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1. Learning Outcomes

After studying this module, you shall be able to know-

- About Head Injury
- About types of skull fracture
- Mechanism of various intracranial injuries
- Various types of intracranial haemorrhages

2. Introduction

Head injury is a morbid state resulting from gross or subtle changes in the scalp, skull, and/or contents of the skull, produced by mechanical force.

- Any kind of cranio-cerebral injury can be caused by any kind of blow on any part of head.
- Commonest cause being blunt external force or impact.

Head injury comprises of injury to scalp, skull and injury to the content of skull i.e. meninges, brain and vessels.

1) **Scalp:** - thickness of scalp is variable, ranging from few mm to 15 mm. most wounds are caused by blunt force to the head as result of assault or fall.

- **Contusions:** bruising of scalp is better felt than seen. It may occur in superficial fascia, in the temporalis muscles or in the loose areolar tissue between galea aponeurotica and the pericranium. Contusions of fascia appear as superficial swelling and are limited in size due to dense tissue. Hematoma of the scalp may be very extensive and spread over most of the skull. Bruises of scalp are associated with prominent oedema. Multiple contusion of scalp may join together and therefore it is often difficult to determine the no. of blows inflicted.

- **Lacerations:** laceration of scalp resemble incised wound. They bleed profusely and even fatal blood loss can occur from an extensive scalp injury if not managed by treatment. Fall on flat surface, a blow from flat object will cause a ragged split which may be linear, stellate or irregular. Mostly gross injury is avulsion of a large area of the scalp, can occur in traffic accidents or if hair become entangled in machinery. Laceration of scalp may reproduce the pattern of inflicting object. Major problem is differentiation between incised and lacerated wound. In case of homicide with head trauma, therefore it is advised to retain a sample of victim's head hair pulled from an area adjacent to area of trauma.
- **Abrasions:** brush abrasions are less common than other sites because of protective effect of the hair. Impact abrasions from a perpendicular fore are imprinted as usual on the scalp, though again intervening hair may reduce the severity.

2) Skull: - The adult cranium consists of two parallel tables of compact bone, the outer being about twice the thickness of inner. The cranium varies in thickness in adults as well as from place to place like occipital bone being thickest, about 15 mm, temporal bone being thinnest about 4mm. fractures may be caused by direct or indirect violence.

Direct injury may be caused by:

1. Compression as by obstetrics forceps or crushing of head under the wheel of a vehicle.
2. An object in motion striking the head eg. Bullets, bricks, hammer etc.
3. Head in motion striking an object, as in fall and traffic injuries.

Indirect injury of skull can occur from fall on feet or buttocks.

3. Mechanism of fracture of skull

1. Fracture due to local deformation: if a small object travelling at great speed strikes the head it will drive the piece of bone inwards. Inner table fractures first then the outer table. The fracture line tends to run circularly to enclose the base of the indentation.

2. Fracture due to general deformation: whenever skull is compressed, parts of the skull distant from the site of application of force may fracture, head may be compressed:

- (i) Between two external objects such as ground and wheel of car
- (ii) Between an external object and spinal column.

4. Types of skull fracture

1. Linear/fissured fracture: - about 70% of skull fracture are linear and produced by general deformation of skull, they may involve whole skull or inner or outer table of skull only. The line fracture runs parallel to the axis of compression. Fracture line tends follow an irregular course and is usually no more than hairs breadth. A fracture line sometimes reaches a suture and follows its course for a while and then starts on its own again. About 20% of linear fractures are not found on x ray. If two blows are struck, it may be possible to determine which blow was struck first as the fracture lines produced by the subsequent blow are arrested by those produced by the first blow.

2. Depressed fracture: also called as “**Fractures a la signature**” (signature fracture), as the pattern often resembles the weapon or the agent which caused it. They are produced with an object having large amount of kinetic energy but having small surface area, they are produced as local deformation of skull. In this fractured bone is driven inwards into the skull cavity. Localized depressed fracture may be caused by blows from heavy objects with small striking surface.eg. Stones, stick, axe, chopper and hammer.

