Posterior Fossa Cisterns

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Introduction

The subarachnoid space, situated between the pia mater and the outer arachnoid membrane, expands at the base of the brain, around the brainstem, and in the tentorial incisura to form compartments filled with cerebrospinal fluid. Numerous trabeculae, septa, and membranes cross the space between the pia mater and the outer arachnoid membrane to divide the subarachnoid space into smaller compartments called cisterns. All of the cranial nerves and major intracranial arteries and veins pass through the cisterns. The cisterns provide a natural pathway through which most operations for intracranial aneurysms, extraaxial brain tumors, and disorders of the cranial nerves are directed. Some cisterns have sheet-like membranes, whereas others have indistinct porous trabeculated walls with openings of various sizes.

The arachnoid membrane that separates the posterior fossa cisterns includes Liliequist's membrane, which separates the chiasmatic and interpeduncular cisterns; the anterior pontine membrane, which separates the prepontine and cerebellopontine cisterns; the lateral pontomesencephalic membrane, which separates the ambient and cerebellopontine cisterns; the medial pontomedullary membrane, which separates the premedullary and prepontine cisterns; and the lateral pontomedullary membrane, which separates the cerebellopontine and cerebellomedullary cisterns. The three cisterns in which the arachnoid trabeculae and membranes are the most dense and present the greatest obstacle at operation are the interpeduncular and quadrigeminal cisterns and the cisterna magna. Numerous arachnoid membranes were found to intersect the oculomotor nerves.

The subarachnoid cisterns are divided into supratentorial and infratentorial groups. The cisterns located in the posterior cranial fossa or that communicate through the tentorial incisura are described here (Fig. 10.1) (15). They include paired and unpaired cisterns.

- Unpaired cisterns
  - Interpeduncular cistern
  - Prepontine cistern
  - Premedullary cistern
  - Quadrigeminal cistern
  - Cisterna magna
- Paired cisterns
  - Cerebellopontine cistern
  - Cerebellomedullary cistern

Interpeduncular Cistern and Liliequist's Membrane

The interpeduncular cistern straddles the anterior portion of the tentorial incisura (Figs. 10.1 and 10.2). It is situated between the cerebral peduncles and the leaves of Liliequist's membrane at the confluence of the supra- and infratentorial parts of the subarachnoid space. The posterior wall of the cistern is formed by the posterior perforated substance. Its upper border is situated at the posterior edge of the mamillary bodies. Its lower border is situated at the junction of midbrain and pons. It is also bordered rostrally and caudally by Liliequist's membrane.

Liliequist's membrane arises from the outer arachnoid membrane covering the posterior clinoid processes and dorsum sellae (11, 12). As this membrane spreads upward from the dorsum and across the interval between the oculomotor nerves, it gives rise to two separate arachnoidal sheets (Fig. 10.3). One sheet, the diencephalic membrane, extends upward and attaches to the diencephalon at the posterior edge of the mamillary bodies and separates the chiasmatic and interpeduncular cisterns. The other sheet, called the mesencephalic membrane, extends backward and attaches along the junction of the midbrain and pons to separate the interpeduncular and prepontine cisterns. The lateral edge of the diencephalic and mesencephalic membranes attaches to the arachnoidal sheath surrounding the oculomotor nerves. The diencephalic membrane is the thicker of the two and is more frequently without perforations so that it acts as a barrier to the passage of air or other substances through the subarachnoid space. The mesencephalic membrane is thinner, more frequently incomplete, and contains an opening through which the basilar artery ascends to reach the interpeduncular fossa. The mesencephalic membrane may form a tight cuff around the basilar artery, but it more commonly has a large opening through which the basilar artery ascends. Many arachnoid trabeculae fan out from the superior edge of the diencephalic membrane to attach to the stalk of the pituitary gland, the mamillary bodies, and the posterior cerebral and posterior communicating arteries. The interpeduncular cistern communicates with the crural and ambient cisterns, which are situated in the tentorial area between the temporal lobe and midbrain.

