The head—basic anatomy and physiology

The scalp

Anatomists describe the SCALP as having five layers: Skin, Subcutaneous tissue, Aponeurosis, Loose areolar tissue and Pericranium. Functionally, it can be considered as two layers:

- a superficial layer from the skin to the galea apponeurotica; and
- a deep layer consisting of the areolar tissue and pericranium.

It is between these layers that the scalp moves. Most scalp lacerations extend the full thickness of the upper layer. The vessels and nerves lie in the subcutaneous tissue (anteriorly—supra-orbital and supratrochlear; laterally—superficial temporal artery and auriculotemporal nerve; posteriorly—posterior auricular artery and occipital artery). The scalp has a rich blood supply and can bleed profusely. In children blood loss can result in shock.

The skull

The skull consists of the calvarium, which contains the brain, and the facial skeleton. The calvarium consists principally of eight bones:

- frontal
- sphenoid (2)
- temporal (2)
- parietal (2)
- occipital bones.

A small part of the ethmoid bone completing the skull base anteriorly.

The skull is thickest over the vertex. It is **thinnest in the temporal region and where it forms the roof of the orbits and nose**. (See for yourself. Get a real skull and hold it up to daylight. This graphically demonstrates how fragile some areas are.) Skull thickness and sinus volume can vary from person to person.

Internally the skull is divided into the anterior, middle, and posterior cranial fossae.

The **anterior cranial fossa** contains the anterior part of the frontal lobe of the brain. It extends back to the lesser wing of the sphenoid bone, and lies above the orbits and nose. The anterior fossa is perforated by the olfactory nerves only (cranial nerve I).

The **middle cranial fossa** is the largest. It is continuous with the anterior fossa above the lesser wing of the sphenoid. It is separated from the posterior fossa by the tentorium cerebelli. The middle fossa is filled by the temporal lobes of the brain and above them contains the remainder of the frontal lobes, the parietal and occiptal lobes. The carotid arteries enter the skull and the cranial nerves II to VI leave the skull via the middle fossa floor.

The **posterior cranial fossa** lies below the tentorium cerebelli. It contains the midbrain, pons, medulla, and cerebellum. The major venous outflow of the brain is through the posterior fossa, where the sigmoid sinus continues as the internal jugular vein. Cranial nerves VII to XII also exit through the posterior fossa. The medulla continues with the spinal cord through the foramen magnum, which is also where the vertebral arteries and spinal root of the accessory nerve enter the skull.

The meninges

The inner surface of the skull is lined by the **duramater**, which is a tough fibrous membrane ('pachy' or thick meninges). It becomes more firmly attached to the skull with age. The dura is reflected internally to form:

(1) the falx cerebrum, which separates the two cerebral hemispheres;
(2) the tentorium cerebelli, which separates the middle and posterior cranial fossae; and
(3) the falx cerebelli, which separates the two cerebellar hemispheres.

The extradural space, external to the dura, is a potential space only: normally it does not exist.

Large **venous sinuses**, which provide the major venous outflow of the brain, lie within the dura. The superior sagittal sinus and inferior sagittal sinus lie along the upper and lower margins of the falx, respectively. The inferior sagittal sinus continues as the straight sinus, which lies where the falx joins the tentorium. The straight and superior saggital sinuses join at the confluence of the sinuses, or torcula, which lies internal to the external occipital protruberence. The sinuses continue laterally as the transverse sinuses, which lie in the lateral margin of the tentorium. The anatomical arrangement of the confluence results in most of the blood from the superior sagittal sinus passing to the right transverse sinus and from the straight sinus to the left. The transverse sinuses continue as the sigmoid sinuses, which curve through the posterior fossa to the jugular foramen.

The cavernous sinuses lie alongside the sella tursica (pituitary fossa) and communicate with the sigmoid sinuses via the superior and inferior petrosal sinuses, which lie along the upper and lower borders of the petrous temporal bone. **The cavernous sinuses receive some venous drainage from the face and are thus a route whereby extra-cranial infection can gain access intra-cranially**. The importance of the venous sinuses is that they can bleed profusely if damaged. Particular care need to be taken if they have been potentially damaged, e.g. by depressed fractures.