3. Elevated Fractures: one end of fractured fragment is elevated over the surface of skull and other end is depressed in to cranial cavity.it is caused by a blow from which elevates the fragment by lateral pull while retrieving it.

4. Communitied Fracture: in this there are multiple fracture also called spider web fracture. There are two or more intersecting lines of fracture which divide the bone into three or more fragments. They are significant force striking over a broad area, such as crushing head injuries, vehicle accidents, and fall from a height on a hard surface or by repeated blow by a weapon with large striking surfaces. E.g. Heavy iron bar or thick stick.

5. Pond or Indented Fracture: they occur only in skulls which are elastic i.e., skull of infants. They may result from an obstetric forceps blade or blow from a blunt object. The inner table is not fractured but fissured fracture may occur in outer table. They resemble a dent in ping pong ball.

6. Gutter Fracture: they are formed when part of the thickness of bone is removed so as to form a gutter. E.g. In oblique bullet wounds.

7. Ring or Foramen Fracture: it is a fissured fracture which encircles the skull in such a manner that the anterior third is separated at its junction with middle and posterior third. But usually the term is applied to fracture which runs at about 3 to 5 cm outside the foramen magnum and encircles it. They occur after fall from height on the feet or buttocks. In very severe cases spine may be driven into the skull cavity. A severe blow to vertex may cause a ring fracture.

8. Perforating Fracture: They are caused by firearms and pointed sharp weapons like daggers and knife. The weapon passes through both tables of skull leaving more or less a clean cut opening corresponding to the size of weapon used.

9. Blow Out fracture: blunt trauma to the eye which causes fracture of floor and medium wall of the orbit.

10. Diastatic or Sutural Fractures: separation of sutures occurs only in young persons. They are particularly common in traffic accidents. It is usually seen in sagittal suture.

5. Circumstances of skull fracture

- **Most** fractures are due to accident i.e. fall or RTA
- **Multiple** localized and depressed fractures suggest homicide.
- Suicide by head injury is rare as it is painful and cannot be produced easily. May be caused when victim jumps from a height.

Injuries of Brain and Meninges: the intra-cerebral lesions are divided according to the state of dura. If dura is lacerated it is called open injury, if it is intact it is called closed injury, whether the skull is fractured or not.

Mechanism of cerebral injuries: - brain injuries may be caused by

- Penetration by a foreign object such as knife or bullet
- By distortion of the skull.
- Acceleration and deceleration injuries occur due to sudden movement of the head which produce intracranial pressure gradients. Shear strain may develop in the underlying brain tissue due to distortion

6. Types of Intracranial injuries

A. Contusions of the Brain- these are circumscribed areas of brain tissue destruction which are accompanied by extravasation of blood into the affected tissue.

- They are produced by blunt force and are found in grey and white matter due to the injury of blood vessels by mechanical stress.
- They present as streaks or group of punctate haemorrhages.
- Most often found in frontal and temporal lobes.
- Most haemorrhages occur at the crest of convolutions facing the dura of falx and tentorium.

