# 15 Meninges

## CHAPTER OBJECTIVES

- To learn the structure and function of the three meninges that surround the brain and spinal cord
- To understand the venous sinuses within the skull and see how the meninges contribute to their walls
- To appreciate the relationship of the meninges to the different forms of cerebral hemorrhage

A 44-year-old woman is seen by a neurologist because she is experiencing intense pain in the right eye. On physical examination, she is found to have a slight medial strabismus of the right eye, and the right pupil is smaller than normal. Further examination reveals numbness over the right cheek. A computed tomography (CT) scan shows the presence of an aneurysm of the right internal carotid artery within the cavernous sinus. The aneurysm is about the size of a pea.

The location of the carotid aneurysm within the cavernous sinus explains the ocular pain; pressure on the right abducens nerve is responsible for the paralysis of the lateral rectus muscle producing the medial strabismus. The small pupil of the right eye is caused by the aneurysm pressing on the sympathetic plexus surrounding the carotid artery and producing paralysis of the dilator pupillae muscle. The numbness over the right cheek is due to pressure of the aneurysm on the right maxillary division of the trigeminal nerve as it passes forward through the lateral wall of the sinus.

This patient illustrates the necessity of knowing the relationships between the structures within the skull, especially in regions like the cavernous sinus, where so many important neural structures lie close to one another.

## BRAIN MENINGES

The brain in the skull is surrounded by three protective membranes or meninges: the dura mater, the arachnoid mater, and the pia mater.

### Dura Mater → dense fibrous membrane (main barrier)

The dura mater of the brain is conventionally described as two layers: the endosteal layer and the meningeal layer (Fig. 15-1). These are closely united except along certain lines where they separate to form **venous sinuses**. 1 (periostal layer)

The **endosteal layer** is nothing more than the periosteum covering the inner surface of the skull bones. At the foramen magnum, it does not become continuous with the dura mater of the spinal cord. Around the margins of all the foramina in the skull, it becomes continuous with the **periosteum** on the outside of the skull bones. At the sutures, it is continuous with the **sutural ligaments**. It is most strongly adherent to the bones over the base of the skull.

forms like a cuff in spinal cord/nerves
forms c̄ dural fold

2 The **meningeal layer** is the dura mater proper. It is a dense, strong fibrous membrane covering the brain (Figs. 15-2 and 15-3) and is continuous through the foramen magnum with the dura mater of the spinal cord. It provides tubular sheaths for the cranial nerves as the latter pass through the foramina in the skull. Outside the skull, the sheaths fuse with the epineurium of the nerves (see Fig. 15-2B).

(dural folds/reflections)

The meningeal layer sends inward four septa—the falx cerebri, falx cerebelli, tentorium cerebelli, and diaphragma sellae—which divide the cranial cavity into freely communicating spaces that lodge the subdivisions of the brain (see Figs. 15-1 and 15-3). The function of these septa is to restrict the displacement of the brain associated with acceleration and deceleration when the head is moved.

The **falx cerebri** is a sickle-shaped fold of dura mater that lies in the midline between the two cerebral hemispheres. Its narrow anterior end is attached to the internal frontal crest and the crista galli. Its broad posterior part blends in the midline with the upper surface of the

Falx cerebri - separates cerebral hemispheres
Tentorium cerebelli - separates cerebrum from cerebellum
Falx cerebelli - b/w cerebellar hemispheres
Diaphragma sellae - roof over sella turcica (pituitary)



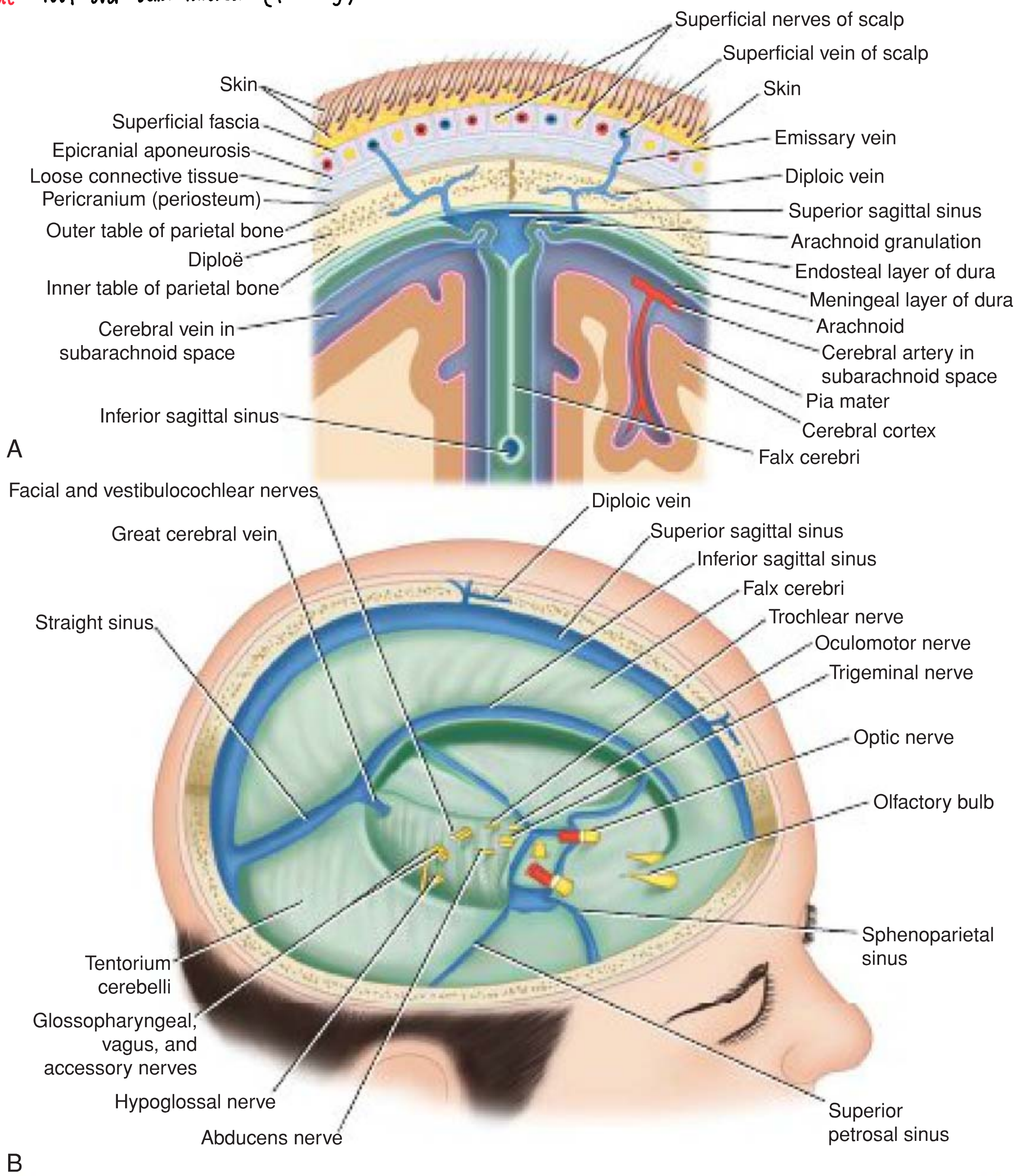


**Figure 15-1** **A:** Coronal section of the upper part of the head showing the layers of the scalp, sagittal suture of the skull, falx cerebri, venous sinuses, arachnoid granulations, emissary veins, and relation of the cerebral blood vessels to the subarachnoid space. **B:** Interior of the skull showing the dura mater and its contained venous sinuses.

**tentorium cerebelli**. The **superior sagittal sinus** runs in its upper fixed margin, the **inferior sagittal sinus** runs in its lower concave free margin, and the **straight sinus** runs along its attachment to the tentorium cerebelli.