The **arachnoid mater** lies deep to the dura. It is a flimsy membrane and consists of the parietal layer of the 'lepto' (or thin) meninges. The subdural space lies between the dura and arachnoid and is usually empty, although the two membranes are not adherent. The subarachnoid space lies deep to the arachnoid and contains the cerebrospinal fluid (CSF). This helps to support and cushion the brain. At various places, mostly around the base of the brain, the subarachnoid space is very wide and forms the 'basal cisterns'.

The **piamater** is the visceral layer of the leptomeninges. It is firmly attached to the brain.

Cerebral blood supply

The internal carotid and vertebral arteries supply the brain. The **internal carotid** arteries divide into the anterior and middle cerebral arteries. The anterior cerebral artery supplies the inferior surface of the frontal lobe and the anterior part of the medial surface of the hemisphere, extending a short distance onto the lateral surface. This includes the leg area of the motor cortex. The middle cerebral artery supplies most of the lateral surface of the hemisphere. This includes the trunk, arm and face areas of the motor cortex, speech area (on the dominant side) and auditory cortex.

The two **vertebral arteries** unite to form the basilar artery, which divides into the two posterior cerebral arteries. The latter supplies the inferior surface of the temporal and occipital lobes and the posterior part of the medial surface of the hemisphere, also extending a short distance onto the lateral surface. This includes the visual cortex. The vertebrobasilar system also supplies the cerebellum, and brainstem.

The brain

Each of the cerebral hemispheres is divided into four lobes. The central sulcus separates the frontal lobe from the parietal lobe, the parieto-occipital fissure separates the parietal and occipital lobes, and the Sylvian fissure separates the temporal lobe from the frontal and parietal lobes. The cortical surface is highly convoluted into gyri (the folds) and sulci (the clefts). This increases the area of the cortex, which is where the higher functions are organized.

Cortical functions are crossed, with one hemisphere dealing with the function of the other side of the body. The left hemisphere is dominant for speech in 99% of right-handed individuals (as the right hemisphere is dominant in 1%, dysphasia can occasionally be caused by a right cerebral lesion). There is a 50:50 likelihood of either hemisphere being dominant for speech in left-handed individuals, but right hemisphere dominance is more likely if there is a strong family history of left-handedness.

Localization of cortical functions:

- **Primary motor area**. Pre-central gyrus of frontal lobe (body image inverted with leg area on the medial hemisphere surface). The basal ganglia are also highly important.
- **Primary sensory area**. Post-central gyrus of parietal lobe (body image inverted with leg area on the medial hemisphere surface).
- **Speech motor area**.* (Broca's area) infero-lateral frontal lobe (just above tip of temporal lobe).
- **Speech interpretation area**.* (Wernicke's area) inferior parietal lobe and upper temporal lobe (behind primary sensory area).
- **Visual cortex**. Tip of occipital lobe, especially medial surface.
- **Auditory cortex**. Superior temporal gyrus.
- **Higher intellectual functions**. Tip of frontal lobe (unilateral lesion causes minor deficit only).
- **Emotions**. Inferior frontal lobe, tip of temporal lobe and cingulated gyrus (on medial surface above corpus callosum). Other deep parts of the limbic system are also involved (a series of structures that surround the lateral ventricle, including the hippocampus, amygdala and fornix).
- **Olfactory function**. Infero-medial temporal lobe.

- **Other parietal lobe functions**: (dominant) numeration, calculation; (non-dominant) body image and awareness of external environment.

* Dominant hemisphere only.

The two hemispheres are connected by the commisures, the largest and most important of which is the corpus callosum. Descending white matter tracts from the cortex converge to form the internal capsule en route to the brainstem. The motor fibres are condensed into the posterior limb. **A small lesion here can produce a major deficit**. Ascending sensory fibres (except olfaction) relay in the thalamus, which is lateral to the internal capsule. The other basal ganglia are concerned with motor function, and have complex interconnections.

The hypothalamus is concerned with autonomic function and endocrine control through the pituitary gland.

Cerebellum

The cerebellum is concerned with **balance and coordination**. It consists of two hemispheres and the midline vermis. It is divided into three lobes (anterior, posterior, and flocculonodular lobe), but these divisions are not usually obvious on external inspection.