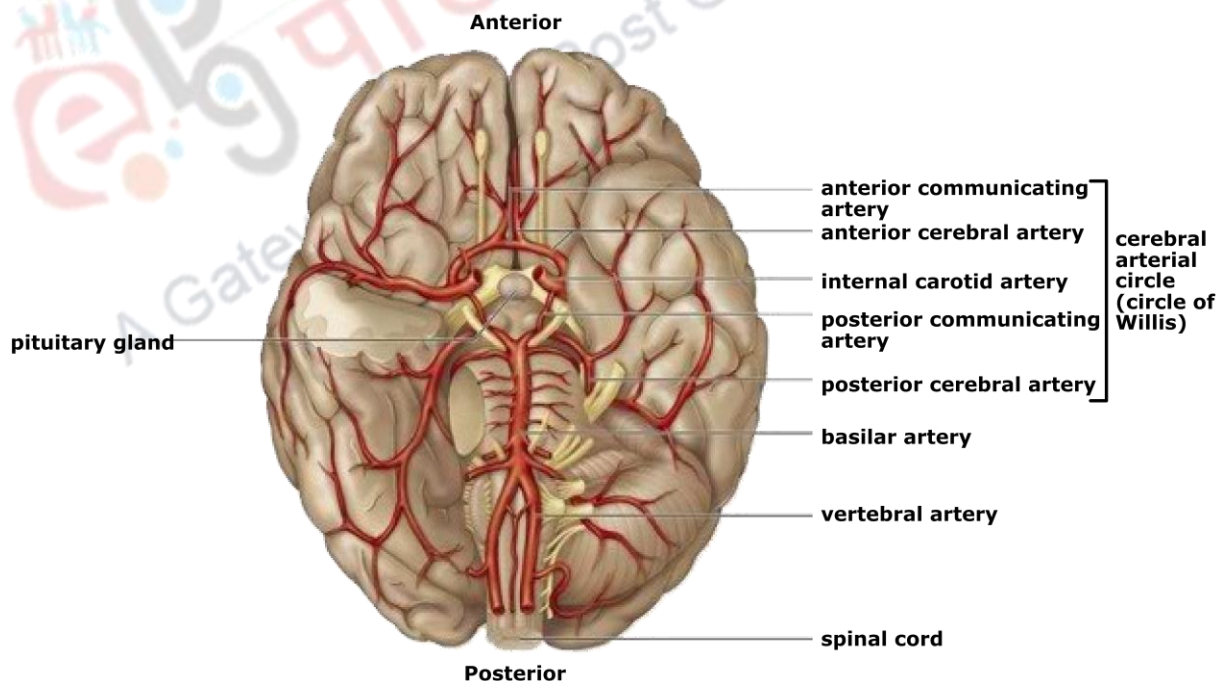
- Blows to the back of head produce little occipital contusions although there may be posterior cerebellar contusion. Blow to the top of head produces minimal coup contusion but prominent contrecoup subtemporal or uncal contusions. Blows to the side of head produces lateral coup lesions and prominent contrecoup contusions. Blows to the front of head usually do not produce cerebral contusion.
- Old contusions appear as shrunken yellowish-brown areas known as “plaques Jaunes”.
- **Laceration-** these are traumatic lesions in which there is loss of continuity of the substance of brain. Surface lacerations are accompanied by ruptures of pia mater and subarachnoid haemorrhages.
 - These tears are caused by stretching and shearing forces within the tissue produced by blunt force.
 - These are usually seen underneath skull fractures.
 - All penetrating injuries produce lacerations of brain.
 - In depressed fractures, fragments of bone may be driven in the brain tissue, lacerating it.
 - In severe hyperextension of head as in RTA, laceration may be produced at the junction of medulla and pons or may lead to avulsion of pons.
- **Contre-coup Lesions:** - coup means that the injury is located beneath the area of impact and results directly by the impacting force. Contre-coup means that the lesion is present in an area opposite the side of impact.
 - Produced chiefly due to local distortion of the skull, and sudden rotation of the head which causes shear strains and undue pulling apart of brain tissue.
 - These lesions are caused when the moving head is suddenly decelerated by hitting a firm surface.
 - Subdural or subarachnoid haemorrhage may be caused.
 - A blow to the head causes skull to move forward but the brain lags behind for a brief period and the skull strikes the brain.

