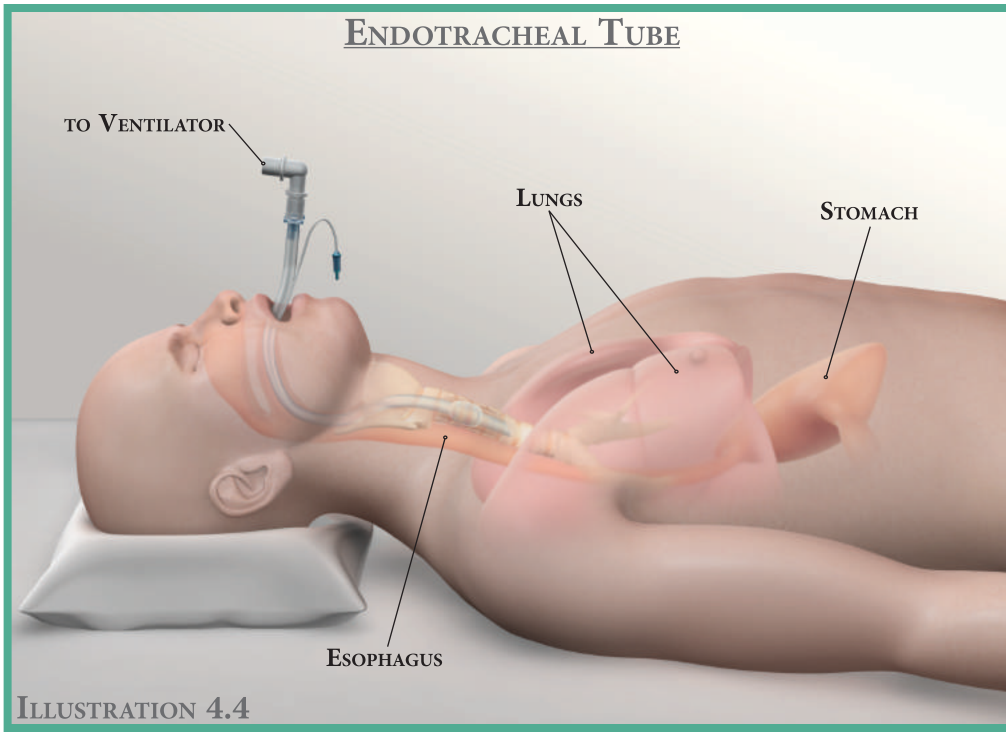


ILLUSTRATION 4.4

If breathing must be controlled for longer than a few days, the surgeon may create an opening directly into the windpipe through the neck. This is called a tracheostomy. This artificial airway is easier to manage and prevents irritation to the throat caused by an endotracheal tube.

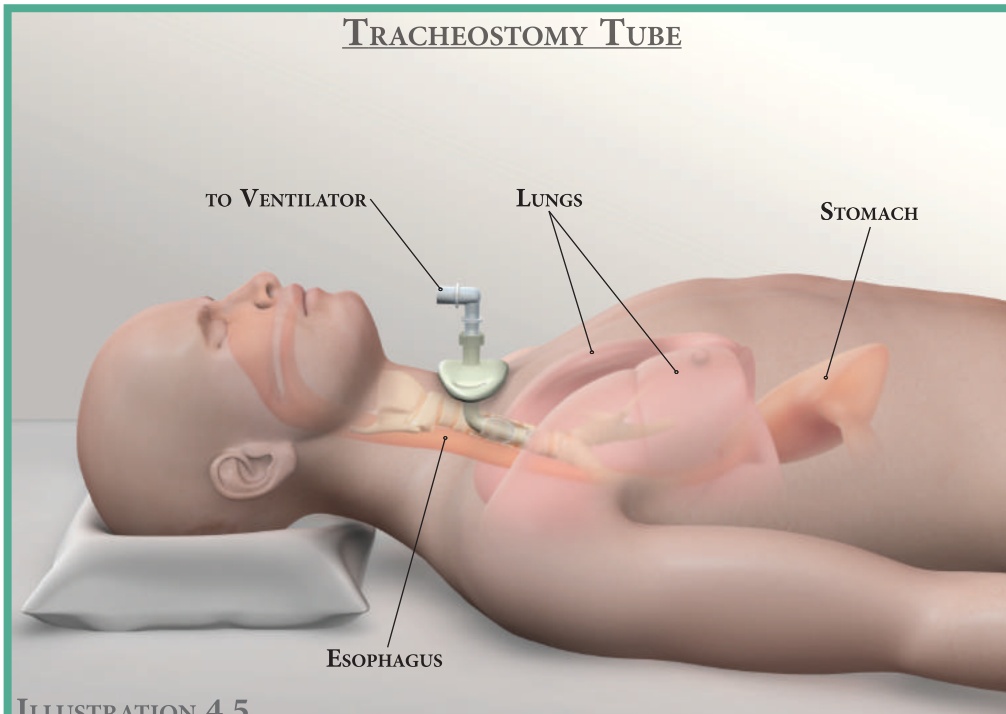


ILLUSTRATION 4.5

Ventilator (Respirator)

A ventilator aids the patient's breathing. This machine moves air and oxygen in and out of the lungs through the endotracheal or tracheostomy tube, which is connected to the ventilator by large plastic tubes. Ventilator controls allow for a variety of settings. Sometimes the patient activates the ventilator by taking a breath. At other times the ventilator automatically delivers air at a given rate and volume. As mentioned in the section on intracranial pressure, some patients require rapid breathing rates (hyperventilation) to help control rising intracranial pressure. To prevent reflexes from competing with the ventilator, some patients may receive medication that temporarily deactivates (paralyzes) the muscles that assist in breathing. This medication may paralyze the muscles in the arms and legs as well.

Suction Catheter

Small, pliable tubes or catheters about the size of a narrow straw are used to clear the nose, mouth, endotracheal tube, or tracheostomy tube of mucus (phlegm or secretions). These catheters connect to tubing that attaches to a wall suction unit. The respiratory therapist or sometimes a nurse uses them to suction the patient regularly, depending on the accumulation of secretions. Patients who can respond may consider suctioning uncomfortable.

