Chapter 20
Disorders of Brain Function

Common Pathways of Brain Damage

- The effects of ischemia
- Excitatory amino acid injury
- Cerebral edema
- Injury due to increased intracranial pressure (ICP)
Conditions Causing Injury to the Brain

- Trauma
- Tumors
- Stroke
- Metabolic derangements
- Degenerative disorders

Manifestations of Global Brain Injury

- Alterations in sensory and motor function
- Changes in the level of consciousness
- Rostral-to-caudal stepwise progression
  - As the diencephalon, midbrain, pons, and medulla are affected, additional respiratory, pupillary, and eye movement reflexes and motor signs become evident.
Classifications of Skull Fractures

- **Simple or Linear**
  - A break in the continuity of bone

- **Comminuted**
  - A splintered or multiple fracture line.

- **Depressed**
  - When bone fragments are embedded into the brain tissue, the fracture is said to be depressed.

- **Basilar**
  - A fracture of the bones that form the base of the skull

Levels of Consciousness

- Confusion
- Delirium
- Obtundation
- Stupor
- Coma
Injury From Excitatory Amino Acids

- **Definition**
  - Injury to neurons caused by overstimulation of receptors for specific amino acids that act as excitatory neurotransmitters

- **Causes**
  - Stroke
  - Hypoglycemic injury
  - Trauma to chronic degenerative disorders such as Huntington disease and Alzheimer dementia

Signs of Diminution in Level of Consciousness

- **Earliest Signs**
  - Inattention, mild confusion, disorientation, and blunted responsiveness

- **With further deterioration**
  - the person becomes markedly inattentive and variably lethargic or agitated.
  - the person may progress to become obtunded and may respond only to vigorous or noxious stimuli.
Medical Documentation of Brain Death

- Cause and irreversibility of the condition
- Absence of brain stem reflexes and motor responses to pain
- Absence of respiration with a PCO₂ of 60 mm Hg or more
- The justification for use of confirmatory tests and their results

Criteria for Diagnosis of Vegetative State

- Absence of awareness of self and environment
- An inability to interact with others
- Absence of sustained or reproducible voluntary behavioral responses
- Lack of language comprehension
- Hypothalamic and brain stem function to maintain life
Criteria for Diagnosis of Vegetative State (cont.)

- Bowel and bladder incontinence
- Variably preserved cranial nerve and spinal cord reflexes
- The condition has continued for at least 1 month.

Hypoxia and Ischemia

- Hypoxia
  - A deprivation of oxygen with maintained blood flow

- Ischemia
  - Reduced or interrupted blood flow
    - Focal cerebral ischemia—stroke
    - Global cerebral ischemia—MI
Question

- Which of the following is not a common cause of neural injury?
  - A. Recreational drug use
  - B. Ischemia
  - C. Excitatory amino acids
  - D. Cerebral edema
  - E. Increased intracranial pressure (ICP)

Answer

- A. Recreational drug use

- Rationale: Recreational drug use can cause damage, but it is not a common cause.
**Intracranial Pressure**

- Increased ICP is a common pathway for brain injury.
  - Can obstruct cerebral blood flow, destroy brain cells, displace brain tissue, and damage delicate brain structures
- Cranial cavity
  - 10% blood, 80% brain tissue, 10% CSF
  - Normal ICP 0 to 15 mm Hg
- Monro-Kellie hypothesis of normalization of ICP

**Brain Herniation**

- **Cingulate**
  - Involves cerebral artery
  - Clinical sign: leg weakness
- **Central Transtentorial**
  - Involves the reticular activating system and corticospinal tract
  - Clinical signs: altered level of consciousness, decorticate posturing, rostral–caudal deterioration
Brain Herniation (cont.)

• Uncal
  
  – Involves the cerebral peduncle, oculomotor nerve, posterior cerebral artery, cerebellar tonsil, respiratory center
  
  – Clinical signs: hemiparesis, pupil dilation, visual field loss, respiratory arrest

Hydrocephalus

• Definition
  
  – An abnormal increase in CSF volume in any part or all of the ventricular system
  
  – Enlargement of the CSF compartment occurs.

