

These have gained increasing notice in the context of litigation involving issues of compensation for those in the civilian work force, professional athletes and the military services.

- *Posttraumatic hydrocephalus* is largely due to obstruction of CSF resorption from hemorrhage into the subarachnoid spaces.
- *Chronic traumatic encephalopathy* (CTE, previously referred to as “dementia pugilistica”) is a dementing illness that develops after repeated head trauma. Affected brains are typically atrophic, with enlarged ventricles, and show accumulation of tau-containing neurofibrillary tangles in a characteristic pattern involving superficial frontal and temporal lobe cortex. Although concussion is thought of as having no structural consequences, it is clear that repeated events are antecedents to CTE. It remains uncertain if the most critical factors that determine if encephalopathy will develop are the number, frequency or severity of events, or some combination of these.
- Other important sequelae of brain trauma include post-traumatic epilepsy, risk of infection, and psychiatric disorders.

## Spinal Cord Injury

The spinal cord is vulnerable to trauma from its skeletal encasement. Most injuries that damage the cord are associated with the transient or permanent displacement of the vertebral column. The level of cord injury determines the extent of the neurologic manifestations: lesions involving the thoracic vertebrae or below can lead to paraplegia; cervical lesions result in quadriplegia; those above C4 can, in addition, lead to respiratory compromise from paralysis of the diaphragm. Damage at the region of impact to descending and ascending white matter tracts isolates the distal spinal cord from the rest of the brain. This interruption, paired with the localized gray matter damage at the level of the impact, is the principal cause of neurologic deficits.

### MORPHOLOGY

The histologic features of traumatic injury of the spinal cord are similar to those found at other sites in the CNS. At the level of injury the acute phase consists of hemorrhage, necrosis, and axonal swelling in the surrounding white matter. The lesion tapers above and below the level of injury. In time central areas of neuronal destruction becomes cystic and gliotic; cord sections above and below the lesion show secondary ascending and descending wallerian degeneration, respectively, involving the long white-matter tracts affected at the site of trauma.

### KEY CONCEPTS

#### Perinatal Brain Injury

- Timing of injury is critical, with earlier events resulting in greater damage and deficits.

- Cerebral palsy is the term describing non-progressive deficits associated with injury during the prenatal and perinatal periods.

#### Trauma

- Physical injury to the brain can occur when the inside of the skull comes into forceful contact with the brain.
- In blunt trauma, if the head is mobile there may be brain injury both at the original point of contact (coup injury) and on the opposite side of the brain (contrecoup injury) owing to impacts with the skull.
- Parenchymal injuries take the form of contusions, with hemorrhage extending into the subarachnoid space.
- Rapid displacement of the head and brain can tear axons (diffuse axonal injury), often causing immediate severe, irreversible neurologic deficits.
- Traumatic tearing of blood vessels leads to epidural or subdural hematoma.

## Cerebrovascular Disease

**Cerebrovascular disease— injury to the brain as a consequence of altered blood flow— can be grouped into ischemic and hemorrhagic etiologies.** “Stroke” is the clinical designation that applies to all these conditions, particularly when symptoms begin acutely. Cerebrovascular disease is the third leading cause of death (after heart disease and cancer) in the United States, and the most prevalent cause of morbidity and mortality from neurologic disease. From the standpoint of pathophysiology and pathologic anatomy, it is convenient to consider cerebrovascular disease as two processes:

- *Hypoxia, ischemia, and infarction* resulting from impairment of blood supply and oxygenation of CNS tissue; in the brain, embolism is a more common etiology than thrombosis. This can either be a global process or focal, with the clinical manifestations determined by the region of brain affected.
- *Hemorrhage* resulting from rupture of CNS vessels. Common etiologies include hypertension and vascular anomalies (aneurysms and malformations).

### Hypoxia, Ischemia, and Infarction

The brain requires a constant supply of glucose and oxygen, which is delivered by the cerebral blood vessels. Although the brain accounts for only 1% to 2% of body weight, it receives approximately 15% of the resting cardiac output and accounts for 20% of the body’s oxygen consumption. Cerebral blood flow remains relatively constant over a wide range of blood pressure and intracranial pressure because of autoregulation of vascular resistance. The brain is a highly aerobic tissue, in which oxygen rather than metabolic substrate is limiting. The brain may be deprived of oxygen by several mechanisms: *hypoxia* caused by a low partial pressure of oxygen ( $PO_2$ ), impairment of the blood’s oxygen-carrying capacity, or inhibition of oxygen use in the tissue; or *ischemia*, either transient or permanent, caused by interruption of the normal circulatory flow. Cessation of blood flow can result from a reduction in perfusion