The **tentorium cerebelli** is a crescent-shaped fold of dura mater that roofs over the posterior cranial fossa (Fig. 15-1; also see Fig. 15-4). It covers the upper surface of the cerebellum and supports the occipital lobes of the cerebral hemispheres. In the anterior edge, a gap, the **tentorial notch**, allows passage of the midbrain, which produces an inner free border and an outer attached or fixed border. The fixed border is attached to the posterior clinoid processes, the superior borders of the petrous bones, and the margins of the grooves for the transverse sinuses on the occipital bone. The free border runs forward at its two ends, crosses the attached border, and is affixed to the anterior clinoid process on each side. At the point where the two borders cross, the third and fourth cranial nerves pass forward to enter the lateral wall of the cavernous sinus.

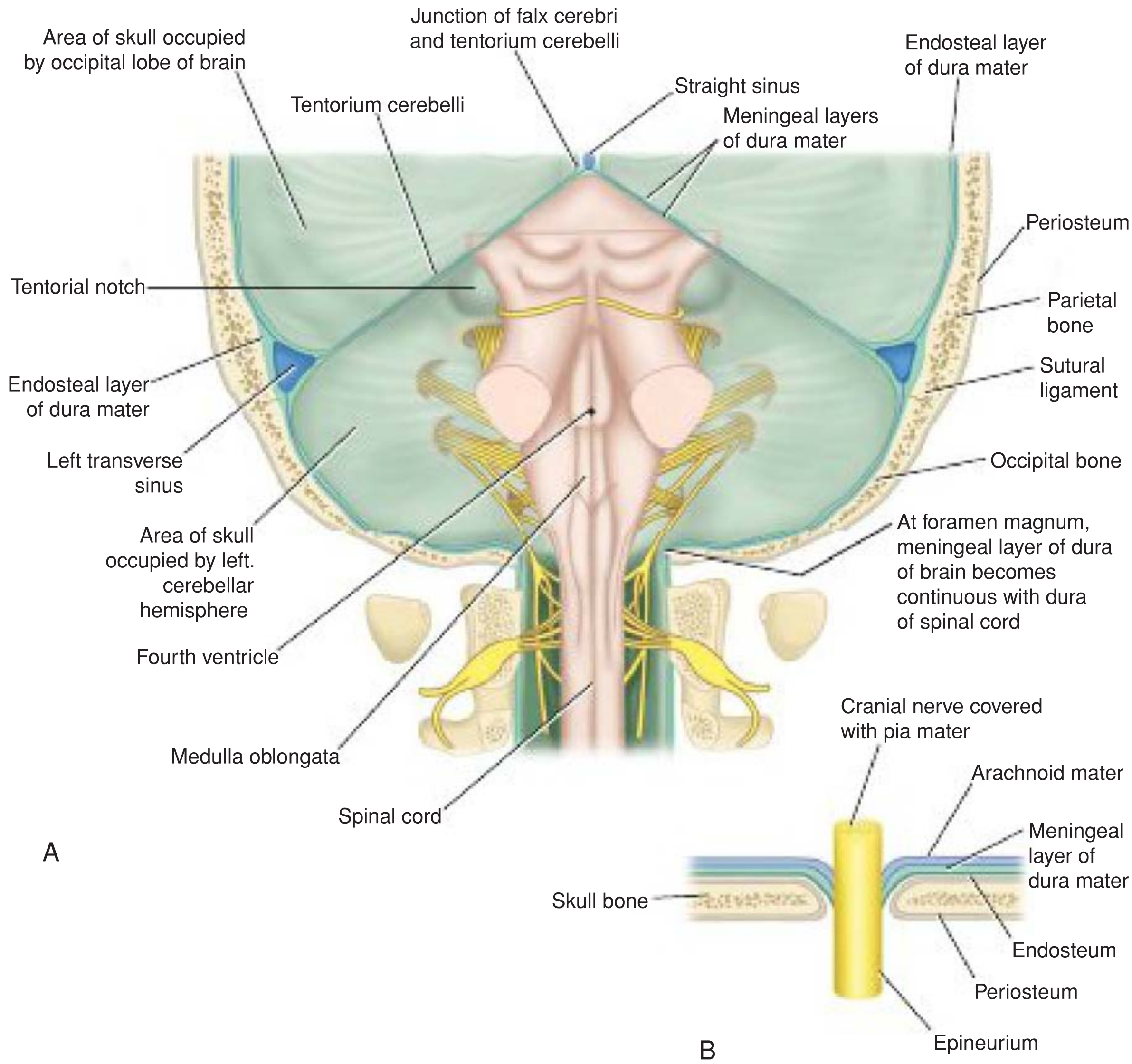


**Figure 15-2** **A:** Posterior view of the interior of the skull after removal of the occipital and parietal bones showing the arrangement of the endosteal and meningeal layers of the dura mater. The brainstem has been left in situ. **B:** The arrangement of the meninges as a cranial nerve passes through a foramen in the skull.

Close to the apex of the petrous part of the temporal bone, the lower layer of the tentorium is pouched forward beneath the superior petrosal sinus to form a recess for the trigeminal nerve and the trigeminal ganglion.

The falx cerebri and the falx cerebelli are attached to the upper and lower surfaces of the tentorium, respectively. The straight sinus runs along its attachment to the falx cerebri, the superior petrosal sinus runs along its attachment to the petrous bone, and the **transverse sinus** runs along its attachment to the occipital bone (see Figs. 15-1 and 15-4).

The **falx cerebelli**, a small, sickle-shaped fold of dura mater attached to the internal occipital crest projects forward between the two cerebellar hemispheres. Its posterior fixed margin contains the **occipital sinus**.

The **diaphragma sellae** is a small, circular fold of dura mater that forms the roof for the sella turcica (Fig. 15-5). A small opening in its center allows passage of the stalk of the **hypophysis cerebri**.
(infundibulum)

### Dural Nerve Supply

Branches of the trigeminal, vagus, and the first three cervical spinal nerves and branches from the sympathetic trunk pass to the dura.

The dura possesses numerous sensory endings that are sensitive to stretching, which produces the sensation of headache. Stimulation of the sensory endings of the trigeminal nerve above the level of the tentorium cerebelli produces referred pain to an area of skin on the same side of the head. Stimulation of the dural endings below the level of the tentorium produces pain referred

dural sinuses → drains CSF
adheres tightly in c̄ sutures
↳ to limit bld from transfering from area to another

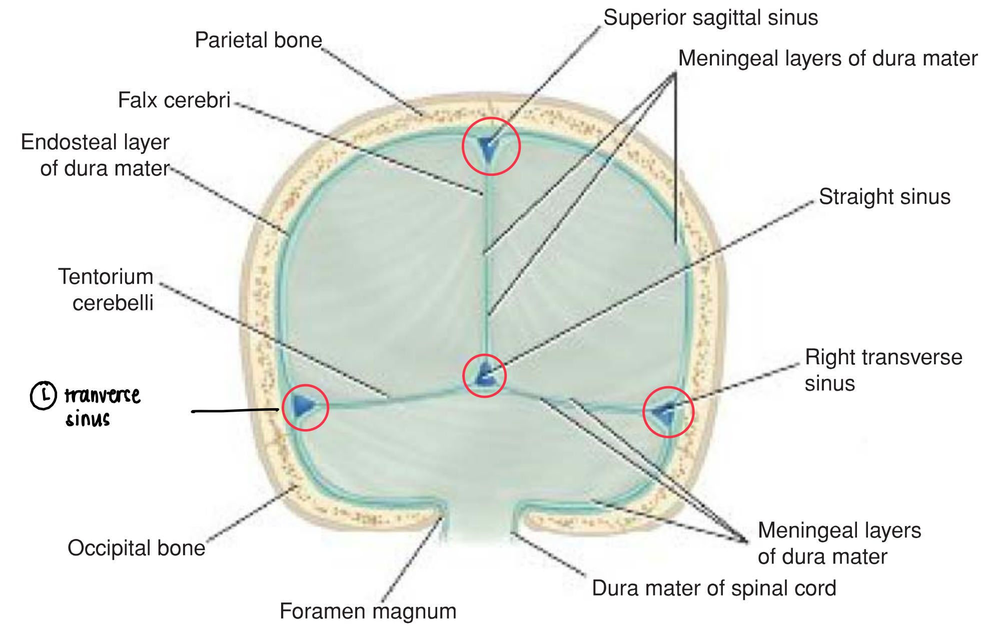


**Figure 15-3** Falx cerebri and the tentorium cerebelli. Note the continuity between the meningeal layer of dura mater within the skull and the dura mater of the spinal cord at the foramen magnum.