ICP Monitor / Ventriculostomy

The monitoring of intracranial pressure (ICP) is vital in patients with brain injury. The ICP monitor is a small tube placed into or just on top of the brain through a small hole in the skull. This is a device with which to measure the intracranial pressure inside the skull and brain. Neurosurgeons monitor an individual's

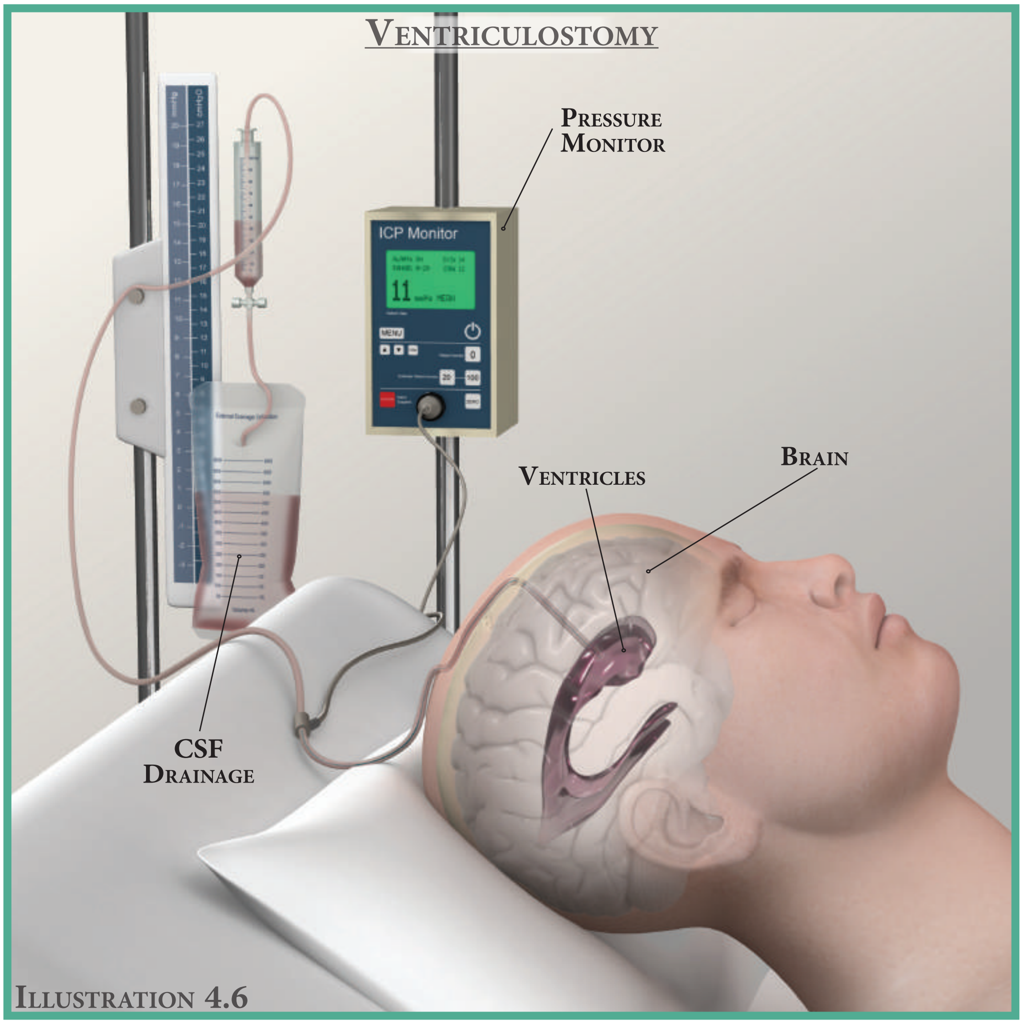


Illustration 4.6

intracranial pressure closely in the ICU (intensive care unit) following a brain injury. Abnormal elevations of intracranial pressure resulting from brain swelling, inflammation or bleeding are treated aggressively by neurosurgeons to prevent further injury to the individual's brain.

ICP can be monitored by several different devices which vary in their placement within the skull cavity and their abilities. The optimal device with which to measure intracranial pressure is a ventriculostomy, also referred to as a ventricular/intraventricular catheter or an external ventricular drain (EVD). An EVD is a small tube placed within the cerebrospinal fluid (CSF) chamber (ventricle) of the brain. This method allows ICP monitoring as well as the ability to drain small amounts of CSF through the tube to help relieve increasing intracranial pressure when the brain swells.

When ICP is high, it may not be possible to utilize an EVD. In an emergent situation when ICP monitoring must occur immediately, other methods may be used. The subarachnoid screw penetrates though the skull and dura matter into the subarachnoid space to monitor pressure. Specialized versions may also be used to drain CSF. Alternate locations for monitoring may include the epidural space, subdural space, and within the cortex (intraparenchymal). An epidural sensor monitors pressure from between the skull and the meninges, in the epidural space. The subdural screw or sensor protrudes through the membrane that covers the brain to monitor ICP from within the subdural space. A fiber optic transducer may be used to monitor pressure from within the epidural space, subdural space, the ventricles, or within the brain tissue. These methods do not allow for the drainage of CSF as with an EVD or subarachnoid screw. However, catheters may be placed into these areas to drain blood accumulated from a hemorrhage or hematoma, thereby lessening the ICP.