• Types
  
  – Communicating
    • Decreased absorption of CSF
  
  – Noncommunicating
    • Overproduction of CSF
Cerebral Edema

- **Vasogenic Edema**
  - Occurs with conditions that impair the function of the blood-brain barrier and that allow transfer of water and protein from the vascular into the interstitial space

- **Cytotoxic Edema**
  - Involves an increase in intracellular fluid

- **Interstitial Cerebral Edema**
  - Edema of the central white matter as in hydrocephalus affecting the brain

Types of Brain Injuries

- **Primary or Direct Injuries**
  - Damage is caused by an impact.
  - Include diffuse axonal injury and the focal lesions of laceration, contusion, and hemorrhage

- **Secondary Injuries**
  - Damage results from the subsequent brain swelling, infection, and cerebral hypoxia.
  - Often diffuse or multifocal, including concussion, infection, and hypoxic brain injury
Types of Hematomas

- Brain injuries can be categorized as traumatic (*i.e.*, epidural hematoma, subdural hematoma, concussion, contusion, or diffuse axonal injury) or nontraumatic brain injury (*i.e.*, stroke, infection, tumor, or seizure).

- Epidural hematomas, subdural hematoma, and traumatic intracerebral hematomas

Focal and Diffuse Brain Injuries

- Primary brain injuries include focal (*e.g.*, contusion, laceration, hemorrhage) and diffuse (*e.g.*, concussion, diffuse axonal injury) injuries.

- Secondary brain injuries are often diffuse or multifocal, including edema, infection, and hypoxic brain damage.
Coup–Contrecoup

- The brain floats freely in the CSF; blunt force to the head accelerates the brain within the skull, and then the brain decelerates abruptly on hitting the inner skull surfaces.

- Coup—direct contusion of the brain at the site of external force

- Contrecoup—rebound injury on the opposite side of the brain

Question

- Rotational acceleration of the head may result in which type of injury?
  - A. Coup
  - B. Contrecoup
Answer

• B. Contrecoup

• Rationale: Contrecoup is the rebound injury on the opposite side of the brain.

Postconcussion Syndrome

• Concussion refers to “an immediate and transient loss of consciousness accompanied by a brief period of amnesia after a blow to the head.”

• Recovery usually takes place in 24 hours.

• Mild symptoms may persist for months:
  - Headache
  - Irritability
  - Insomnia
  - Poor concentration and memory
Types of Hematomas

- **Epidural Hematoma**
  - Usually caused by head injury in which the skull is fractured
  - Develops between the inner table of the bones of the skull and the dura

- **Subdural Hematoma**
  - Usually is the result of a tear in the small bridging veins that connect veins on the surface of the cortex to dural sinuses
  - Develops in the area between the dura and the arachnoid (subdural space)

Types of Hematomas (cont.)

- **Traumatic Intracerebral Hematomas**
  - May be single or multiple
  - Occur in any lobe of the brain but are most common in the frontal or temporal lobes
Structures Supplying Blood Flow to the Brain

- Two internal carotid arteries anteriorly
  - Ophthalmic, posterior communicating, anterior choroidal, anterior cerebral, and middle cerebral

- Vertebral arteries posteriorly

- Internal carotid and vertebral arteries communicate at the base of the brain through the circle of Willis.

Cerebral Blood Flow

- Autoregulation
- Sympathetic stimulation
- Metabolic factors
  - Carbon dioxide
  - Hydrogen ion
  - Oxygen concentration
Risk Factors and Deficits of Stroke

- Age, sex, race
- Family history
- Hypertension
- Smoking
- Diabetes mellitus
- Asymptomatic carotid stenosis
- Sickle cell disease
- Hyperlipidemia
- Atrial fibrillation

Stroke Related Deficits
- Motor deficits
- Dysarthria and Aphasia
- Cognitive and Other Deficits

Two Main Types of Strokes (Brain Attack)

- **Ischemic Strokes**
  - Caused by an interruption of blood flow in a cerebral vessel and are the most common type of strokes, accounting for 70% to 80% of all strokes.

- **Hemorrhagic Strokes**
  - Caused by bleeding into brain tissue usually from a blood vessel rupture caused by hypertension, aneurysms, arteriovenous malformations, head injury, or blood dyscrasias
Warning Signs and Danger Zones

- Ischemic penumbra in evolving stroke

- Transient ischemic stroke
  - Brain angina

- Watershed zone

Signs and Symptoms of Cerebral Aneurysms

- Most small aneurysms are asymptomatic.

- Large aneurysms may cause chronic headache, neurologic deficits, or both.

- Other manifestations include signs of meningeal irritation, cranial nerve deficits, stroke syndrome, cerebral edema and increased ICP, and pituitary dysfunction.