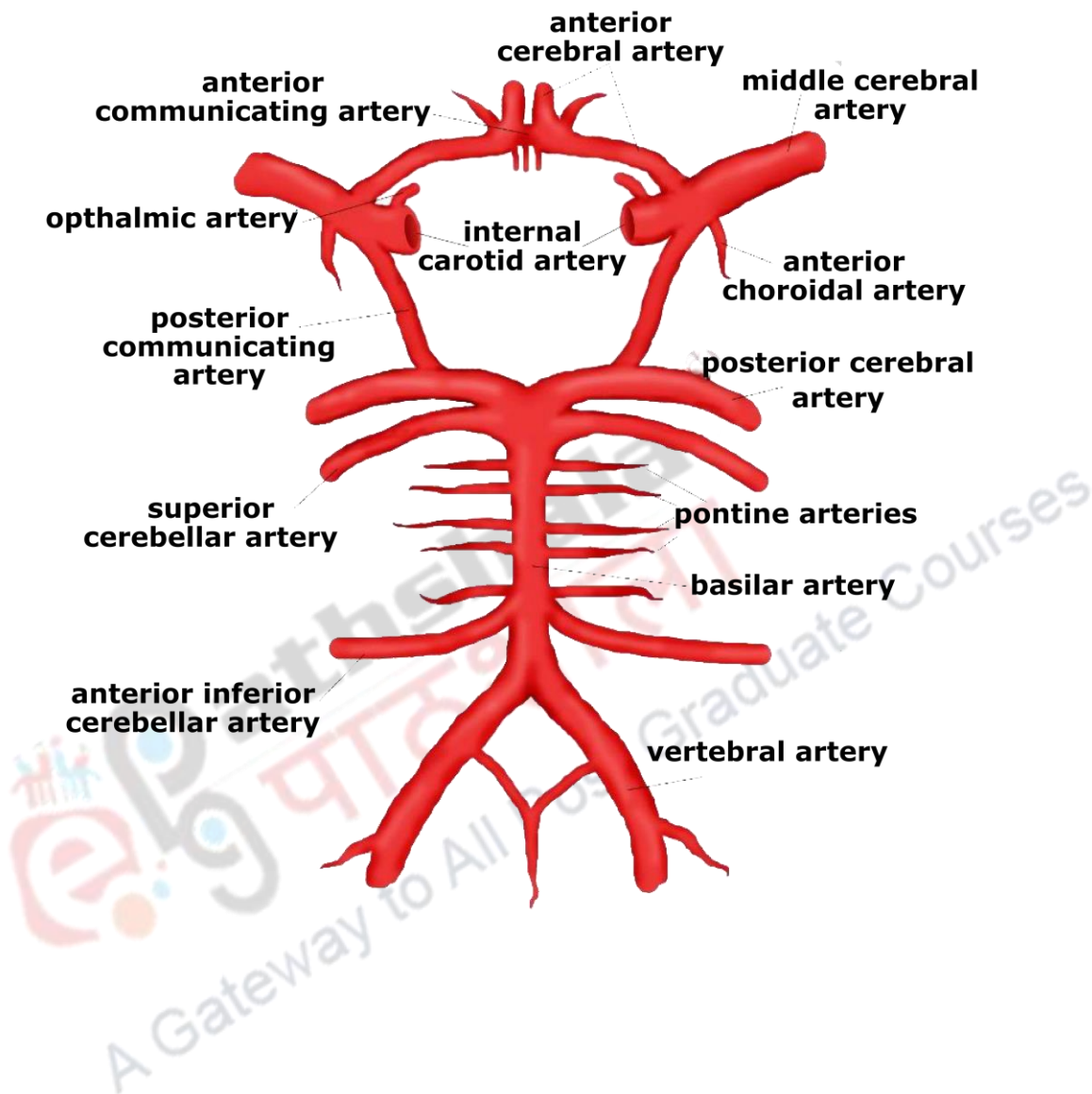
- Another factor responsible is formation of a cavity or vacuum in the cranial cavity on the opposite side of impact which exerts a suction effect which damages the brain.
- Occipital injuries produce contrecoup lesion in the frontal region. A blow to the front of head may damage the inner and lower parts of the back of brain. A fall on the side of head may cause a fracture at that side and contusion of the opposite side.
- **Concussion of the brain:** - it is a state of temporary unconsciousness due to partial or complete paralysis of cerebral functions, due to head injury, comes on immediately after the injury and is always followed by amnesia and tends to spontaneous recovery.
 - They occur due to acceleration/deceleration of the head. Violent head movements cause shearing or stretching of the nerve fibres and axonal damage.
 - Severe injuries occur in coronal head motions only, sagittal head motions produce mild or moderate damage.
 - They may be produced by direct impact to the head or by indirect violence as a result of fall on feet or buttocks.
 - There is diffuse axonal injury, a functional abnormality of the nerve cells and their connections
- **Oedema of brain and swelling:** - In brain swelling, oedema is mainly intracellular. The organ is enlarged and firm but has a relatively dry cut surface. In the oedema of brain, fluid collection is interstitial. The organ is enlarged and soft and has a very watery cut surface.
 - It may occur following significant head injury, it may be focal or diffuse involving bilateral hemispheres.