Intracranial Pressure Monitoring Locations

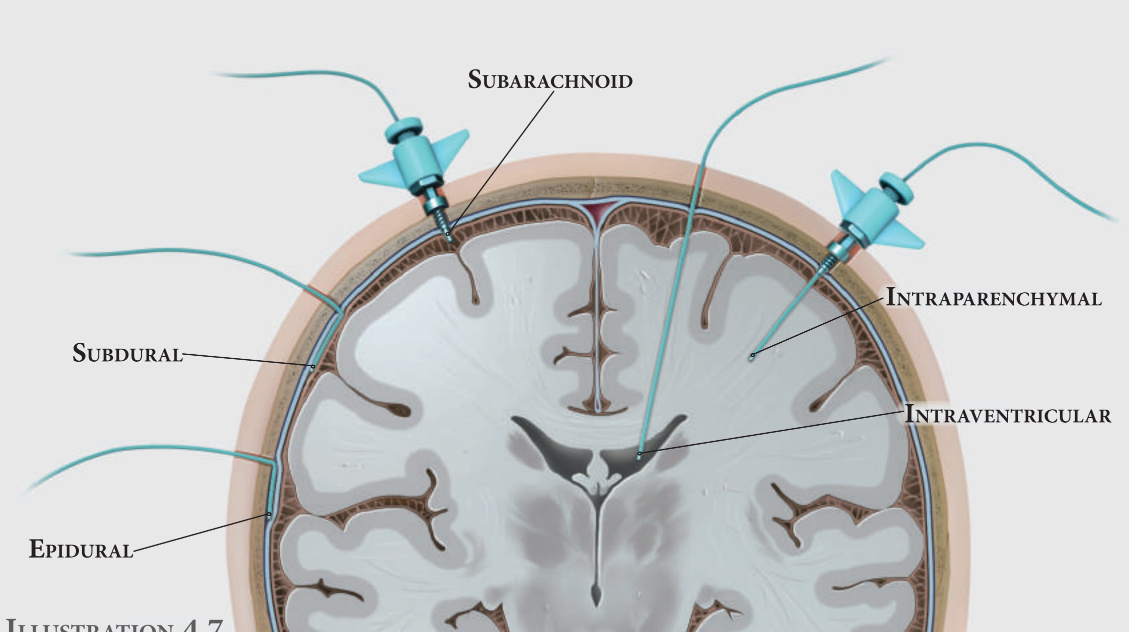


Illustration 4.7

This section will discuss the acute rehabilitation phase of care, including:

- **Rancho Los Amigos Scale of Cognitive Functioning**
- **Physical Care**
- **Airway Management**
- **Maintaining Nutrition and Fluid Balance**
- **Promoting Normal Elimination Patterns**
- **Preventing Eye Irritations**
- **Skin Care**
- **Positioning and Exercise**

Physicians discharge brain trauma patients from intensive care units (ICU's) once their vital signs are stable for a period of time and they are no longer at risk of acute medical and surgical problems, such as bleeding or rapidly increasing intracranial pressure. Following discharge from the ICU, patients are transitioned to a "step down unit" where there is less intensive nursing and medical care, but still close observation.

As they progress, patients may be transferred to specialized brain injury rehabilitation programs or units. Some hospitals have special units for patients with specific types of neurological problems. These programs are designed to assess the physical, cognitive, and behavioral status of patients, to establish specific treatment, and to prevent complications. Rehabilitation staff members evaluate each patient carefully and devise individual plans of care.

Family members and friends may know that discharge from the ICU is a step forward. They may be relieved that the patient's condition has stabilized to the point where he or she no longer needs intense observation. Still, they may feel anxious about leaving the security of the ICU. They may have come to know and trust the ICU staff and now must become acquainted with a whole new group of caregivers. Often times, staff is aware of these feelings and is available to help patients and families become accustomed to a new unit.

Many patients are in a semi-comatose or confused and restless state when they are discharged from the ICU. In these patients, physical problems may be easily identified, while cognitive and behavioral deficits remain more difficult to recognize. A neuropsychologist usually assists the medical team in identifying and treating specific areas of a patient's neuropsychological dysfunction (behavioral and cognitive problems). The Rancho Los Amigos Scale of Cognitive Functioning, named for the center where it was developed, is used in rehabilitation settings throughout the country. It assists the rehabilitation team in assessing a patient's level of cognitive and behavioral recovery.

Rancho Los Amigos Scale of Cognitive Functioning

The following is a brief explanation of the Rancho Los Amigos Scale of Cognitive Functioning:

Level 1 – No response. The patient appears to be in a very deep sleep and does not respond to voices, sounds, lights, movement, or touch.

Level 2 – Generalized response. The patient may move, but movement does not seem to have a purpose or consistency. Patients may open their eyes but do not seem to focus on anything in particular. There are inconsistent, non-purposeful, non-specific reactions to stimuli. Patients respond to pain, but the response may be delayed.

Level 3 – Localized response. Patients begin to move their eyes and look at specific people and objects. They turn their heads in the direction of loud voices or noise. Patients at Level 3 may follow a simple command, such as, "Squeeze my hand," but response to commands and stimuli are inconsistent.

Level 4 – Confused and agitated. The patient is very confused and agitated about where he or she is and what is happening in the surroundings. These patients are disoriented and unaware of present events and demonstrate frequent bizarre and inappropriate behavior.

Level 5 – Confused, inappropriate, but not agitated. The patient is confused but alert and able to follow simple directions. There are non-purposeful, random or fragmented responses to instructions when task complexity exceeds abilities. Stressful situations may provoke some upset, but agitation is no longer a major problem. Patients may experience some frustration as elements of memory return.

Level 6 – Confused but appropriate. The patient's speech makes sense, and he or she is able to do simple things such as dressing, eating, and teeth brushing. Behavior is goal-directed. Conversation is appropriate to the situation but with incorrect responses due to memory difficulties.

Level 7 – Automatic, appropriate. Patients can perform all self-care activities. They may have difficulty remembering recent events and discussions. Rational judgment, calculations, and solving multi-step problems present difficulties, yet patients may not seem to realize this. Insight is poor but overall these patients are oriented to the place or the setting.

Level 8 – Purposeful and appropriate. At this level patients are independent and can process new information. They remember distant and recent events and can solve complex and simple problems. However, difficulties with abstract reasoning may remain. Tolerance to stressful situations may be poor.

As patients improve after a brain injury, they may move from one Rancho cognitive level to the next, but often demonstrate characteristics of more than one level at a time. Depending on the extent and type of injury, they may remain at any one level for an extended period.

Using information from this scale, the health care team can begin treatment that will help develop skills and promote appropriate behavior. Health care professionals often suggest the following simple measures to family and friends while the patient is still in a coma:

- Always talk as if the patient hears when you are nearby.
- Speak directly to the patient about simple things and reassure him or her frequently.
- Explain events and noises in the surrounding area. Tell the patient what has happened and where he or she is.
- Touch and stroke the patient gently. Tell the patient who you are each time you approach the bedside. Hold his or her hand.
- Play the patient's favorite music or tape a soothing message that can be played when you are away from the bedside.
- For parents of young children, tape yourself singing or reading your child's favorite stories.