- Damage to the vermis causes ataxia and unsteadiness on sitting (truncal ataxia).
- Damage to the cerebellar hemispheres causes incoordination on the same side of the lesion.

Brainstem

The midbrain, pons, and medulla contain nuclei for the third to twelfth cranial nerves, together with descending and ascending fibre tracts. The midbrain contains a gaze-control centre. The brainstem **reticular formation** contains centres for the vital functions (wakefulness, pulse and blood pressure control, breathing).

Ventricular system

The two lateral ventricles are C-shaped cavities within the cerebral hemispheres. They connect via the foramen of Monro with the midline, slit-like third ventricle. This, in turn, connects via the cerebral aqueduct with the pyramidal fourth ventricle, between the brainstem and cerebellum. The exit from the fourth ventricle is via the median foramen of Magendie and the lateral foramina of Luschka.

Each of the ventricles contains the frond-like choroid plexus, which produces **CSF**. The total volume of CSF in a normal adult is 150 ml, but only 22 ml are in the ventricles, the rest being in the sub-arachnoid space. CSF production is **450 ml per day** so CSF is replaced three times per day. CSF is absorbed through the arachnoid villi over the cortical surface by a passive, pressure-dependent process. Blood in the CSF can block this process resulting in **raised intra-cranial pressure (ICP)**

- inotropes- maintain CPP by BP elevation;
- hyperventilation—reduce pCO_2 to 3.5 kPa;
- barbiturates—lowers cerebral metabolism;
- hypothermia—lowers cerebral metabolism;
- CSF drainage (the ventricles are usually small and difficult to cannulate so this is not often used);
- decompressive craniotomy—allows additional space for the brain to expand into.

CSF leaks

Facial fractures that extend into the base of the skull (e.g. Le Fort II, Le Fort III, naso-ethmoidal and occasionally fractures involving the mandibular condyle) can tear the dural lining and allow cerebral spinal fluid (CSF) to leak from the nose (rhinorrhoea) or from the ear (otorrhoea). Clear CSF tends to mix with blood and presents as a heavily blood-stained, watery discharge. This trickles down the side of the face, where peripherally the blood tends to clot while the non-clotted blood in the centre is washed away by CSF. This creates two parallel lines referred to as **'tramlining'**. One test for CSF is the 'ring test' (allow drops to fall on blotting paper, blood clots centrally, the CSF diffusing outwards to form a target sign). Other tests include examining for eosinophils and sugar. This is helpful in distinguishing between CSF and mucous. More sensitive indicators include B2 transferrin and tau protein, although practically it is easier to simply assume that a leak is present. **Tell the patient not to blow their nose for three weeks. If they do the increased pressure can force air intra-cranially through the tear, which then cannot escape. This is the neurosurgical equivalent of a tension pneumothorax!**

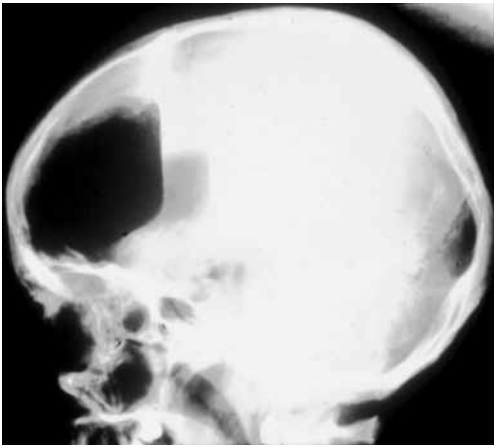

Fig. 4.4 A 'tension' pneumocephalocele.

Head injuries in children

These can be difficult to assess. Many of the features, which would lead to concern in adults are often present even with minor injuries (vomiting, drowsy, headaches, etc.). Carefully consider the mechanism of injury, other injuries present and whether the parents are capable of taking the child home for close observations. Interpretation of skull X-rays can be difficult as large fractures may be confused with wide sutures or vascular markings. CT scans are difficult to get and nearly always require general anaesthesia in an uncooperative child. If in doubt either refer or admit. **Remember NAI**.