- **Cerebral compression:** - any increase in the size of the brain, due to generalized swelling or space occupying lesions, results in compression of the brain. This leads to decrease in the amount of CSF in the ventricles and subarachnoid space. A further rise in the pressure leads to progressive interference with the blood supply of brain.
- **Injuries to brain stem:** - it may be injured by
 - 1) Stretching of peduncles when the hemispheres shift.
 - 2) Deceleration against basisphenoid and dorsum sellae.
 - 3) Lateral shift of peduncles against tentorial margins.
 - 4) Stretch or avulsion from it of cranial nerves.
 - 5) Traction on its vascular supply

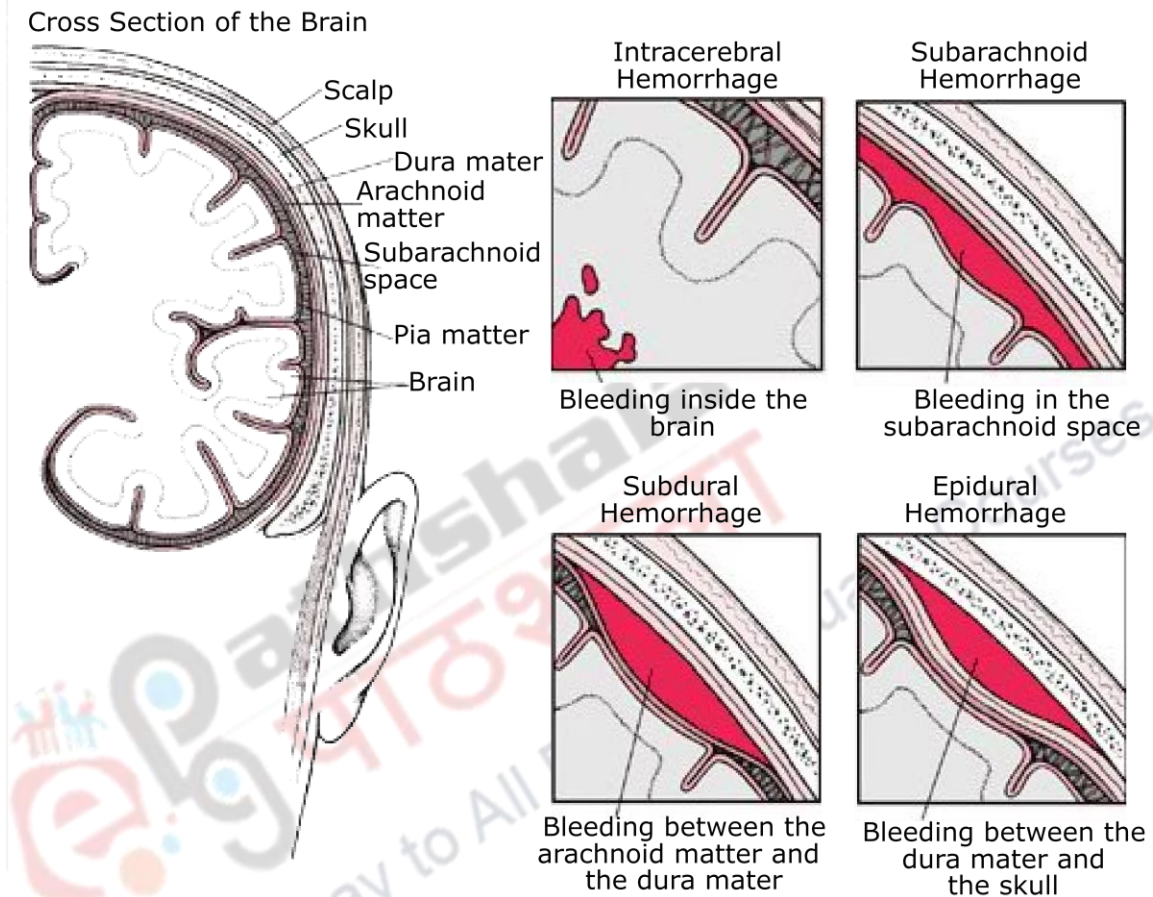
Spontaneous pontine bleed is usually single. There may be multifocal bleed which later unites. Pinpoint pupils not reacting to light in case of head injury indicates pontine bleed.