Physical Care

Physical care may be less complex once patients leave the ICU, but it is still the basis of good rehabilitation. In this phase, family members and friends can participate more extensively in the patient's care under guidance of the health care team.

Airway Management

Physicians remove endotracheal tubes before patients leave the ICU, but can leave tracheostomy tubes in place. These patients receive humidified air through a clear plastic mask-like device that fits over the tracheostomy. Moist air keeps secretions loose, and thus easy to cough up or remove with suction.

Respiratory therapists often work with patients to promote good air exchange. They may place the patient in positions that facilitate chest drainage and clap and vibrate the patient's chest and back to loosen lung secretions and stimulate coughing (chest physical therapy). Prevention of pneumonia is an important part of the treatment plan.

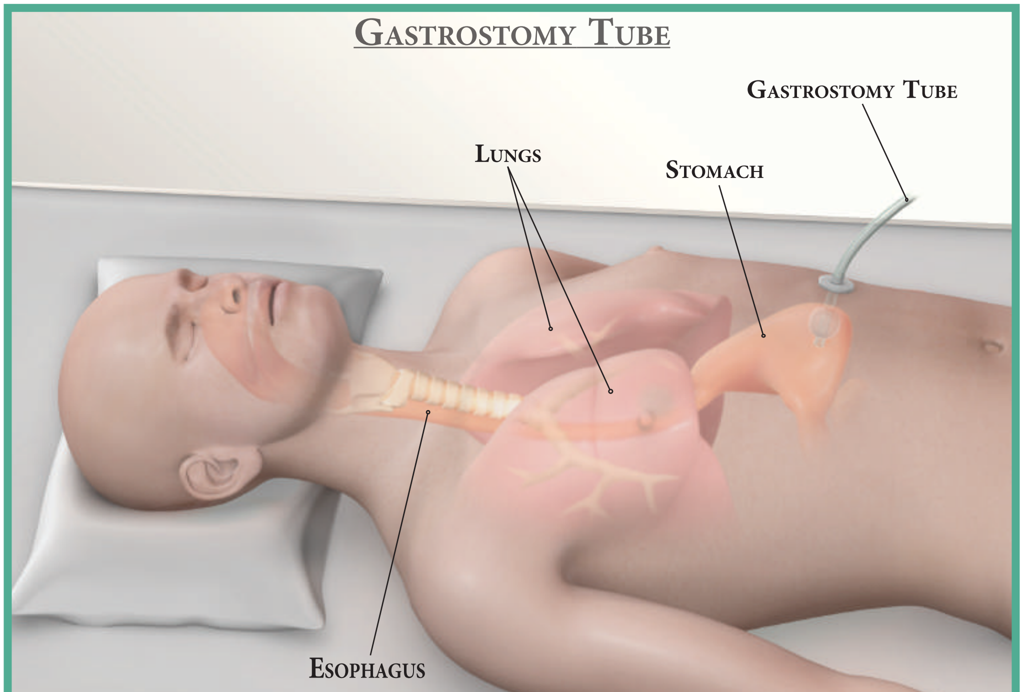


Illustration 5.1

Maintaining Nutrition and Fluid Balance

It may take several weeks or longer before patients can eat or drink. Because of injury to certain areas of the brain, they may be unable to coordinate taking food into the mouth and then swallowing. Sometimes the gag reflex, which prevents choking, is inadequate. Staff members begin retraining patients to eat and drink as soon as possible, but in the interim, many patients may require tube feedings. Tube feedings often begin in the ICU via a nasogastric (NG) tube. For patients who require tube feedings for any length of time, physicians may place a gastrostomy tube (G-tube) directly into the stomach. The G-tube eliminates irritation to the nose and throat that may occur with prolonged use of an NG tube.

To place a gastrostomy tube, a physician (gastroenterologist, radiologist, or surgeon) places a tube between the stomach and the abdominal wall using one of several methods (percutaneous, fluoroscopic, or open). Ready-to-use tube feeding products, slowly infused through the tube and into the stomach, contain all the essential nutrients required by the body to grow, heal, and maintain its functions.

Promoting Normal Elimination Patterns

Another goal of rehabilitation is to help patients regain bladder and bowel regularity and the control of elimination. By scheduling regular, well-tolerated feedings and administering stool softeners and certain medications, nurses and doctors help the patient regain regular bowel habits. External drainage systems can help keep the patient dry and protect sensitive skin from the irritation of urine and feces.

Preventing Eye Irritations

Brain injuries may interfere with the blinking reflex, which protects the eyes from injury and helps keep eye membranes moist. Nurses keep the eyes of comatose patients closed and instill lubricating eye drops every few hours. As patients emerge from a coma, they may continue to need lubricating drops depending on the nature of their injury.

Skin Care

Another essential aspect of care that begins in the ICU and continues through all phases of treatment is skin care. Patients who are confined to bed or sit in one position for a long time can develop bedsores (decubiti). To prevent this, nurses change the patient's position frequently, massage the bony areas over the joints where the skin is more likely to break down and use moisturizing lotion on all areas of the skin. Special types of mattresses that redistribute weight and protective devices for elbows and heels also help prevent skin irritation. Family members and friends can assist with this aspect of patient care.

Positioning and Exercise

To prevent future dysfunction and loss of mobility, nurses place the patient's joints in positions that promote maximum use. When patients are unable to move about, nurses change their positions in the bed or chair frequently. Sometimes, physical therapists design splints for arms, legs, feet, hands, and the neck to help maintain proper positioning. These techniques assist with the prevention of contractures – the shortening of muscles due to inactivity or increased muscle tone.

Physical therapy begins as soon as possible to help restore or maintain muscle tone, strength, and joint range of motion. While patients are unable to move about themselves, nurses and physical therapists stimulate their joints through passive exercises. Family members are often instructed on how they may be able to help with passive range of motion exercises.