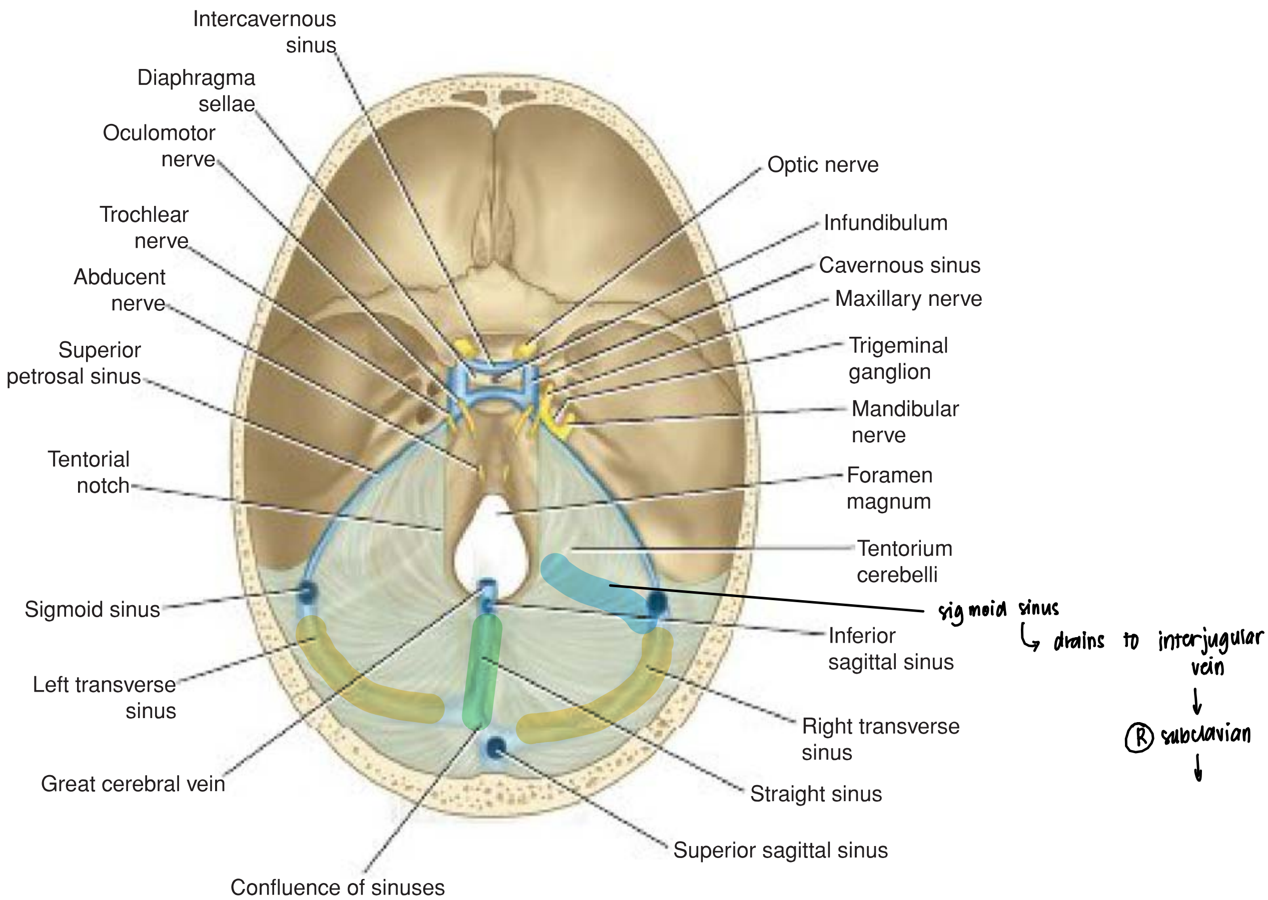


**Figure 15-4** Superior view of the diaphragma sellae and tentorium cerebelli. Note the position of the cranial nerves and venous sinuses.

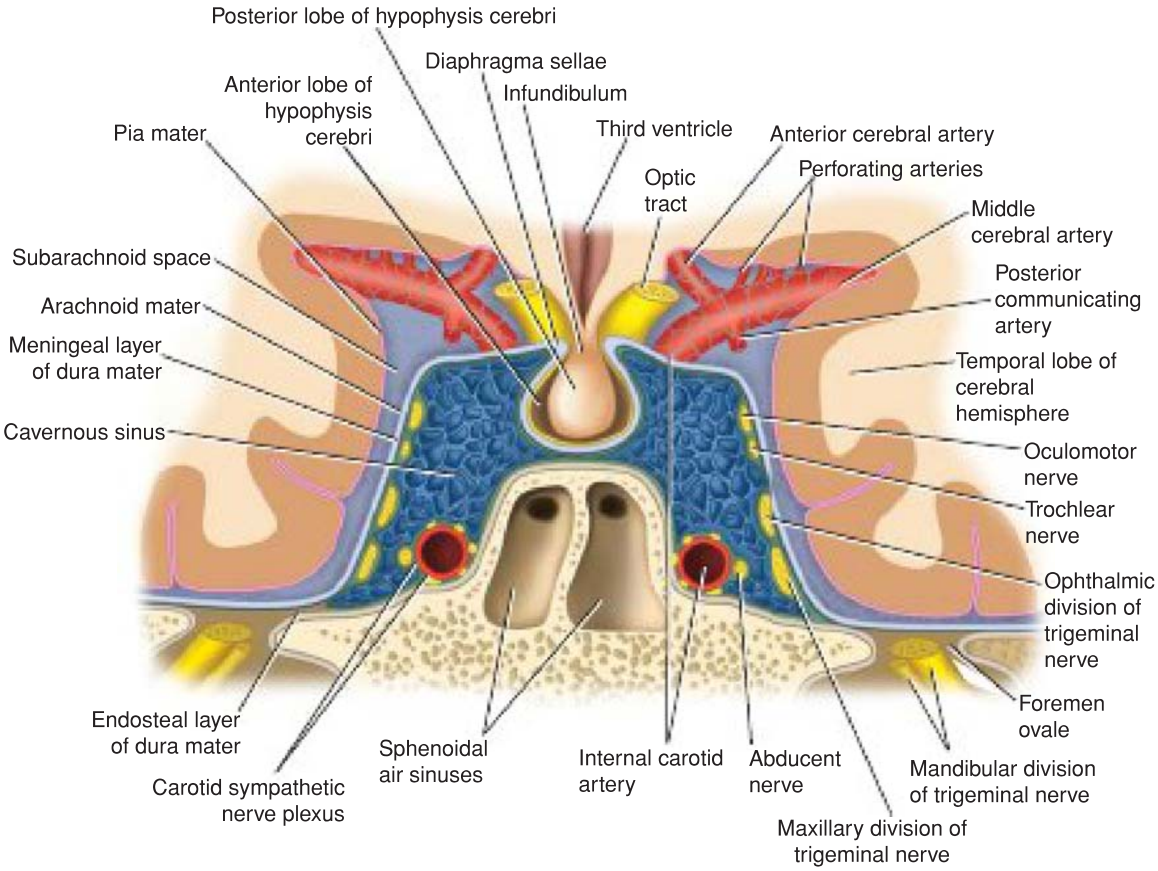


**Figure 15-5** Coronal section through the body of the sphenoid bone showing the hypophysis cerebri and cavernous sinuses. Note the position of the internal carotid artery and the cranial nerves.

to the back of the neck and the back of the scalp along the distribution of the greater occipital nerve.