- Hypertension and cardiac dysrhythmias result from massive release of catecholamines triggered by the subarachnoid hemorrhage.
Aneurysmal Subarachnoid Hemorrhage

• Bleeding into the subarachnoid space

• Causes

• Congenital defect
  – Acute increases in ICP
  – Cigarette smoking
  – Hypertension
  – Excessive alcohol intake

Hemodynamic Effects of Arteriovenous Malformations

• First, blood is shunted from the high-pressure arterial system to the low-pressure venous system without the buffering advantage of the capillary network.
  – The draining venous channels are exposed to high levels of pressure, predisposing them to rupture and hemorrhage.

• Second, the elevated arterial and venous pressures divert blood away from the surrounding tissue, impairing tissue perfusion.
Question

• Which type of stroke is the result of a ruptured blood vessel?
  – A. Ischemic
  – B. TIA
  – C. Arteriovenous malformation
  – D. Hemorrhagic

Answer

• D. Hemorrhagic

• Rationale: Hemorrhagic strokes are caused by the rupturing of a major vessel in the brain.
Typical Problems Arising from Stroke

- Motor deficits are most common, followed by deficits of language, sensation, and cognition.

Classifications of Infections of the CNS

Type of Invading Organism

- By structure
  - Meninges: meningitis
  - Brain parenchyma: encephalitis
  - Spinal cord, myelitis
  - Brain and spinal cord: encephalomyelitis

- By type of invading organism
  - Bacterial, viral, or other
Meningitis

- Inflammation of the pia mater, the arachnoid, and the CSF-filled subarachnoid space
- Fever and chills; headache; stiff neck; back, abdominal, and extremity pains; and nausea and vomiting
  - Acute lymphocytic meningitis
  - Acute purulent meningitis
  - Bacterial meningitis
    - Pneumococcus
    - Meningococcus
  - Viral meningitis

Encephalitis

- Infection of the parenchyma of the brain or spinal cord
- Local necrotizing hemorrhage
- Progressive degeneration of nerve cell bodies
- Prominent edema
- Transmission
  - Ingestion
  - Mosquito
  - Rabid animal

- Types
  - Viral
    - Herpes simplex virus, West Nile virus
  - Bacteria
  - Fungi
Classification of Brain Tumors

• Primary intracranial tumors of neuroepithelial tissue
  – Neurons, neuroglia
• Primary intracranial tumors that originate in the skull cavity but are not derived from the brain tissue itself
  – Meninges, pituitary gland, pineal gland, primary CNS lymphoma
• Metastatic tumors
• Benign versus malignant

Types and Symptoms of Brain Tumors

• Ependymomas
• Meningiomas
• Primary CNS lymphomas

• Increased ICP
• Focal disturbances in brain function
  – Edema
  – Disturbances in blood flow
  – Tumor infiltration
  – Brain compression
Treatment and Evaluation Methods for Brain Tumors

- Surgery
- Irradiation
- Chemotherapy
- MRI
- CT scans
- Electroencephalogram
- Visual field and funduscopic examination
- Include physical and neurologic examinations

Epilepsy

- Syndromes of associated seizure types
  - EEG patterns
- Exam findings
- Hereditary patterns
- Precipitating factors
Seizures and Convulsions

**Seizure**
- The abnormal behavior caused by an electrical discharge from neurons in the cerebral cortex
- A discrete clinical event with associated signs and symptoms that vary according to the site of neuronal discharge in the brain
- Manifestations generally include sensory, motor, autonomic, or psychic phenomenon

**Convulsion**
- Specific seizure type of a motor seizure involving the entire body

Causes of Epilepsy

- Seizures may be caused by alterations in cell membrane permeability or distribution of ions across the neuronal cell membranes.

- Another cause may be decreased inhibition of cortical or thalamic neuronal activity or structural changes that alter the excitability of neurons.

- Neurotransmitter imbalances such as an acetylcholine excess or γ-aminobutyric acid (GABA, an inhibitory neurotransmitter) deficiency have been proposed as causes.
Causes of Epilepsy (cont.)

- Certain epilepsy syndromes have been linked to specific genetic mutations causing ion channel defects.

Types of Seizures

- Partial Seizures
  - Simple partial seizures
  - Complex partial seizures
  - Partial seizures evolving to secondarily generalized seizures

- Unclassified Seizures
  - Inadequate or incomplete data
Types of Seizures (cont.)

- Generalized Seizures
  - Absence seizures
  - Atonic seizures
  - Myoclonic seizures
  - Tonic seizures
  - Tonic–clonic seizures

Status Epilepticus

- Continual seizures
- Do not stop spontaneously
- Many types
- If untreated or not stopped can lead to death due to respiratory failure