Symptoms After Brain Injury

Brain injury results in three main types of impairments. This section will discuss:

- **Physical Problems**
- **Cognitive (Thinking and Comprehending) Impairments**
- **Behavioral Disorders**

Physical Problems

Physical problems may be simpler for family to understand because they are easier to see or identify than emotional or cognitive impairments. Physical problems may include painful headaches, seizures, decreases in muscular strength and coordination, loss of sensation to a part of the body, loss of vision, hearing, taste or smell, and complaints of pain. Because of damage to specific areas of the brain and lack of activity, patients' muscles may contract and joints may become stiff. For example, some patients involuntarily maintain their feet in a rigid position with the toes pointed downward (foot drop). These patients require special splints and exercises to keep their ankles bent and their feet in the position normally used in walking. Many show weakness or are unable to move one side of their body (hemiparesis). Difficulties with vision, speech, hearing, smell, and taste are among other physical problems.

Cognitive Impairments

Less apparent than physical problems, cognitive impairments or disturbances in thought processes may be more difficult for family to understand. Examples include: problems or deficits in reasoning, short-term and long-term memory; slowness in thinking; poor attention span; difficulties in reading, writing, and speaking; inability to comprehend or process information; and problems with planning, organizing, insight, and judgment.

Behavioral Disorders

Changes in behavior and personality may be the most difficult problems for family members and friends to face. As individuals emerge from a coma, normally quiet, well-mannered persons may become agitated and aggressive. Later, mood swings may be sharp and occur without warning. Preexisting personality traits often become magnified following a brain injury. Individuals may become impulsive and disinhibited, resulting in socially inappropriate behaviors. Depression, anxiety, irritability, and restlessness are other common problems. These complex behaviors may result directly from the brain injury as well as indirectly from the patient's emotional response to frustration and confusion caused by the trauma. Physical and cognitive problems often intensify the frustration associated with behavioral disorders. A brain trauma patient's abnormal behavioral symptoms often resolve gradually over time with the help of intensive neuropsychological rehabilitation interventions including the use of structured therapy settings and the aggressive redirection of inappropriate behaviors. In some cases the attending rehabilitation physician may need to temporarily prescribe medications to calm a patient's extreme restlessness and agitation. The team neuropsychologist is often able to assist the family with adjustment issues related to changes in both emotional and cognitive functions of a brain injury patient.

Family Adjustment

This section presents some common feelings families and friends may experience after a loved one has suffered a brain injury.

When a brain injury occurs, the family suffers along with the patient. Many family members and friends find their reactions quite similar to the grieving that occurs after a death. In fact, some claim that severe brain injury can be more difficult to deal with than death. Family members may spend day after day at the hospital and see very little improvement, or they may see coma change to aggression, agitation and confusion. The person they loved and may have depended on is alive, yet different.

In the first days and weeks after the injury, family members and friends often experience disorientation and anger as they try to come to terms with this overwhelming crisis. Strong feelings that are difficult to accept or express seem to inundate them. Although these experiences are quite normal, loved ones may feel guilty and confused. This section describes many of the feelings sustained during the intensive care and acute rehabilitation phases of the recovery process.

Feelings of Panic

Generally, the first reaction family experience after sudden brain injury is panic and fear. While physicians and nurses are busy assessing the patient and providing emergency care, family members can only sit and wait. When details become available, their fears intensify since the news often presents life-threatening injury. Until the patient becomes medically stable and the imminent danger of death has passed, physical and emotional feelings of panic may continue to resurface. Often during this difficult period of time family members may feel dizzy and short of breath. They may breathe rapidly, be unable to eat or sleep, or have an upset or nervous stomach and experience the sensation of a constant lump in their throat. Some may cry frequently, and some feel numb inside, as if everything around them is unreal. They may find it difficult to concentrate and may be unable to remember answers to questions they asked just an hour or two ago. Health care personnel realize that family members are under great strain and often encourage that they start a journal to help remember conversations with staff members and the answers to questions. In most hospitals, social workers and clinical psychologists are available to help families at this time and through the various stages of adjustment and reaction after a brain injury. Many families benefit from counseling with the clinical psychologist.

Anxiety and Hope

As a patient becomes more stable, anxiety about survival is coupled with hope. The thought, “If only he lives…that’s all that matters,” gives way to, “Maybe he’ll open his eyes, look at me, smile and talk to me again.” Hope and anxiety are constant companions in the early days and weeks after an injury. Each small change and improvement often fuels a hope that the patient will recover completely. However, the slow pace of changes, setbacks, and complications may cause more worry.

Denial

In some situations denial is a healthy defense response to an overwhelming crisis or loss. Some family members may find that they are unable to completely comprehend and accept that the injury has actually occurred. They may say to themselves, “No, this isn’t really happening. There’s some mistake. It can’t be as serious as the doctor says it is.” One parent of a teenager with a brain injury compared denial to a raincoat, a necessary protection against stormy weather. Denial may help some individuals by protecting them from constant, intense emotional pain and gives them time to gather their strength and face the crisis.

Later, denial can become a problem for family members and friends if they begin to set unrealistic goals for recovery without paying attention to information provided by the health care team. When the patient cannot meet the goals, both the family member and the patient feel depressed and guilty.

Anger

Feelings of anger are very common for family members and friends after a brain injury. As they let go of denial, they may be flooded with feelings of rage at the person or situation they blame for the injury. They may be angry with the patient for having "allowed" the injury to happen, at other family members, hospital staff, God and their church, or even the manufacturers of products associated with the injury. As frustration often goes hand in hand with anxiety and anger, the brain injury of a loved one can raise frustration to extreme levels. Since each brain injury is different, the hospital course does not always follow a predictable pattern, and the answer to so many questions is an indefinite, "wait and see." Often talking about feelings to other family members, a friend, or a hospital psychologist, helps individuals cope with these issues.

Fatigue

Even when family members begin to sleep regularly again, they may feel constantly exhausted. The stress of the initial sleepless nights following their loved one's injury takes its toll, and the constant pressure of uncertainty and anxiety drains energy. Family members may find themselves becoming irritable and short-tempered with those whose support and love they need the most. Sometimes, in an effort to regain some control, they begin to concentrate on small details and lose sight of the overall situation. Talking over feelings and issues with close friends, relatives, and professional counselors can help. Often, people need to take a second look at the amount of time they are spending at the hospital and must begin to re-establish some routines that allow time away from the hospital setting.