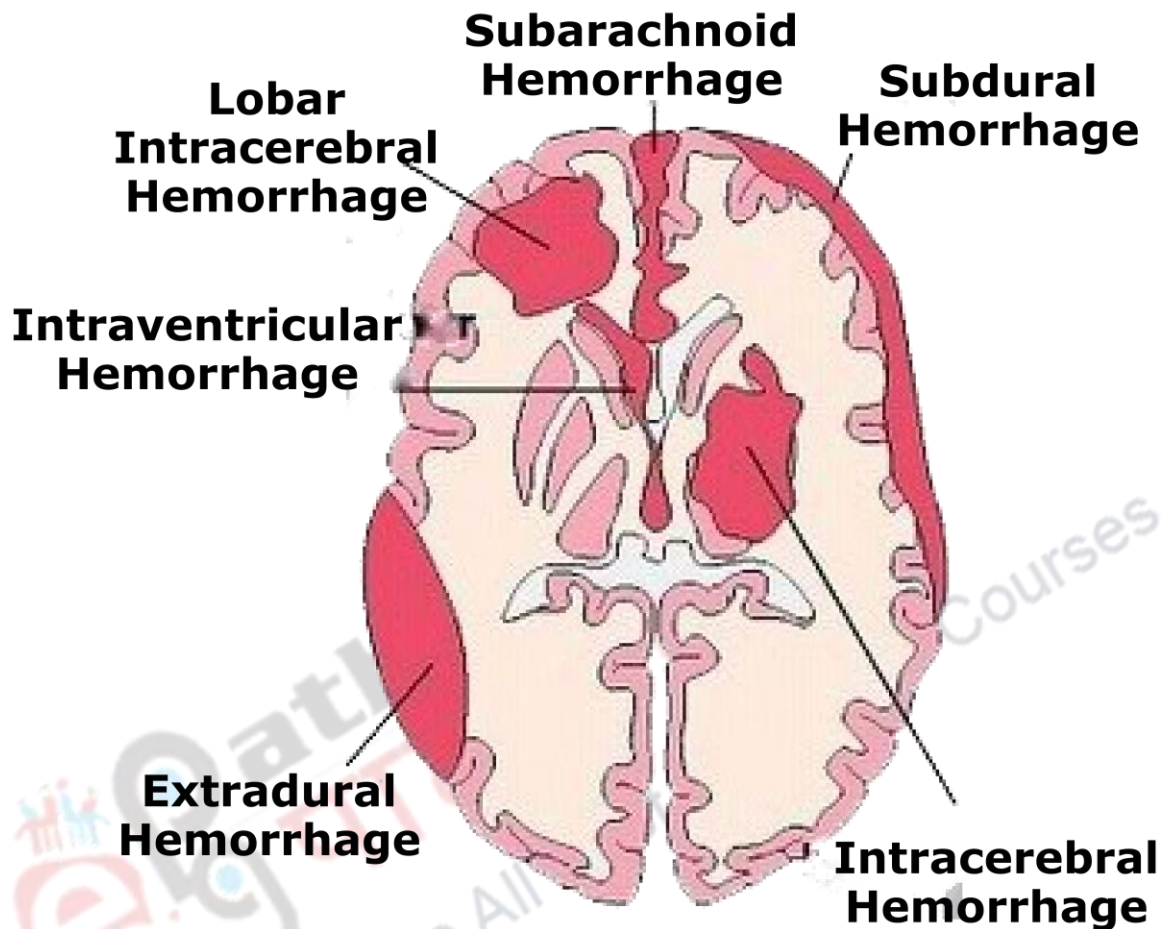
7. Intracranial haemorrhage





Sites of Brain Hemorrhage





1. Extra Dural Hemorrhage: - the dura is strong, the outer layer of which is firmly attached to skull and inner layer merges with arachnoid.

Causes -

It is caused almost exclusively due to trauma. It may be caused by fall from a height or on being hit by a moving object or after a minor accident. In almost all cases, the haematoma is directly under the site of injury.

- 1) A blow over the lateral convexity of the head may fracture temporal bone and injure the middle meningeal artery, especially in its posterior course. Less commonly the posterior meningeal artery near the foramen magnum (parieto-

- occipital hematoma) or the anterior meningeal artery near the cribriform plate are injured (fronto-temporal)
- 2) A blow over the forehead involves the anterior ethmoidal artery.
 - 3) A blow over the occiput or behind the ear may tear the transverse sigmoidal sinus and produce posterior fossa hematoma.
 - 4) A blow on the vertex may cause hemorrhage from sagittal sinus.
 - 5) Venous extradural hemorrhage accompanies fracture of skull and is due to bleeding from the diploic veins.

It is the least common type of meningeal bleed and is seen in 1 to 3% of the cases. It is rare in first two years of life due to greater adherence of the dura to the skull, but are common in adults.

