

The Meninges

The meninges refer to the **membranous** coverings of the brain and spinal cord. There are three layers of meninges, known as the **dura mater**, **arachnoid mater** and **pia mater**.

These coverings have two major functions:

- Provide a **supportive framework** for the cerebral and cranial vasculature.
- Acting with cerebrospinal fluid to **protect** the CNS from mechanical damage.

The meninges are often involved cerebral pathology, as a common site of **infection** (meningitis), and **intracranial bleeds**.

In this article, we shall look at the anatomy of the three layers, and their clinical correlations.

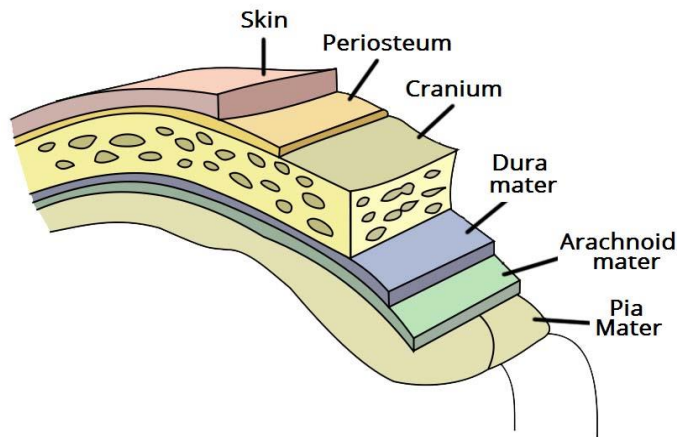


Fig 1 – Overview of the meninges, and their relationship to the skull and brain.

Dura Mater

The dura mater is the **outermost** layer of the meninges, lying directly underneath the bones of the skull and vertebral column. It is thick, tough and inextensible.

Within the cranial cavity, the dura contains two connective tissue sheets:

- **Periosteal layer** – lines the inner surface of the bones of the cranium.
- **Meningeal layer** – deep to the periosteal layer inside the cranial cavity. It is the only layer present in the vertebral column.

Between these two layers, the **dural venous sinuses** are located. They are responsible for the venous vasculature of the cranium, draining into the **internal jugular** veins.

In some areas within the skull, the meningeal layer of the dura mater folds inwards as **dural reflections**. They partition the brain, and divide the cranial cavity into several compartments. For

example, the **tentorium cerebelli** divides the cranial cavity into supratentorial and infratentorial compartments.

The dura mater receives its own vasculature; primarily from the **middle meningeal** artery and vein. It is innervated by the **trigeminal nerve** (V1, V2 and V3).

Clinical Relevance: Extradural and Subdural Haematomas

A haematoma is a collection of **blood**. As the cranial cavity is effectively a closed box, a haematoma can cause a rapid increase in **intra-cranial pressure**. Death will result if untreated.

There are two types of haematomas involving the dura mater:

- **Extradural** – arterial blood collects between the skull and periosteal layer of the dura. The causative vessel is usually the middle meningeal artery, tearing as a consequence of brain trauma.
- **Subdural** – venous blood collects between the dura and the arachnoid mater. It results from damage to cerebral veins as they empty into the dural venous sinuses.

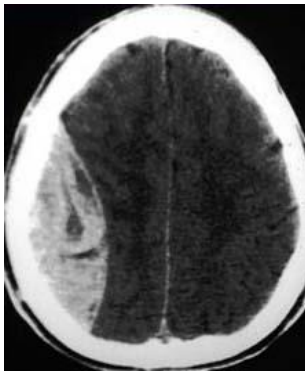


Fig 2 – CT scan of a massive extradural haematoma

Arachnoid Mater

The arachnoid mater is the middle layer of the meninges, lying directly underneath the dura mater. It consists of layers of connective tissue, is **avascular**, and does not receive any innervation.

Underneath the arachnoid is a space known as the **sub-arachnoid space**. It contains [cerebrospinal fluid](#), which acts to cushion the brain. Small projections of arachnoid mater into the dura (known as **arachnoid granulations**) allow CSF to re-enter the circulation via the dural venous sinuses.