Social workers can help family members and friends discuss sharing responsibilities. In the acute rehabilitation phase, this becomes even more important. When the patient begins to emerge from a coma, health care staff members may wish to involve the family in the rehabilitation program. The stress of dealing with a confused, aggressive, or agitated patient can be very demanding.

Guilt

Most individuals feel a certain amount of guilt after a family member or friend sustains a serious brain injury. No matter how unreasonable it seems, they feel that they should have somehow been able to prevent the injury. This is especially true when the patient is a child or adolescent, since parents feel responsible for protecting their children from physical harm.

Later, guilt may be connected to feelings of inadequacy and helplessness. No matter what family members and friends do and say, and despite how much they pray, the patient's condition may stay the same or change gradually. People usually think there has to be something more they can do to speed up the recovery process.

Isolation

Immediately after the injury, family members may be surrounded by concerned friends and relatives offering support and assistance. As the patient's condition stabilizes and the days turn into weeks, friends return to the demands of their own lives. Additionally, family members may find themselves unable to communicate as easily with friends. They may find it difficult to explain the complexities of brain injury to those not directly involved in the day-to-day experience. Close friends may remain in touch, but after such a dramatic event people often change and find they have less in common with those they were close to in the past.

Friends of those with brain injuries may find it uncomfortable to visit the hospital when the patient is confused or agitated. Honest explanations from family members may help them continue to offer the attention and support that can be so helpful to patients. Sharing this booklet is another way to help them understand.

Social workers can help families form new relationships when they feel ready, possibly with others who have gone through a similar traumatic experience. Often there are local support and informational groups in addition to national support groups located throughout the country.

Expectations

Patients and family members learn to expect both good and bad days. Several days of progress may be followed by days of agitation, confusion, or medical complications. In fact, what health team members label as improvement may be construed as set-backs by observers. The hostility and agitation patients demonstrate as they emerge from coma can be terribly upsetting. Patients may begin to look more and more like themselves as swelling from injury subsides, tubes are removed, and they sit up in a chair. Yet, family members often find that the person they knew and loved has disappeared. It remains unclear for some time how much of the "old personality" will return and what changes will last.

How to Help

Since each patient's care and rehabilitation plan is different, the family's involvement in the early stages of rehabilitation varies. Health team members often instruct about specific ways people can become involved in the treatment plan. **The following guidelines will help during the acute rehabilitation phase:**

Avoid overstimulation. This is especially important in the early stages. A patient who is tired or physically weakened fatigues quickly. Later, overstimulation may only increase agitation and confusion.

Use the familiar. A patient with a short attention span is more likely to focus on something familiar and comfortable than something new and strange. Familiar voices, music, and objects may help a patient's memory and reduce confusion.

Be consistent. Staff, family, and friends should use a routine approach with the patient. The staff can assist family members in developing helpful approaches and responses, as it can be difficult to cope with a confused, agitated, and aggressive patient. In addition, consistency can help improve memory, reduce confusion, foster language skills, and promote emotional control. Following a daily routine in the acute rehabilitation phase can help the patient become oriented and feel more secure.

Stay calm. Family and staff should serve as role models for the patient. Observing a loved one's calmness can help to decrease the patient's confusion and agitation.

Give step-by-step directions. When the patient begins to follow simple commands, give directions one step at a time. This approach lessens fatigue and confusion, improves memory, and gives the patient a sense of success in completing a task while reducing opportunity for agitation.

Do not remind the patient of past abilities. As patients gradually become aware of their deficits, reminding them of abilities they no longer have may upset, embarrass, or agitate them.

Do not talk down to the patient. Talk with patients at a level appropriate to their age and current level of understanding.

Avoid arguments and stressful situations. Remember that patients are particularly sensitive to stress after a brain injury.

Allow response time. As patients' abilities to speak and comprehend return, they may take longer to respond to a question or join in conversation.

Maintain a sense of humor. A sense of humor has a healing influence. Once a patient's condition stabilizes and improves, family members find their ability to laugh returns. Moreover, they find that laughter helps them as well as the patient.

Remember to praise. When family members tell patients how proud they are of their progress, they promote further improvement. This simple advice may be easy to remember when dealing with children, but it applies to adults as well.

Managing Stress

This section offers simple tips on dealing with stress.

Learning to manage stress is important for those closest to the person with a brain injury. Many individuals become so involved with the crisis that they neglect their own health, their jobs, and other family responsibilities. Time away from the bedside and the hospital is essential for the health and emotional welfare of all family members.

Following a brain injury, the strain of worry and the upheaval of family life can quickly take its toll. Of course, avoiding stress is unrealistic, but there are ways to manage it. Those who do not pay attention to their own needs may become unable to help the patient because of exhaustion and irritability.

Some warning signs of stress include: inability to sleep, poor self-care, constant self-blaming, frequent feelings of loneliness, nightmares, excessive use of alcohol and/or medications, a sense of worthlessness, and not knowing where to turn for help.

Some tips for managing and preventing stress are listed below:

Eat properly. Skipping meals, eating on the run, or filling up on junk food will diminish energy reserves. A regular diet rich in nutrition will help the body to better manage the effects of stress.

Try to get enough rest. Immediately following the injury and during the first days of uncertainty, one's body will run on "nervous energy," but that soon ends. Plan to take turns at the hospital, sharing the task with family members and friends, and use some time away from the hospital to rest. One may find that giving constant progress reports to concerned friends and relatives can be very draining. Give information to one person and have that person contact others.

Avoid excessive use of alcohol and sedative medications. Instead of relieving stress, overuse of these substances may only create more problems.

Express feelings. Discuss positive and negative feelings with trusted friends, family members, or staff. As mentioned in the introduction to this booklet, some people find it helpful to keep a diary or journal of their feelings and experiences. Use the blank pages in this booklet. List problems and worries and then ask three things: What things can I change and how can I change them? What further information do I need and where can I get that information? What things are beyond my control to change? This exercise may help to clear the mind, redirect nervous energy, and allow one to take action when necessary and possible.

Seek out professional help. Physicians, nurses, social workers, psychologists, psychiatrists and clergy are easily accessible in most hospitals. They can offer assistance and suggest other sources of help.