## Dural Arterial Supply

Numerous arteries supply the dura mater from the **internal carotid, maxillary**, **ascending pharyngeal**, **occipital**, and **vertebral arteries**. From the clinical standpoint, the most important is the **middle meningeal artery**, which can be damaged in head injuries (Fig. 15-6). @ pterion (weakest)

The **middle meningeal artery** arises from the maxillary artery in the infratemporal fossa. It enters the cranial cavity through the **foramen spinosum** and then lies between the meningeal and endosteal layers of dura. The artery then runs forward and laterally in a groove on the upper surface of the squamous part of the temporal bone. The anterior branch deeply grooves or tunnels the anterior-inferior angle of the parietal bone, and its course corresponds roughly to the line of the underlying precentral gyrus of the brain. The posterior branch curves backward and supplies the posterior part of the dura mater (Fig. 15-7).

The **meningeal veins** lie in the endosteal layer of dura (see Fig. 15-6). The middle meningeal vein follows the branches of the middle meningeal artery and drains into the pterygoid venous plexus or the sphenoparietal sinus. The veins lie lateral to the arteries.

## Dural Venous Sinuses

The venous sinuses of the cranial cavity are situated between the layers of the dura mater (see Figs. 15-3 to 15-5 and 15-7). Their main function is to receive blood from the brain through the cerebral veins and the cerebrospinal fluid (CSF) from the subarachnoid space through the **arachnoid villi** (see Fig. 16-18). The blood in the dural sinuses ultimately drains into the internal jugular veins in the neck. The dural sinuses are lined by endothelium, and their walls are thick but devoid of muscular tissue. They have no valves. **Emissary veins**, which are also valveless, connect the dural venous sinuses with the **diploic veins** of the skull and with the veins of the scalp (see Fig. 15-1).

The **superior sagittal sinus** occupies the upper fixed border of the falx cerebri (see Figs. 15-1 and 15-4). It begins anteriorly at the foramen cecum, where it occasionally receives a vein from the nasal cavity. It runs posteriorly, grooving the vault of the skull; at the internal occipital protuberance, it deviates to one or the other side (usually the right) and becomes continuous with the corresponding **transverse sinus.** The sinus

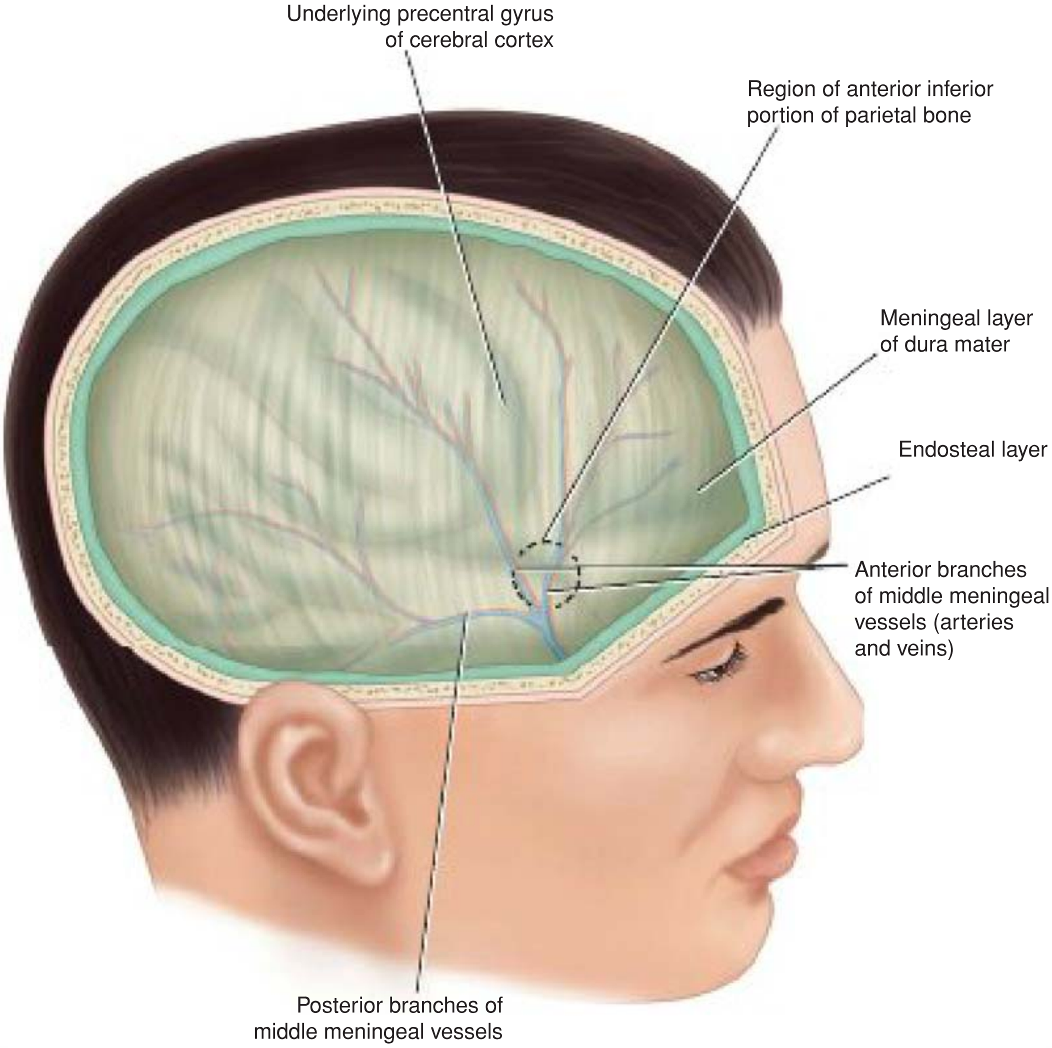


**Figure 15-6** Right side of the head showing the relation of the middle meningeal vessels to the layers of the dura mater and the skull.

communicates through small openings with two or three irregularly shaped **venous lacunae** on each side (see Fig. 15-7). Numerous arachnoid villi and granulations project into the lacunae, which also receive the diploic and meningeal veins (see Fig. 15-1).

The superior sagittal sinus in its course receives the **superior cerebral veins** (Fig. 15-1; see Fig. 17-5). At the internal occipital protuberance, it is dilated to form the **confluence of the sinuses** (see Fig. 15-4). Here, the superior sagittal sinus usually becomes continuous with the right transverse sinus; it is connected to the opposite transverse sinus and receives the **occipital sinus.** The **inferior sagittal sinus** occupies the free lower margin of the falx cerebri (see Fig. 15-1). It runs backward and joins the **great cerebral vein** at the free margin of the tentorium cerebelli to form the straight sinus (see Figs. 15-1 and 15-4). It receives a few cerebral veins from the medial surface of the cerebral hemispheres.

The **straight sinus** occupies the line of junction of the falx cerebri with the tentorium cerebelli. It is formed by the union of the **inferior sagittal sinus** with the **great cerebral vein**. It ends by turning to the left (sometimes to the right) to form the **transverse sinus**.

The **transverse sinuses** are paired structures that begin at the internal occipital protuberance (see Figs. 15-3 and 15-4). The right sinus is usually continuous with the superior sagittal sinus, and the left is continuous with the straight sinus. Each sinus occupies the attached margin of the tentorium cerebelli, grooving the occipital bone and the posteroinferior angle of the parietal bone. The transverse sinuses receive the **superior petrosal sinuses**, the **inferior cerebral** and **cerebellar veins**, and the **diploic veins**. They end by turning downward as the **sigmoid sinuses** (see Fig. 15-4).