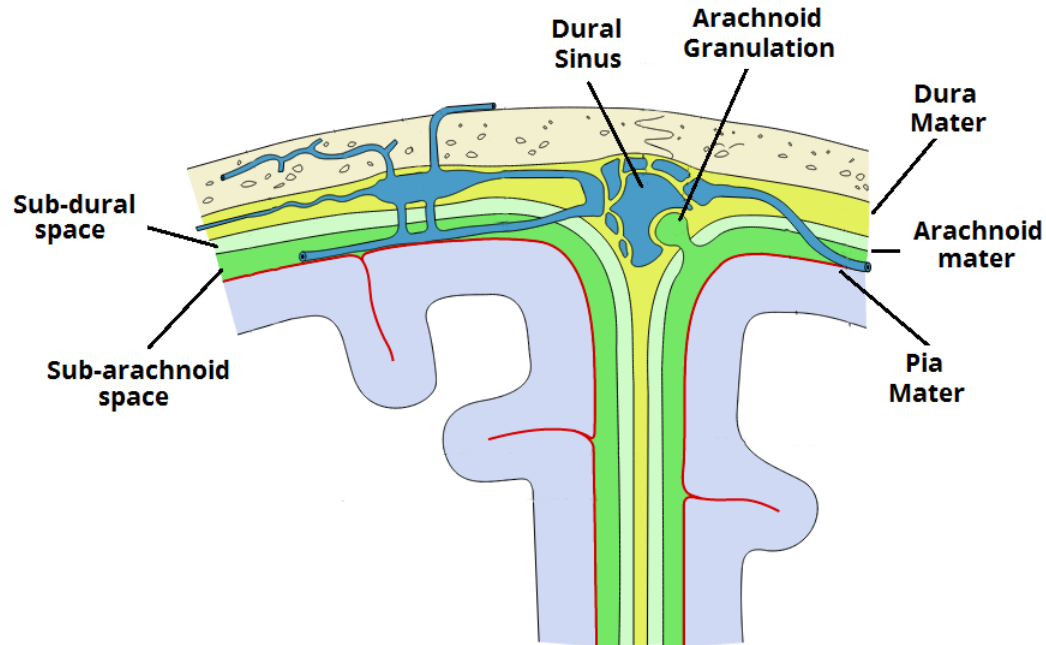


Fig 3 – Coronal section of the skull, meninges and cerebrum. An arachnoid granulation is visible in the centre.

Pia Mater

The pia mater is located underneath the sub-arachnoid space. It is very thin, and **tightly adhered** to the surface of the brain and spinal cord. It is the only covering to follow the contours of the brain (the gyri and fissures).

Like the dura mater, it is **highly vascularised**, with blood vessels perforating through the membrane to supply the underlying neural tissue.

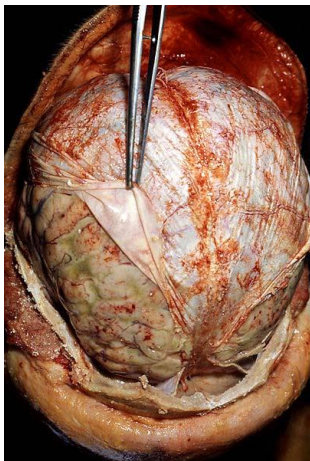


Fig 4 – Autopsy of a patient with meningitis. The dura mater is being retracted to show a grossly swollen cerebrum with pus accumulation.

Clinical Relevance: Meningitis

Meningitis refers to **inflammation** of the meninges. It is usually caused by pathogens, but can be drug induced.

Bacteria are the most common infective cause. The most common organisms are *Neisseria meningitidis* and *Streptococcus pneumoniae*.

The immune response to the infection causes **cerebral oedema**, consequently raising intra-cranial pressure. This has two main effects:

- Part of the brain can be forced out of the cranial cavity – this is known as **cranial herniation**.
- In combination with systemic hypotension, raised intracranial pressure **reduces cerebral perfusion**.

Both of these complications rapidly result in death.