Be kind to yourself. Take time for exercise or a meal with a friend. By taking care of your own needs, you will be better able to respond to the patient's needs.

Let others help. When someone offers to help, accept the offer. Be specific about how the person can help, either at home or in the hospital. Ask hospital staff about support groups within the hospital or the surrounding community.

Ask questions. Write questions down and ask hospital staff members for answers. Although many questions may have no clear-cut answers, a more thorough understanding of a situation or problem can help one to manage or cope better with them.

Members of the Team

Because brain injury is a complex problem, many members of the hospital team plan and deliver care. It can be confusing to meet the numerous people who provide such a variety of services. **The following list includes many treatment team members and briefly describes their responsibilities.**

Anesthesiologist: A physician who administers anesthesia for surgery and special procedures. Anesthesiologists usually meet with patients and family members before surgery.

Attending Physician: The physician who is primarily responsible for the care of the patient. This is often a neurosurgeon immediately following the trauma.

Clinical Psychologist: An expert in the management of cognitive, emotional and behavioral problems. Psychologists also work closely with the rehabilitation team.

Consulting Physician: A physician who is a specialist in a medical field other than that of the attending physician. Consulting physicians may be called in by the attending physician to provide opinions on various aspects of care.

Intern: A physician who has finished medical school and is usually in the first year of specialty training. Interns work under the supervision of attending physicians and residents.

Internist: A physician who specializes in internal medicine. Internists are often consulted after a brain injury to assist in the management of problems of the heart, digestive tract, or other internal organs.

Neurologist: A physician who specializes in disorders of the brain, spinal cord, nerves, and muscles. Neurologists do not perform surgery. A neurologist often directs the post-acute care of a brain injury patient.

Neuropsychologist: A psychologist who specializes in working with patients who have experienced brain injuries. Neuropsychologists often administer special psychometric tests of brain function and work very closely with the rehabilitation team.

Neurosurgeon: Neurosurgeons operate on the brain and spinal cord and are often attending physicians for patients with brain injuries during the acute hospitalization.

Nurse: An allied health professional with special training in the care of patients with various medical problems. As part of the brain-injury team, nurses also have special training and experience in caring for patients with diseases and injuries of the brain and spinal cord.

Nutritionist: An expert in the nutritional requirements of patients. Nutritionists are also adept at nutritional augmentation through various alternative methods of feeding for those patients unable to take in food and fluid by mouth.

Occupational Therapist (OT): A specialist involved in the retraining of patients with brain injuries to resume the self-care activities important to daily living. OTs work to improve function in the patient's hands and upper body and become involved during the acute rehabilitation phase.

Physical Therapist (PT): An expert in maintaining and improving the movement and function of joints and limbs. Physical therapists may begin to work with patients while they are still in the intensive care unit.

Speech Language Pathologist (SLP): A therapist responsible for the evaluation and treatment of problems with speech and language including: auditory, cognitive comprehension, attention, writing, reading, and expression skills.

Psychiatrist: A physician who specializes in the management of emotional and behavioral problems.

Psychologist: (see Clinical Psychologist and Neuropsychologist).

Physiatrist: A physician who specializes in physical medicine and rehabilitation, and is responsible for coordinating the rehabilitative needs of a patient.

Resident: A physician who has completed medical school and an internship who is taking additional training in a specialty, such as neurology, neurosurgery or psychiatry. Residents work under the supervision of attending physicians.

Respiratory Therapist (RT): An allied health professional who provides assessment and treatment of patients with breathing problems. This may include, but is not limited to, maintenance of an endotracheal tube, tracheostomy, and mechanical ventilator.

Social Worker (SW): A trained specialist in the social, emotional, and financial needs of families and patients. Social workers often help families and patients locate and obtain the services they have been prescribed.

Unit Secretary/Clerk: A person who coordinates messages and manages the clerical work on the nurses' station under the direction of the nurses.

How long does it take for patients to come out of a coma?

It is very difficult to predict when an individual with a brain injury will regain consciousness. The time varies from minutes to months, or even longer. Usually, the more severe an injury is, the longer the period of unconsciousness or coma. Unconsciousness of one-half hour or less is classified as a mild brain injury, while unconsciousness lasting more than 24 hours is considered a severe brain injury.

How do patients act as they come out of a coma?

"Waking up" from a coma is not like waking up after sleep. It is a much more gradual process. Initial reflex responses to pain may be seen, after which localized responses emerge. This is typically followed by response to verbal commands. During this time, patients may be confused and agitated. They may not know where they are or what has happened, and may not recognized family members. This period of confusion and agitation can last from a few days to several weeks. While a patient's agitation may subside, they may remain confused. It will also take several weeks or longer before doctors can evaluate the long-lasting effects of the injury.

What does it mean when the patient moves while in a coma?

Those in deep coma may only move due to an involuntary response to something uncomfortable or painful. As coma lightens, and consciousness is regained, patients may respond to a simple request, such as "squeeze my hand" or "open your eyes."

Is there anything I can do to bring the patient out of a coma?

Once a person's brain has been injured, it takes time to heal. There seems to be very little anyone can do to speed up emergence from a coma. The extent to which the presence of caring people and the sound of familiar voices may be beneficial to a patient in a coma remains unknown. However, take time to touch, hold, and talk to the patient and express feelings of love and caring.

What can I tell my children about a coma and brain injury?

Adults often find it difficult to understand and explain brain injury and coma to themselves as well as to children. Talk simply and honestly with children and use judgment as to what each one can comprehend. Often, hospital social workers or counselors can help in finding the right words. Like any other family member, children may feel shock, sadness, anger, guilt, and worry at different times, and may not want to believe what has really happened. There will be times when talking together will be very important; times when they may wish to be alone; and times when they wish to be with others without talking about the patient.

Glossary

ANOSMIA - Loss of the sense of smell.

ANOXIA - A lack of oxygen. Brain cells need oxygen to exist. When blood flow to the brain is reduced or when oxygen in the blood is low, brain cells are damaged.

CATHETER - A flexible plastic tube of varying sizes utilized for withdrawing fluids from or introducing fluids into a cavity of the body. This tubing is also used in specialized medical procedures.