The **sigmoid sinuses** are a direct continuation of the transverse sinuses. Each sinus turns downward and medially and grooves the mastoid part of the temporal bone. Here, the sinus lies posterior to the mastoid antrum. The sinus then turns forward and then inferiorly through the posterior part of the jugular foramen to become continuous with the **superior bulb** of the **internal jugular vein**.

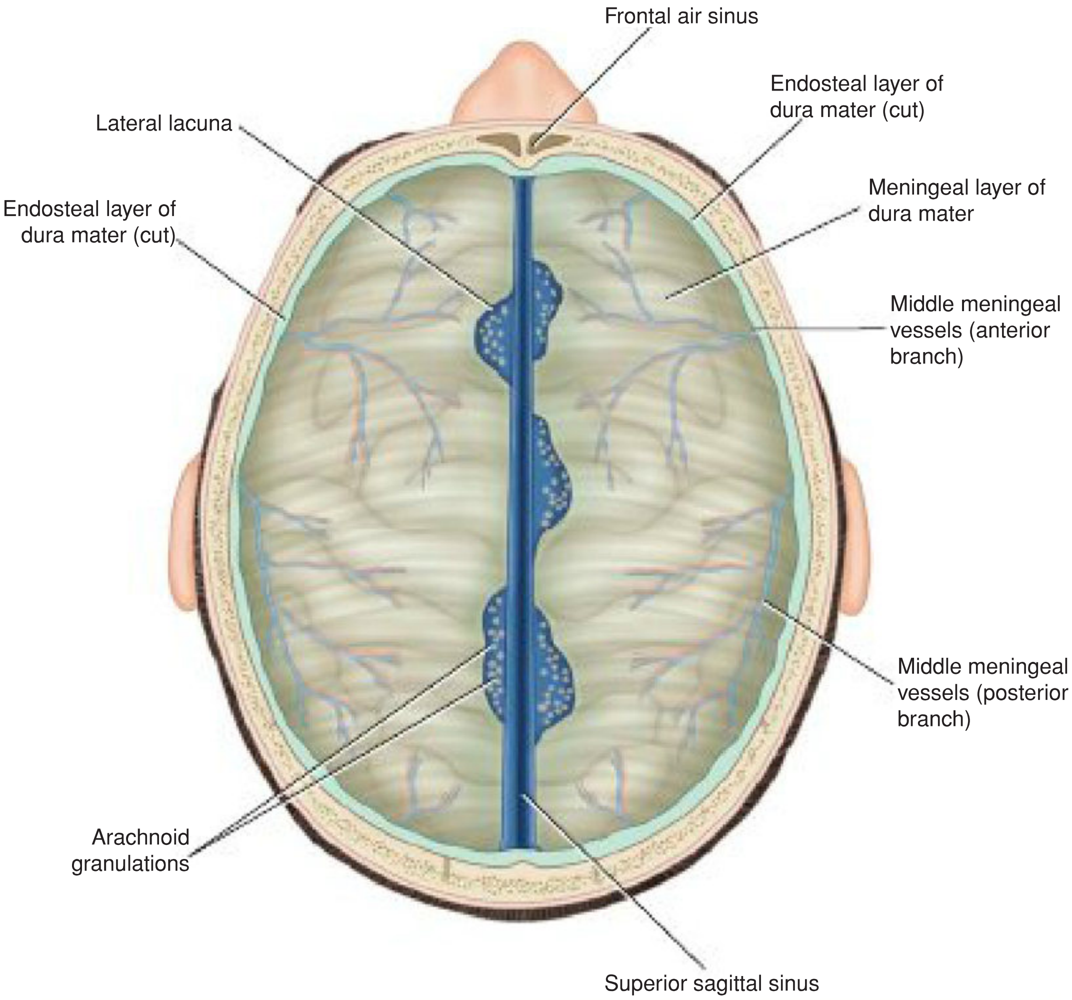


**Figure 15-7** Superior view of the head with the calvarium removed. The greater part of the endosteal layer of dura mater has been removed, exposing the underlying meningeal layer of dura and the interior of the superior sagittal venous sinus.

The **occipital sinus** is a small sinus occupying the attached margin of the falx cerebelli. It commences near the foramen magnum where it communicates with the **vertebral veins** and drains into the **confluence of sinuses**.

The **cavernous sinuses** are situated in the middle cranial fossa on each side of the body of the sphenoid bone (see Fig. 15-5). Numerous trabeculae cross their interior, giving them a spongy appearance, hence the name. Each sinus extends from the superior orbital fissure in front to the apex of the petrous part of the temporal bone behind.

The **internal carotid artery**, surrounded by its **sympathetic nerve plexus**, runs forward through the sinus. The **abducens nerve** also passes through the sinus. The internal carotid artery and the nerves are separated from the blood by an endothelial covering.

The **third** and **fourth cranial nerves** and the **ophthalmic** and **maxillary divisions of the trigeminal nerve** run forward in the lateral wall of the sinus. They lie between the endothelial lining and the dura mater. The tributaries are the **superior** and **inferior ophthalmic veins**, the **inferior cerebral veins**, the **sphenoparietal sinus**, and the **central vein of the retina**.

The sinus drains posteriorly into the **superior** and **inferior petrosal sinuses** and inferiorly into the **pterygoid venous plexus**.

The two sinuses communicate with each other by means of the **anterior** and **posterior intercavernous sinuses**, which run in the diaphragma sellae anterior and posterior to the stalk of the hypophysis cerebri (see Fig. 15-4). Each sinus has an important communication with the facial vein through the superior ophthalmic vein. (This is a route by which infection can travel from the facial skin to the cavernous sinus.)

The **superior** and **inferior petrosal sinuses** are small sinuses situated on the superior and inferior borders of the petrous part of the temporal bone on each side of the skull. Each superior sinus drains the cavernous sinus into the transverse sinus, and each inferior sinus drains the cavernous sinus into the internal jugular vein.

spider web

## Arachnoid Mater → loc circle of willis

The arachnoid mater is a delicate, impermeable membrane covering the brain and lying between the pia mater internally and the dura mater externally (see Fig. 15-1). It is separated from the dura by a potential space, the **subdural space**, filled by a film of fluid; it is separated from the pia by the **subarachnoid space**, which is filled with **CSF**. The outer and inner surfaces of the arachnoid are covered with flattened mesothelial cells.

The arachnoid bridges over the sulci on the surface of the brain, and in certain situations, the arachnoid and pia are widely separated to form the **subarachnoid cisternae**. The **cisterna cerebellomedullaris** lies between the inferior surface of the cerebellum and the roof of the fourth ventricle. The **cisterna interpeduncularis** lies between the two cerebral peduncles. All the cisternae are in free communication with one another and with the remainder of the subarachnoid space.

In certain areas, the arachnoid projects into the venous sinuses to form **arachnoid villi.** The arachnoid villi are most numerous along the superior sagittal sinus. Aggregations of arachnoid villi are referred to as **arachnoid granulations** (see Fig. 15-7). Arachnoid villi serve as sites where the CSF diffuses into the bloodstream.

The arachnoid is connected to the pia mater across the fluid-filled subarachnoid space by delicate strands of fibrous tissue.

Structures passing to and from the brain to the skull or its foramina must pass through the subarachnoid space. All the cerebral arteries and veins lie in the space, as do the cranial nerves (see Figs. 15-1 and 15-5). The arachnoid fuses with the epineurium of the nerves at their point of exit from the skull (see Fig. 15-2B). In the case of the **optic nerve**, the arachnoid forms a sheath for the nerve, which extends into the orbital cavity through the optic canal and fuses with the sclera of the eyeball (Fig. 15-8). Thus, the subarachnoid space extends around the optic nerve as far as the eyeball.