Blood Clot - the clot has typical limitations due to dural attachment at the suture lines. The clot is sharply defined, presses the dura inwards and causes a localized concavity of the external surface of brain. The clot is oval or circular, rubbery in consistency, reddish purple about 10-20 cm in diameter, 2-6 cm thick and is adherent to dura. Usually 100 ml is the minimum associated with fatality. About 20 to 50 percent cases are fatal.

Chronic Type - chronic extradural hematomas are rare and may or may not be associated with skull fractures. They are commonly seen in older children and young adults. Sudden death may occur after several days.

2. Subdural Hemorrhage: - The arachnoid is thin vascular meshwork and is intimately applied to the inner surface of the dura. The cerebral veins cross this space to reach the sinuses.

Causes -

Subdural hemorrhage is commoner than extradural and occurs in the subdural space between dura mater and the arachnoid.

Occurrence- it may occur from relatively slight trauma. About 70% occur due to falls and assault and 25% are due to vehicle accidents. More likely to be found in alcoholics and old persons owing to atrophy or shrinkage of the brain. It may occur in the absence of skull fractures.

Death may occur if hematoma is about 100-150 ml. it is commonly seen over the upper lateral surface of cerebral hemispheres but can occur anywhere or even bilaterally. It usually appears as thick layers of blood. The haemorrhage may remain fluid or may clot in a firm mass. It is essentially venous or capillary and not arterial.

Types: - divided according to the time of onset of symptoms after the injury.