CEREBROSPINAL FLUID - The liquid that fills the ventricles of the brain and surrounds the brain and spinal cord.

CLOSED HEAD INJURY - Trauma to the head that does not penetrate or fracture the skull, but results in injury to the brain.

COGNITION - The conscious process of the mind by which one becomes aware of thoughts and perceptions, including all aspects of perceiving, thinking, and remembering.

COMA - A state of unconsciousness from which the patient cannot be aroused, even by powerful stimulation. Coma involves the loss of awareness of self and the surrounding environment.

COMPUTERIZED TOMOGRAPHY (CT) SCAN or COMPUTERIZED AXIAL TOMOGRAPHY (CAT) SCAN - A series of computerized X-rays which may be taken at various levels of the body's anatomy to reveal structure or abnormalities. An imaging technique of the brain that reveal tumors, blood clots, hemorrhages, or other abnormal anatomy.

DECUBITUS ULCER - A bed sore or discolored, open area of skin damaged by pressure. Common areas for breakdown of skin are the buttocks, hip, shoulder areas, ankles, heels and elbows.

DEFICIT - A lacking or deficiency in the amount or quality of functioning.

DIPLOPIA - Double vision; the perception of two images of a single object.

ELECTROENCEPHALOGRAM - The recording of electrical activity of the brain by positioning electrodes on the scalp.

ELECTROCARDIOGRAM - A method for evaluating heart rate and rhythm by positioning electrode pads on the patient's chest, which are connected to a monitor.

EYE TAPE - Tape used to close the eyes of a patient who is unable to blink. Blinking is important to keep the eyes moist.

FEEDING TUBE – A generalized term referring to one of many variations of a device inserted into the digestive tract with the purpose of providing nutrition to a patient who is unable to swallow. Variations include: nasogastric (NG), gastronomy (G), percutaneous endoscopic gastrostomy (PEG), jejunostomy (J), or gastronomy-jejunostomy (GJ).

HALO - A metal ring used for patients with upper spinal cord injuries that surrounds or encircles the patient's head, allowing for proper alignment of the neck and spinal column.

MAGNETIC RESONANCE IMAGING (MRI) - A diagnostic procedure that uses magnetic fields to create pictures of specific areas of anatomy. MRI can provide a more detailed picture than the CT scan in some situations.

ORTHOSIS - Splint or brace used to support, align and improve function of movable parts of the body.

PERSISTENT VEGETATIVE STATE - A condition in which the patient is unable to speak, follow simple commands, and does not respond in any psychologically meaningful way. The transition from coma to a vegetative condition reflects changes from a period of no response to the internal or external environment (other than reflexively) to a state of wakefulness but with no indication of awareness.

PLATEAU - A temporary or more permanent leveling off in the recovery or rehabilitation process.

RESPIRATOR - (see ventilator)

SCANNING - An active, usually visual search of the environment for information. Used in reading, driving, and other daily activities.

SEIZURE - An uncontrolled discharge of nerve cells that may spread to other cells throughout the brain. The sudden attack may be accompanied by loss of bowel and bladder control, involuntary movements, and a change in mental activity.

SENSORY INTEGRATION - Interaction of two or more sensory processes in a way that enhances the adaptiveness of the brain.

SENSORY STIMULATION - Arousal of the brain through any of the senses.

SEQUENCING (motor) - Contracting muscles in an orderly and meaningful manner.

VENTILATOR - Equipment that mechanically does the breathing for the unresponsive patient. The machinery serves to deliver air with the appropriate percentage of oxygen and at the appropriate rate.

VENTRICULO-PERITONEAL SHUNT (VP SHUNT) - A method of removing excessive fluid from the ventricles of the brain in hydrocephalus. A surgically placed tube connected to a ventricle deposits fluid in to the abdominal cavity, heart or large vein in the neck.

Classes of Medications

ANTIBIOTICS - Used to treat a variety of infections, which may occur in hospitalized patients such as pneumonia and urinary tract infections. Patients may also be placed on antibiotics to help prevent possible infections.

ANTICOAGULANTS - Medications, such as heparin or coumadin, utilized to slow down normal blood clotting and prevent clots from forming.

ANTICONVULSANTS - Anti-seizure medications. These medications help to prevent seizures.

ANTIDEPRESSANTS - These medications help the patient control the symptoms and signs of depression.

ANTIPSYCHOTICS - These medications add a calming influence and help prevent sudden mood swings.

BLOOD PRESSURE MEDICATIONS - A group of medications used to reduce agitation, rapid heart-beat, elevated blood pressure, and tremors. These may include antihypertensives, vasodilators, and beta blockers.

DIURETICS - Medication (such as Lasix) which help the body to eliminate water by increasing the excretion of sodium through the body's urinary system.

LAXATIVES - These medications are usually used along with a carefully supervised dietary program to promote bowel regularity. Constipation often occurs because of nervous system damage and long periods of inactivity in bed.

MUSCLE RELAXANTS - These drugs relax the muscles for greater comfort, to ease therapy, and to reduce spasticity.

PAIN RELIEVING (ANALGESICS) - Act to relieve pain. This may include narcotics such as Morphine Sulfate.

SEDATING AGENTS – May be used to increase ventilator compliance, reduce agitation, or reduce intracranial pressure (ICP). These may include: benzodiazepines, narcotics, and hypnotics such as propofol.

Specific Medications

DIAZEPAM (VALIUM) - A benzodiazepine that can be used to stop repetitive seizures. Also may be used as a muscle relaxant.

ETIDRONATE DISODIUM (DIDRONEL) - Given to patients who demonstrate a tendency to form calcium deposits and abnormal bone formation around joints and in injured soft tissues.

MANNITOL - This drug helps remove water from the brain, and helps decrease intracranial pressure and brain swelling.

PENTOBARBITOL (NEMBUTAL) - A barbiturate used in extreme cases to help control the pressure inside the head. This drug can be effective in cases in which other measures fail to reduce abnormally elevated intracranial pressure or to stop seizures.

PANCURONIUM BROMIDE (PAVULON) - Relaxes skeletal muscles to keep the patient from working against the respirator.

Appendix of Medical Illustrations

The Head and Brain

Brain Injuries

Intensive Care

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