The oculomotor nerves course in the lateral wall of the interpeduncular cistern and form the pillars to which the leaves of Liliequist's membrane attach. In addition, the oculomotor nerves are the site of attachment of other arachnoid membranes that separate the cisterns of the junction of the supra- and infratentorial areas (Figs. 10.2 and 10.3). The membranes that converge on and form a sleeve around the nerves are the mesencephalic membrane, which separates the interpeduncular and prepontine cisterns; the diencephalic membrane, which separates the interpeduncular and chiasmatic cisterns; the anterior pontine membrane, which separates the cerebellopontine and prepontine cisterns; the lateral pontomesencephalic membrane, which separates the ambient and cerebellopontine cisterns; the medial carotid membrane, which separates the chiasmatic and carotid cisterns; and the lateral carotid membrane, which forms the lateral wall of the carotid cistern.

The interpeduncular cistern contains the posterior thalamoperforating arteries, the bifurcation of the basilar artery, the origins of the posterior cerebral artery (PCA), superior cerebellar artery (SCA), and medial posterior choroidal arteries, the peduncular, posterior communicating, and median anterior pontomesencephalic veins, and the vein of the pontomesencephalic sulcus (3–5, 16, 24).

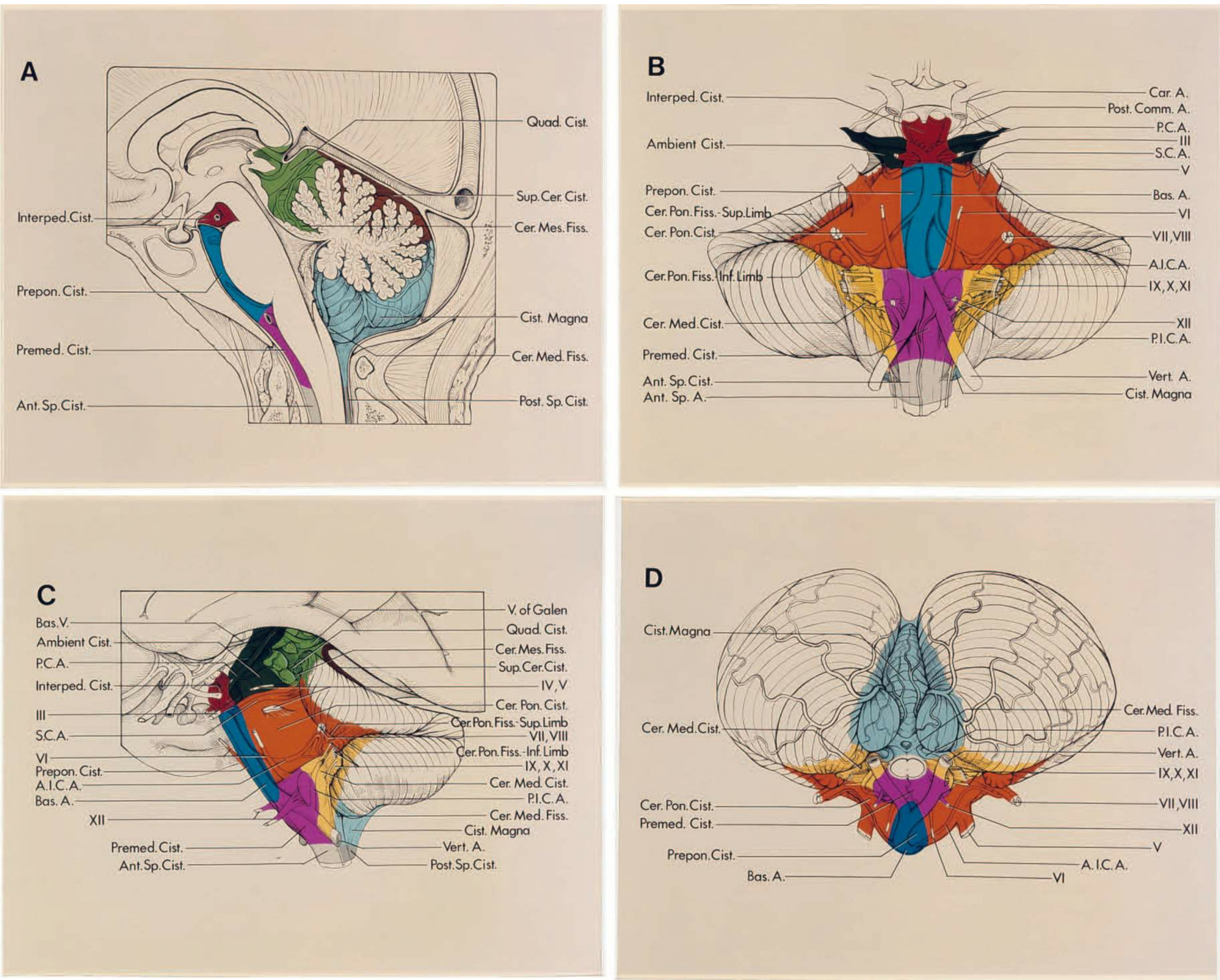
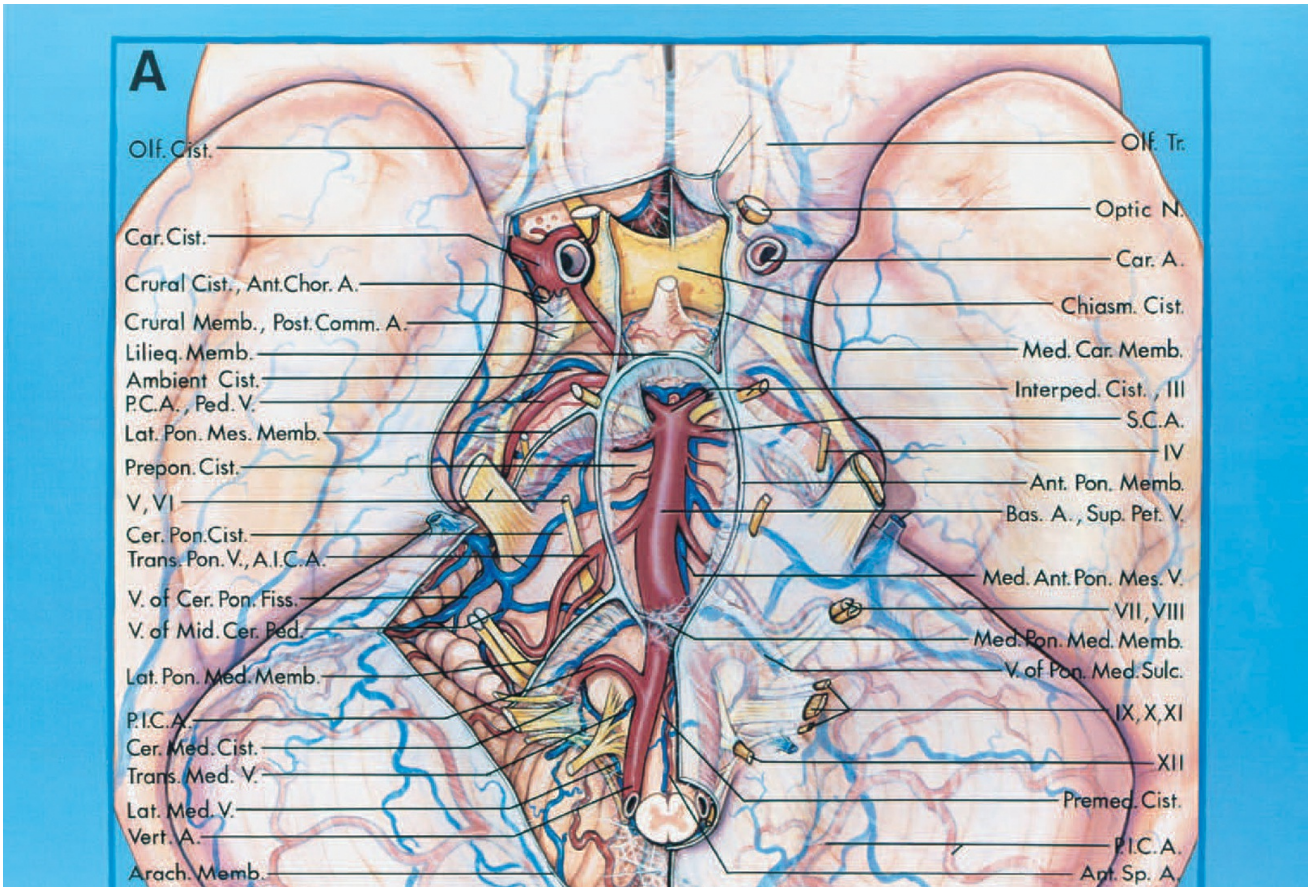
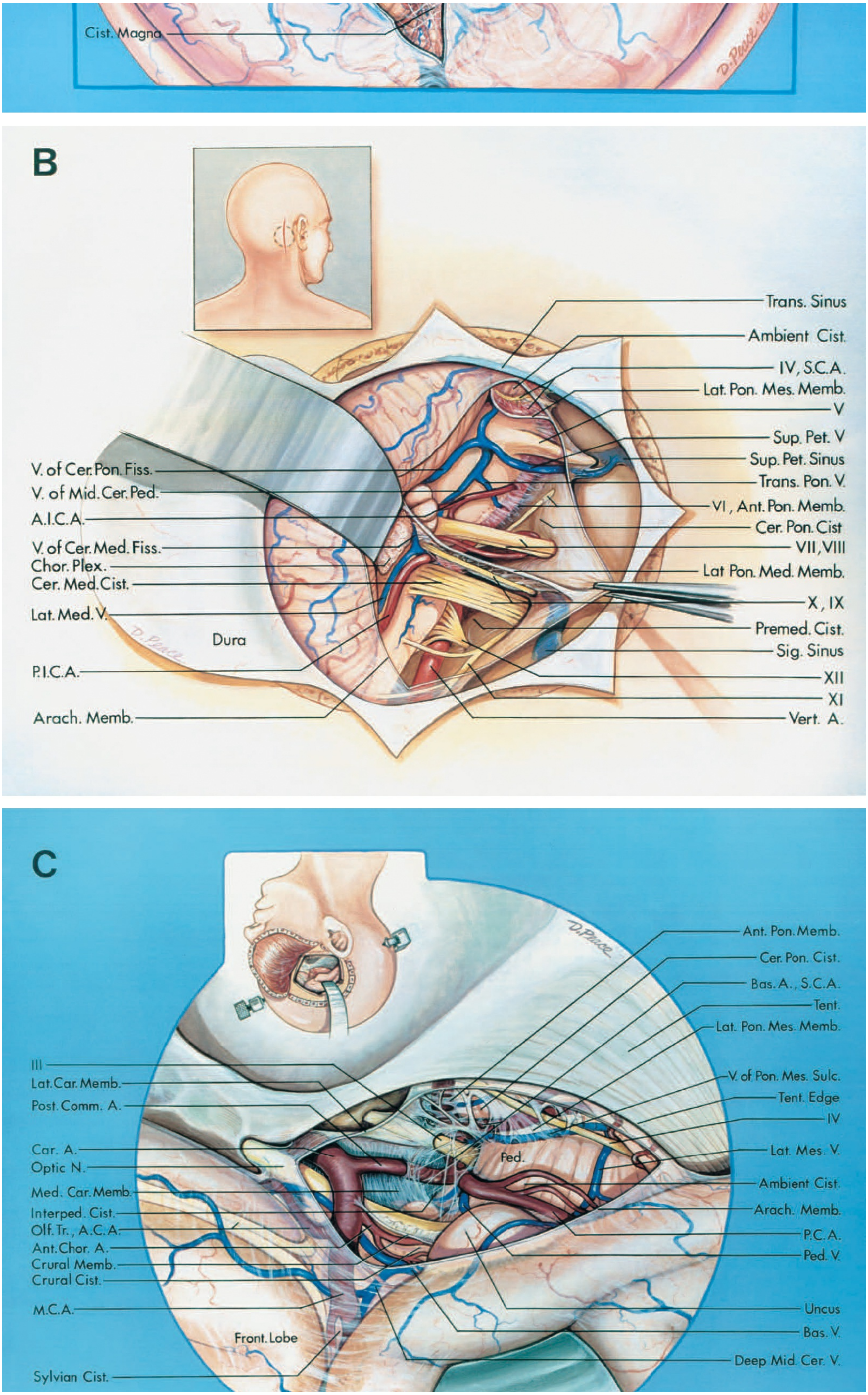