The **CSF** is produced by the **choroid plexuses** within the lateral, third, and fourth ventricles of the brain. It escapes from the ventricular system of the brain through the three foramina in the roof of the fourth ventricle and so enters the subarachnoid space. It now circulates both upward over the surfaces of the cerebral hemispheres and downward around the spinal cord. The spinal subarachnoid space extends down as far as the **second sacral vertebra** (see pp. 426-427). Eventually, the fluid enters the bloodstream by passing into the arachnoid villi and diffusing through their walls.

In addition to removing waste products associated with neuronal activity, the CSF provides a fluid medium in which the brain floats. This mechanism effectively protects the brain from trauma. In addition, the fluid is now believed to play a role in hormonal transport.

## Pia Mater

The pia mater is a vascular membrane covered by flattened mesothelial cells. It closely invests the brain, covering the gyri and descending into the deepest sulci (see Fig. 15-1). It extends out over the cranial nerves and fuses with their epineurium. The cerebral arteries entering the substance of the brain carry a sheath of pia with them.

The pia mater forms the **tela choroidea** of the roof of the third and fourth ventricles of the brain, and it fuses with the ependyma to form the choroid plexuses in the lateral, third, and fourth ventricles of the brain.

# SPINAL CORD MENINGES

Like the brain, the spinal cord in the vertebral column is also protected by three layers of meninges.

## Dura Mater

The dura mater is a dense, strong, fibrous membrane that encloses the spinal cord and the cauda equina

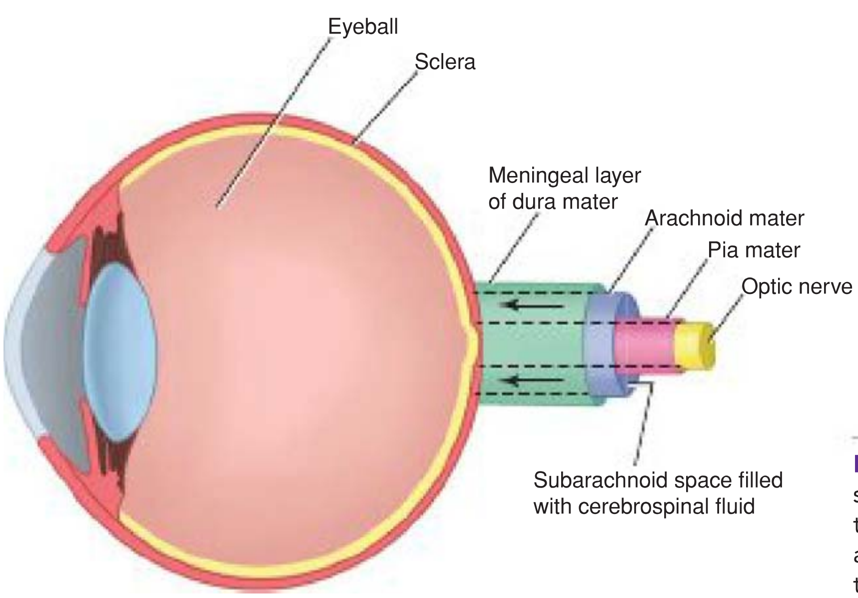


**Figure 15-8** Sagittal section of the eyeball showing the attachment of the meninges to the sclera. Note the extension of the subarachnoid space around the optic nerve to the eyeball.

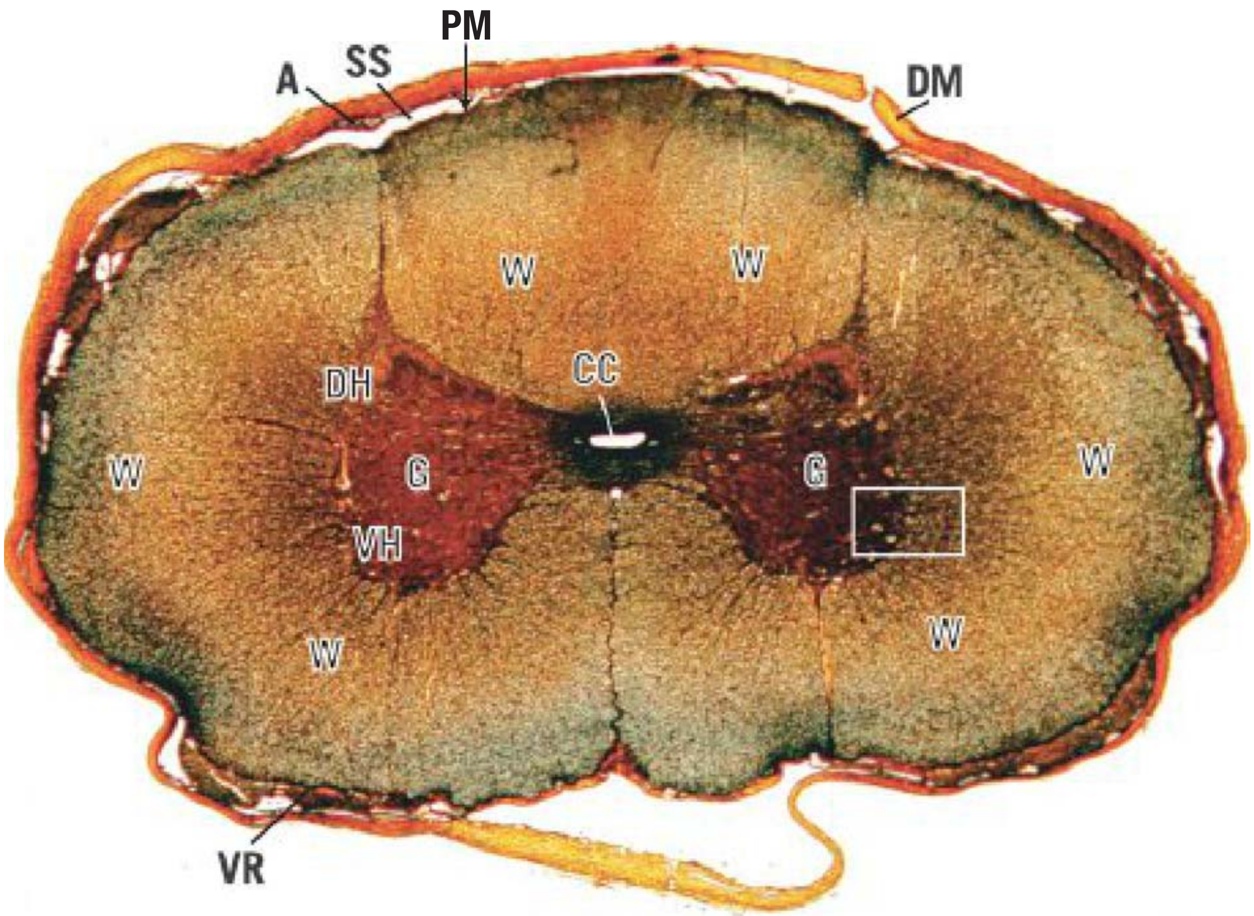


**Figure 15-9** This silver stain of a cat spinal cord shows the spinal cord and its meninges: dura mater (DM), arachnoid mater (A) with its subarachnoid space (SS), and pia mater (PM). W, white matter; G, gray matter; DH, dorsal horn; VH, ventral horn; Gc, gray commissure; CC, central canal; VR, ventral roots; DR, dorsal roots. (From Gartner, L. P. (2018). *Color atlas and text of histology* (7th ed.). Baltimore, MD: Wolters Kluwer.)

(Figs. 15-9 to 15-11). It is continuous above through the foramen magnum with the meningeal layer of dura covering the brain. Inferiorly, it ends on the filum terminale at the level of the lower border of the second sacral vertebra. The dural sheath lies loosely in the vertebral canal and is separated from the wall of the canal by the **extradural space**. This contains loose areolar tissue and the **internal vertebral venous plexus**. The dura mater extends along each nerve root and becomes continuous with the connective tissue surrounding each spinal nerve (epineurium). The inner surface of the dura mater is in contact with the arachnoid mater (see Fig. 4-5).