1. **ACUTE-** in this type, bleeding occurs immediately and very rapidly after trauma. The blood is usually liquid to semi-liquid. It may vary from a thin layer of one mm to 2 to 3 cm thickness. Commonly affected area is frontotemporoparietal. Fresh subdural haematoma over the top of brain can easily be washed off, in contrast to subarachnoid hemorrhages.
2. **SUBACUTE-** the symptoms develop from several days to 2 to 3 weeks after the injury, due to pressure of the haematoma. This occurs when the bleeding is from smaller bridging veins.
3. **CHRONIC-** This type results from slight trauma in which symptoms develop some weeks or even months later. These are usually seen over the parietal lobe and near the midline

3. Subarachnoid Hemorrhage: - The space between arachnoid and pia is called subarachnoid space. It contains the blood vessels of the brain, portion of cranial nerves and network of connective tissue fibres as well as CSF.

Causes-

- 1) Rupture of bridging veins near the sagittal sinus.
- 2) Laceration and contusion of the brain and the pia-arachnoid.
- 3) Rupture of a saccular Berry aneurysm which account for 90% of the aneurysms that rupture. It may occur due to sudden rise of blood pressure, emotional stress such as assault, sudden exercise and sexual intercourse. They are usually found at the bifurcation of middle cerebral, anterior cerebral and posterior communicating arteries. It accounts for 50% cases of spontaneous subarachnoid hemorrhages. A hard blow to the head may rupture the aneurysm.
- 4) Angiomas and arteriovenous malformations.
- 5) Asphyxia
- 6) Tear of ventricular ependyma.
- 7) Rupture of intracranial hemorrhage of non-traumatic origin into subarachnoid space.
- 8) Kick or blow on the side of neck.

It is common in acute alcoholism. This is the most common form of traumatic intracranial hemorrhage. In all cases of significant brain injury, some degree of subarachnoid hemorrhage is found.

Subarachnoid blood can be distinguished from subdural blood because the later will wash away under gently running water.

4. Intracerebral Hemorrhage: - this may be found on the surface or substance of brain. These are usually accompanied by other types of brain injury.

Causes -

- 1) Capillary haemorrhages are found in softening due to anoxia, thrombosis and in asphyxia deaths.
- 2) Spontaneous haemorrhage in the region of the basal ganglia by the rupture of lenticulostriate artery is common in middle age and elderly persons.
- 3) Angiomas and malignant tumours of brain.
- 4) Hypertensive cerebral vascular disease.
- 5) Laceration of the brain.
- 6) Blow on the head, with or without fractures of skull

Traumatic intracerebral haemorrhage results from coup-contrecoup mechanisms. It is mostly seen in fronto temporal region and is often associated with fracture of skull.

Non-traumatic intracerebral haemorrhage is due to cerebral aneurysm, degeneration of arteries, syphilis and tumours specially angiomas. The usual source of haemorrhage is rupture of a lenticulostriate branch of middle cerebral artery.

5. Intraventricular Hemorrhage: - small intraventricular haemorrhages occur in all kinds of cranio-cerebral injuries.

True traumatic ventricular haemorrhage as a sole finding occurs due to head striking a firm object e.g. fall. Death may be rapid or delayed for several days.

Cause of death in head injury-

- 1) Raised intracranial pressure due to hematoma, contusions, lacerations, infarctions or swelling is the common cause of death.
- 2) Diffuse axonal injury.
- 3) Ischaemic brain damage.
- 4) Fat embolism

8. Summary

- Head injury is a morbid state resulting from gross or subtle changes in the scalp, skull, and/or contents of the skull, produced by mechanical force.
- Different types of skull fractures produced are linear, depressed, elevated, gutter, comminuted, pond, ring as well as sutural separation
- Various types of intracranial hemorrhages include Extradural, Subdural, subarachnoid, intracerebral and intraventricular.
- Traumatic intracerebral haemorrhage results from coup-contrecoup mechanisms. It is mostly seen in fronto temporal region and is often associated with fracture of skull.
- Non-traumatic intracerebral haemorrhage is due to cerebral aneurysm, degeneration of arteries, syphilis and tumours specially angiomas.