FIGURE 10.1. A–D. Posterior fossa cisterns. A, midsagittal section; B, anterior view; C, lateral view; D, inferior view. The cisterns in the posterior fossa are the interpeduncular (red), the prepontine (dark blue), the cerebellopontine (orange), the premedullary (purple), the cerebellomedullary (yellow), the quadrigeminal (light green), the superior cerebellar (brown), and the cisterna magna (light blue). The anterior spinal (light gray) and posterior spinal (dark gray) cisterns communicate through the foramen magnum with the posterior fossa cisterns. The ambient cistern (dark green) is a supratentorial cistern. The quadrigeminal cistern opens inferiorly into the cerebellomesencephalic fissure. The cerebellopontine cistern extends laterally to the cerebellopontine fissure. The latter fissure has superior and inferior limbs. The cisterna magna opens into the cerebellomedullary fissure. The apex of the basilar artery, the origin of the PCA, and the oculomotor nerves are situated in the

interpeduncular cistern. The SCAs arise at the junction of the interpeduncular and prepontine cisterns. The trigeminal, abducens, facial, and vestibulocochlear nerves arise in the cerebellopontine cisterns. The basilar artery gives off the AICAs in the prepontine cistern. The SCAs and AICAs pass through the cerebellopontine cisterns. The vertebral arteries give rise to the PICAs and anterior spinal arteries in the premedullary cistern. The hypoglossal nerves pass through the premedullary cistern. The glossopharyngeal, vagus, and spinal accessory nerves arise in the cerebellomedullary cisterns. The PICAs pass through the cerebellomedullary cisterns and the cisterna magna. The basal vein empties into the vein of Galen in the quadrigeminal cistern. The carotid and posterior communicating arteries are in the supratentorial cisterns. A., artery; A.I.C.A., anteroinferior cerebellar artery; Ant., anterior; Bas., basilar; Car., carotid; Cer., cerebellar; Cer. Med., cerebellomedullary; Cer. Mes., cerebellomesencephalic; Cer. Pon., cerebellopontine; Cist., cistern, cisterna; Comm., communicating; Fiss., fissure; Inf., inferior; Interped., interpeduncular; P.C.A., posterior cerebral artery; P.I.C.A., posteroinferior cerebellar artery; Post., posterior; Premed., premedullary; Prepon., prepontine; Quad., quadrigeminal; S.C.A., superior cerebellar artery; Sp., spinal; Sup., superior; V., vein; Vert., vertebral.