## Arachnoid Mater

The arachnoid mater is a delicate impermeable membrane that covers the spinal cord and lies between the pia mater internally and dura mater externally. It is separated from the pia mater by a wide space, the **subarachnoid space**, which is filled with **CSF**. The subarachnoid space is crossed by a number of fine strands of connective tissue. The arachnoid mater is continuous above through the foramen magnum with the arachnoid covering the brain. Inferiorly, it ends on the filum terminale at the level of the lower border of the second sacral vertebra (see Figs. 15-10 and 15-11). The arachnoid mater continues along the spinal nerve roots, forming small lateral extensions of the subarachnoid space.

## Pia Mater

The pia mater, a vascular membrane that closely covers the spinal cord (see Fig. 15-9B), is thickened on either side between the nerve roots to form the **ligamentum denticulatum**, which passes laterally to adhere to the arachnoid and dura. By this means, the spinal cord is suspended in the middle of the dural sheath. The pia mater extends along each nerve root and becomes continuous with the connective tissue surrounding each spinal nerve.


**Figure 15-10** Dissection of the back of the head and neck. The greater part of the occipital bone has been removed, exposing the periosteal layer of dura. On the right side, a window has been made in the dura below the transverse venous sinus to expose the cerebellum and the medulla oblongata in the posterior cranial fossa. In the neck, the dura and arachnoid have been incised in the midline to expose the spinal cord and rootlets of the cervical spinal nerves. Note the cervical spinal nerves leaving the vertebral canal enveloped in a meningeal sheath.


**Figure 15-11** Dissection of the lower part of the back, including a complete laminectomy of the lumbar and sacral regions of the vertebral column. The meningeal sheath has been incised and reflected laterally, exposing the subarachnoid space, the lower end of the spinal cord, and the cauda equina. Note the filum terminale surrounded by the anterior and posterior nerve roots of the lumbar and sacral spinal nerves forming the cauda equina.

# Clinical Notes

## Functional Significance

The meninges of the brain and spinal cord form three concentric membranous coverings. The outermost covering, the dura mater, by virtue of its toughness, serves to protect the underlying nervous tissue. The dura protects the cranial nerves by forming a sheath that covers each cranial nerve for a short distance as it passes through foramina in the skull. The dura mater also provides each spinal nerve root with a protective sheath.

In the skull, the falx cerebri, which is a vertical sheet of dura between the cerebral hemispheres, and the tentorium cerebelli, which is a horizontal sheet that projects forward between the cerebrum and cerebellum, serve to limit excessive movements of the brain within the skull.

The arachnoid mater is a much thinner impermeable membrane that loosely covers the brain. The interval between the arachnoid and pia mater, the subarachnoid space, is filled with CSF. The CSF gives buoyancy to the brain and protects the nervous tissue from mechanical forces applied to the skull.

The pia mater is a vascular membrane that closely invests and supports the brain and spinal cord.

## Excessive Brain Movement

When a moving patient's head is suddenly halted, the momentum of the brain causes it to travel onward until its movement is resisted by the skull or the strong septa of the dura mater. In lateral movements, the lateral surface of one hemisphere hits the side of the skull and the medial surface of the opposite hemisphere hits the side of the falx cerebri. In superior movements, the superior surfaces of the cerebral hemispheres hit the vault of the skull, and the superior surface of the corpus callosum hits the sharp free edge of the falx cerebri; the superior surface of the cerebellum presses against the inferior surface of the tentorium cerebelli.

Movements of the brain relative to the skull and dural septa may seriously injure the cranial nerves that are tethered as they pass through the various foramina. Furthermore, the fragile cortical veins that drain into the dural sinuses may be torn, resulting in severe **subdural** or **subarachnoid hemorrhage**. The tortuous arteries, with their strong walls, are rarely damaged.

## Intracranial Hemorrhage

Excessive brain movement or other cranial trauma can put significant traction on the cranial vessels, leading to rupture and hemorrhage. Intracranial hemorrhage is described based on its relationship to the adjacent layers of the meninges: epidural, subdural, and subarachnoid.

### Epidural Hemorrhage

Epidural hemorrhage results from injuries to the meningeal arteries or veins. The most common artery to be damaged is the **anterior division of the middle meningeal artery**. A comparatively minor blow to the side of the head, resulting in fracture of the skull in the region of the anterior-inferior portion of the parietal bone, may sever the artery. Arterial or venous injury is especially liable to occur if the vessels enter a bony canal in this region. Bleeding occurs and strips up the meningeal layer of dura from the internal surface of the skull. The intracranial pressure rises and the enlarging blood clot exerts local pressure on the underlying motor area in the precentral gyrus. Blood also passes laterally through the fracture line to form a soft swelling under the temporalis muscle.

To stop the hemorrhage, the torn artery or vein must be ligated or plugged. The burr hole through the skull wall should be placed about 1½ in (4 cm) above the midpoint of the zygomatic arch.

### Subdural Hemorrhage

Subdural hemorrhage results from tearing of the **superior cerebral veins** at their point of entrance into the superior sagittal sinus. The cause is usually a blow on the front or the back of the head, causing excessive anteroposterior displacement of the brain within the skull. Acute and chronic forms of the condition occur.

### Computed Tomography Scans

The different appearances of the blood clots in these two conditions as seen on CT scans are related to the anatomy of the area (Fig. 15-12). In an epidural hemorrhage, the blood strips up the meningeal layer of the dura from the endosteal layer of dura (periosteum of the skull), producing a **lens-shaped** hyperdense collection of blood that compresses the brain and displaces the midline structures to the opposite side. The shape of the blood clot is determined by the adherence of the meningeal layer of dura to the periosteal layer of dura.

In patients with subdural hematoma, the blood accumulates in the extensive potential space between the meningeal layer of dura and the arachnoid, producing a long **crescent-shaped,** hyperdense rim of blood that extends from anterior to posterior along the inner surface of the skull. With a large hematoma, the brain sulci are obliterated and the midline structures are displaced to the opposite side.

### Subarachnoid and Cerebral Hemorrhages

Subarachnoid and cerebral hemorrhages are described on page 474.

## Intracranial Hemorrhage in the Infant

Intracranial hemorrhage may occur during birth and may result from excessive molding of the head. Bleeding may occur from the cerebral veins or the venous sinuses. Excessive anteroposterior compression of the head often tears the anterior attachment of the falx cerebri from the tentorium cerebelli. Bleeding then takes place from the great cerebral veins, the straight sinus, or the inferior sagittal sinus.

The shaken baby syndrome is described on page 22.

## Headache

The brain itself is insensitive to pain; therefore, headaches are due to the stimulation of receptors outside the brain.

### Meningeal Headaches

The dura mater receives its sensory nerve supply from the trigeminal and the first three cervical nerves. The dura above the tentorium is innervated by the trigeminal nerve, and the headache is referred to the forehead and face. The dura below the tentorium is innervated by the cervical nerves, and the headache is referred to the back of the head and neck. **Meningitis**, or inflammation of the meninges, causes severe headache over the entire head and back of the neck.

### Headaches Caused by Cerebral Tumors

An expanding tumor with its associated raised intracranial pressure produces severe, continuous, and progressive headache caused by the irritation and stretching of the dura. A tumor above the tentorium tends to produce a headache referred to the front of the head, while a tumor below the tentorium produces a headache referred to the back of the head.

### Migraine Headache

Migraine is a common form of headache, which may be unilateral or bilateral, recurring at intervals and associated with prodromal visual disturbances. The prodromal visual disturbances are thought to be due to sympathetic vasoconstriction of the cerebral arteries supplying the visual cortex. The headache is chiefly due to the dilation and stretching of other cerebral arteries and branches of the external carotid artery. The disease therefore appears to affect arteries both inside and outside the skull, and its cause is unknown, although genetic, hormonal, and biochemical factors may initiate an attack. β-blockers bring relief to some patients due to the reduction in cerebral vasodilation.

