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Lecture [2]

IMAGING OF HEAD TRAUMA

Learning objectives:

1. To know the term of traumatic brain injury [TBI] and its types.
2. To understand classification of head injury and imaging finding of each category.

Traumatic brain injury (TBI) is a leading cause of mortality and morbidity in the world's population, especially those young ages.

Imaging Techniques

Skull x-ray are poor predictors of intracranial pathology and should not be performed to evaluate adult TBI, however, skull x-ray may identify a fracture.

Computed tomography (CT), CT is the modality of choice because it is fast, widely available, and highly accurate in the detection of skull fractures and intracranial hemorrhage. CT is usually superior to MR in revealing skull fractures and radio-opaque foreign bodies.

Magnetic resonance imaging (MRI) is recommended for patients with acute TBI when the neurologic findings are unexplained by CT. MR is also the modality of choice for subacute or chronic injury.

Classification

TBI can be classified into **primary** and **secondary** injuries.

- **Primary lesions** are the direct result of trauma to the head
  - **Extra-axial lesions** include epidural, subdural, subarachnoid, and intraventricular hemorrhage.
  - **Intra-axial lesions** include cortical contusions, intracerebral hematomas, axonal shearing injuries, gray matter injury, and vascular injury.
- **Secondary lesions** arise as complications of primary lesions.
  - **Acute:** includes cerebral edema, ischemia, and brain herniation.
  - **Chronic:** includes hydrocephalus, the cerebrospinal fluid (CSF) leak, leptomeningeal cyst, and encephalomalacia.

Imaging Findings

1) Scalp Injury: Scalp injury includes

- Soft-tissue lacerations
- Subgaleal hematoma
- Cephalohematoma
- Residual foreign bodies.

The subgaleal hematoma is the most common manifestation of scalp injury. It can be recognized as focal soft tissue swelling located beneath the subcutaneous fibrofatty tissue and above the temporalis muscle and calvarium.

2) Skull Fractures

- Non-displaced linear fracture.
- Depressed and compound fracture.

- Isolated linear skull fractures usually do not require treatment unless they are associated with an epidural hematoma.
- Surgical treatment is usually indicated for depressed and compound skull fractures.
- Depressed skull fractures can be associated with an underlying contusion.

3) Temporal Bone Fractures

According to their orientation relative to the long axis of the petrous bone classified as:

- **Longitudinal fracture** (>70%) → Conductive hearing loss
- **Transverse fracture** → Sensorineural hearing loss

PRIMARY HEAD INJURY

Extra-Axial Injury

The epidural hematoma (EDH)

- It's located in the space between the inner table of the skull and the dura.
- It's frequently result from a skull fracture that disrupts the middle meningeal artery.
- On CT, the acute EDH appears as a well-defined, **hyperdense**, biconvex, extra-axial collection (**lens shape**).
- Mass effect with sulcal effacement and midline shift is frequently seen.

Subdural hematomas (SDH)

- It's result from laceration of bridging cortical veins during sudden head deceleration.
- On CT, the acute SDH appears as **hyperdense**, homogenous, **crescent-shaped**, extra-axial collection.
- The degree of mass effect seen frequently appears more severe relative to the size of the collection.

- **Acute SDH** appears hyperdense.
- **Subacute SDH** appears isodense.
- **Chronic SDH** appears hypodense.
- **Acute on chronic** → hematocrit effect (CSF-blood level)

Traumatic subarachnoid hemorrhage (SAH)

- Can result from the disruption of small pial vessels, extension into the subarachnoid space.
- CT is modality of choice in acute SAH.
- On CT, SAH appears as **linear or serpentine areas of high attenuation** that conform to the morphology of the cerebral sulci and cisterns.
- Chronic hemorrhage on MR scans may show hemosiderin staining in the subarachnoid space, which appears as areas of decreased signal intensity on T1- and T2-weighted sequences **(superficial hemosiderosis)**
- SAH may lead to **communicating hydrocephalus** by impeding CSF resorption at the level of arachnoid villi.

Traumatic intraventricular hemorrhage (IVH)

On CT, IVH usually appears as **CSF-hyperdense fluid level**, layering within the ventricular system

Intra-Axial Injury

BRAIN CONTUSIONS

- **Non-hemorrhagic contusions** are difficult to detect initially until the development of associated edema.
- **Hemorrhagic contusions** are more easily identified and appear as foci of high attenuation within superficial gray matter.

INTRACEREBRAL HEMATOMA

On CT: intracerebral hematomas tend to have high density area with less surrounding edema

DIFFUSE AXONAL INJURY (DAI)

- It results from rotational acceleration and deceleration forces that produce shearing deformations of brain tissue.
- Clinically, DAI is characterized by loss or severe impairment of consciousness
- MRI is clearly superior to CT for detecting DAI.
- CT is mostly limited to depicting **small, petechial hemorrhages at the gray–white junction** of the cerebral hemispheres and corpus callosum.

VASCULAR INJURY

- Traumatic vascular injuries include the **arterial dissection**, **pseudoaneurysm**, and **arteriovenous fistula**.
- **Magnetic resonance angiography** and **MDCT angiography** serve as important screening tools in the evaluation of patients with suspected vascular injury.

SECONDARY HEAD INJURY

ACUTE

- **Diffuse cerebral swelling** arises from an increase in cerebral blood volume (hyperemia), vasogenic edema, or an increase in tissue fluid (cerebral or cytotoxic edema). Imaging demonstrates effacement of the cerebral sulci and cisterns and compression of the ventricles.
- **Brain herniation** occurs secondary to mass effect produced by other causes. the subfalcine herniation is the most common form of herniation; where, the cingulate gyrus is displaced across the midline under the falx cerebri.
- **Infarction or ischemia** can complicate TBI as a result of increased intracranial pressure or mass effect on cerebral vasculature by herniation or hematoma.

CHRONIC

- **Traumatic hydrocephalus** occurs secondary to impaired CSF reabsorption at the level of the arachnoid villi or secondary to obstruction of the cerebral aqueduct and 4th ventricular outflow by SAH.
- **Encephalomalacia** is a common, but nonspecific, sequelae of prior parenchyma injury. On CT, the imaging appearance consists of an area of low attenuation with volume loss. It typically follows CSF signal intensity on both CT and MRI.
- **CSF leak** usually results from a dural tear secondary to a skull base fracture (CSF otorrhea & CSF rhinorrhea)
- **The leptomeningeal cyst or "growing fracture"** is a pediatric lesion that is also caused by a tear in the dura in association with a calvarial defect. The leptomeningeal cyst appears as a lytic skull defect on CT or plain skull films, which can enlarge over time.

Further readings:

Diagnostic imaging, seventh edition
Andrea Rockall
Andrew Hatrick
Peter Armstrong
Martin Wastie