Cist. Magna
B
Trans. Sinus
Ambient Cist.
IV, S.C.A.
Lat. Pon. Mes. Memb.
V
Sup. Pet. V
Sup. Pet. Sinus
Trans. Pon. V.
VI, Ant. Pon. Memb.
Cer. Pon. Cist.
VII, VIII
Lat Pon. Med. Memb.
X, IX
Premed. Cist.
Sig. Sinus
XII
XI
Vert. A.
V. of Cer. Pon. Fiss.
V. of Mid. Cer. Ped.
A.I.C.A.
V. of Cer. Med. Fiss.
Chor. Plex.
Cer. Med. Cist.
Lat. Med. V.
Dura
P.I.C.A.
Arach. Memb.
C
Ant. Pon. Memb.
Cer. Pon. Cist.
Bas. A., S.C.A.
Tent.
Lat. Pon. Mes. Memb.
V. of Pon. Mes. Sulc.
Tent. Edge
IV
Lat. Mes. V.
Ambient Cist.
Arach. Memb.
P.C.A.
Ped. V.
Uncus
Bas. V.
Deep Mid. Cer. V.
III
Lat. Car. Memb.
Post. Comm. A.
Car. A.
Optic N.
Med. Car. Memb.
Interped. Cist.
Olf. Tr., A.C.A.
Ant. Chor. A.
Crural Memb.
Crural Cist.
M.C.A.
Front. Lobe
Sylvian Cist.
Ped.

FIGURE 10.2. A. Anterior view. The arachnoid membrane has been removed to expose the following cisterns: olfactory, carotid, chiasmatic, ambient, crural, interpeduncular, prepontine, premedullary, cerebellopontine, and cerebellomedullary and the cisterna magna. The oculomotor nerves course in an arachnoidal intersection situated in the junction of the walls of the carotid, chiasmatic, prepontine, interpeduncular, and cerebellopontine cisterns. The medial carotid membrane separates the carotid and chiasmatic cisterns. The crural membrane separates the crural and ambient cisterns. The anterior pontine membrane separates the prepontine and cerebellopontine cisterns. The lateral pontomesencephalic membrane separates the ambient and cerebellopontine cisterns. The medial pontomedullary membrane separates the prepontine and premedullary cisterns, and the lateral pontomedullary membrane separates the cerebellopontine and cerebellomedullary cisterns. The interpeduncular cistern is situated between the diencephalic and mesencephalic leaves of Liliequist's membrane. The bifurcation of the basilar artery is in the interpeduncular cistern. The carotid and posterior communicating arteries course within the carotid cisterns. The anterior choroidal artery arises in the carotid cistern and courses through the crural cistern. The optic nerves and chiasm and the stalk of the pituitary gland are situated in the chiasmatic cistern. The olfactory cisterns enclose the olfactory tracts. The SCAs arise at the junction of the interpeduncular and prepontine cisterns. The PCAs and trochlear nerves course through the ambient cisterns. The AICAs arise in the prepontine cistern. The premedullary cistern contains the hypoglossal nerves and vertebral arteries and the origin of the PICAs and anterior spinal arteries. The abducens, trigeminal, facial, and vestibulocochlear nerves and a segment of the SCA and AICA pass through the cerebellopontine cisterns. The cerebellomedullary cisterns contain the glossopharyngeal, vagus, and accessory nerves and a segment of the PICAs. The veins that course through the cisterns include the peduncular, transverse pontine, transverse medullary, lateral