### Alcoholic Headache

Alcoholic headache is due to the direct toxic effect of alcohol on the meninges.

### Headaches Due to Diseases of the Teeth, Paranasal Sinuses, and Eyes

Dental infection and sinusitis are common causes of headache. The pain is referred to the skin of the face and the forehead along the branches of the trigeminal nerve. Tonic spasm of the ciliary muscle of the eye, when attempting to focus on an object for prolonged periods (e.g., reading small print), may cause severe orbital headache. This commonly occurs in individuals who need lenses for the correction of presbyopia.

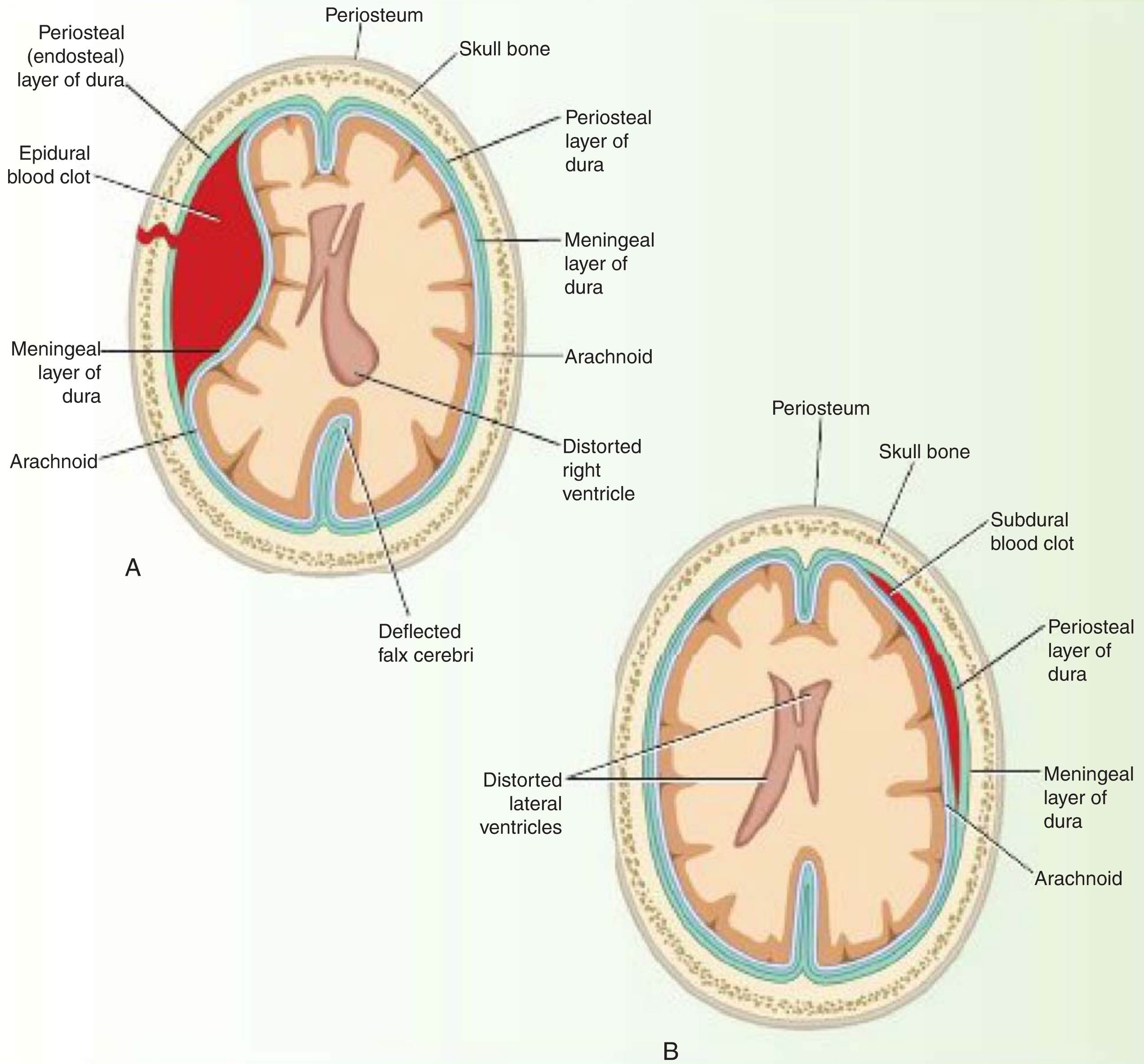


**Figure 15-12** Diagrammatic representation of an epidural hemorrhage and a subdural hemorrhage. **A:** Epidural hemorrhage from the middle meningeal artery or vein on the left side. The hematoma is lens shaped and occupies the space between the endosteal layer of dura (periosteum of the skull) and the meningeal layer of dura (true dura, hence the name *epidural*). **B:** Subdural hemorrhage from the cerebral veins at the site of entrance into the venous sinus on the right side. The hematoma is crescent shaped and occupies the space between the meningeal layer of dura and the arachnoid (i.e., beneath the dura).

# Key Concepts

## Brain Meninges

- The brain in the skull and the spinal cord in the vertebral canal are surrounded by three protective membranes or meninges: dura mater, arachnoid mater, and pia mater.

### Dura Mater

- In the skull, the dura mater has two layers, an endosteal layer and a meningeal layer. The endosteal layer is essentially the periosteum of the skull and therefore not present in the vertebral canal.
- The meningeal layer or dura mater proper is a dense, strong fibrous membrane that forms four inward septa, which divide the cranial cavity into freely communicating spaces.
- The falx cerebri is the largest dural fold and separates the two cerebral hemispheres at midline.
- The tentorium cerebelli is continuous with the falx cerebri and separates the cerebrum from the cerebellum.
- The falx cerebelli separates the two cerebellar hemispheres.
- The diaphragma sellae forms the roof over the sella turcica, which houses the pituitary gland.

#### DURAL NERVE SUPPLY

- Branches of the trigeminal, vagus, and the first three cervical spinal nerves innervate the cranial dura.

#### DURAL ARTERIAL SUPPLY

- Multiple arteries supply the dura but from the clinical standpoint, the middle meningeal artery is the most important as it is the only arterial vessel found between the meningeal and endosteal layers of dura.

#### DURAL VENOUS SINUSES

- The venous sinuses are found between the two layers of dura.
- The superior and inferior sagittal sinuses are located within the falx cerebri.
- The inferior sagittal sinus joins the straight sinus which is located at the junction of the falx cerebri and tentorium cerebelli.
- The occipital sinus is located within the falx cerebelli.
- The superior sagittal sinus, straight sinus, and occipital sinus come together at the confluence of sinuses, which then drains laterally into two transverse sinuses.
- The sigmoid sinuses are a direct continuation of the transverse sinuses and eventually exit the cranial cavity through the jugular foramen, at this point becoming the internal jugular vein.

### Arachnoid Mater

- A delicate impermeable membrane lying between the dura mater and pia mater.
- It is separated from the pia mater by the subarachnoid space, which is filled with CSF.
- In certain areas, the arachnoid protrudes into the dural venous sinuses as arachnoid villi, which serve as sites where CSF diffuses into the bloodstream.
- The vasculature for the central nervous system is located in the subarachnoid space.

### Pia Mater

- The pia mater is a vascular membrane that closely invests the brain, covering the gyri and descending into the deepest sulci.
- The cerebral arteries entering the substance carry a sheath of pia with them.

## Spinal Cord Meninges

- The dura mater of the spinal cord is continuous with the meningeal layer of the cranial dura.
- The arachnoid mater is continuous with cranial arachnoid mater and maintains the same meningeal relationships in the vertebral canal as the cranial cavity.
- The pia mater closely covers the spinal cord and has multiple thickenings on either side, called denticulate ligaments, that form a means of suspension for the spinal cord in the dural sheath.