medullary, and median anterior pontomesencephalic veins and the veins of the pontomedullary sulcus, cerebellopontine fissure, and middle cerebellar peduncle. The veins in the cerebellopontine or cerebellomedullary cisterns join to form the superior petrosal veins. B. Cisterns exposed through a unilateral suboccipital craniectomy. The insert (upper left) shows the site of the skin incision (solid line) and craniectomy (interrupted line). The arachnoid membrane forming the posterior wall of the cerebellopontine and cerebellomedullary cisterns has been opened. The anterior pontine membrane is medial to the abducens nerve. The lateral pontomedullary membrane separates the cerebellopontine and cerebellomedullary cisterns. The flocculus and choroid plexus protrude into the junction of the cerebellomedullary and cerebellopontine cisterns near the foramen of Luschka. C. Cisterns in the tentorial incisura. View through a right frontotemporal craniotomy. The insert shows the direction of view. The inferior surface of the temporal lobe has been elevated. The arachnoid membrane medial to the free edge of the tentorium has been opened to expose the carotid, ambient, crural, cerebellopontine, interpeduncular, and sylvian cisterns. The lateral carotid membrane is on the lateral side of the carotid artery, and the medial carotid membrane separates the carotid and chiasmatic cisterns. The crural membrane extends from the optic tract to the uncus and between the origins of the posterior communicating and anterior choroidal arteries. A., artery; A.C.A., anterior cerebral artery; Ant., anterior; Arach., arachnoid; Bas., basilar; Car., carotid; Cer., cerebellar; Cer. Med., cerebellomedullary; Cer. Pon., cerebellopontine; Chiasm., chiasmatic; Chor., choroid; Cist., cistern, cisterna; Comm., communicating; Fiss., fissure; Front., frontal; Interped., interpeduncular; Lat., lateral; Lilieq., Liliequist's; M.C.A., middle cerebral artery; Med., medial, medullary; Memb., membrane; Mid., middle; N., nerve; Olf., olfactory; P.C.A., posterior cerebral artery; Ped., peduncular; Pet., petrosal; P.I.C.A., posteroinferior cerebellar artery; Pon., pontine; Pon. Med., pontomedullary; Pon. Mes., pontomesencephalic; Premed., premedullary; Prepon., prepontine; S.C.A., superior cerebellar artery; Sig., sigmoid; Sp., spinal; Sulc., sulcus; Temp., temporal; Tent., tentorium; Tr., trunk; Trans., transverse; V., vein; Vert., vertebral.

Prepontine Cistern

The prepontine cistern lies between the arachnoid membrane resting on the clivus and the anterior surface of the pons (Figs. 10.1–10.4). The upper end of the cistern is wider than the lower. The prepontine cistern is separated from the interpeduncular cistern by the mesencephalic leaf of Liliequist's membrane. The lower boundary of the cistern is situated at the level of the pontomedullary sulcus, the site of a less well-defined membrane called the medial pontomedullary membrane. This membrane is formed by the thick trabeculae that surround the junction of the vertebral and the basilar arteries. The lateral edges of the prepontine cistern are separated from the cerebellopontine cisterns by the paired anterior pontine membranes. These membranes cross the interval between the pons and the outer arachnoid membrane that rests on the clivus. The anterior pontine membranes intersect the oculomotor nerves superiorly and extend downward along the medial side of the abducens nerves. The anterior pontine membranes become progressively thinner as they extend caudally and may disappear on the lower pons. No cranial nerves were found in the prepontine cistern. The basilar artery courses through and gives rise to the anteroinferior cerebellar artery (AICA) within this cistern (14).

Cerebellopontine Cistern

The cerebellopontine cistern lies between the anterolateral surface of the pons and cerebellum and the arachnoidal membrane that rests on the posterior surface of the petrous bone (Figs. 10.1–10.4). Superiorly, at the level of the tentorium, this cistern is separated from the ambient cistern by the lateral pontomesencephalic membrane. This membrane is attached to the brainstem at the junction of the midbrain and pons and to the outer arachnoidal membrane near the free edge of the tentorium. Anteriorly, it intersects the oculomotor nerve. This membrane spans the interval between the PCA and SCA. Inferiorly, the cerebellopontine cistern is separated from the cerebellomedullary cistern by the lateral pontomedullary membrane, which crosses the subarachnoid space between the vestibulocochlear and glossopharyngeal nerves. The latter membrane stretches from the junction of the pons and medulla to the outer arachnoidal membrane. Medially, the cerebellopontine cistern is separated from the prepontine cistern by the anterior pontine membrane. Laterally, the cerebellopontine cistern extends to the edge of the cerebellar surface that wraps around the pons to form the cerebellopontine fissure.

The trigeminal nerve arises from the midpons and courses through the superolateral portion of the cistern. The abducens nerve arises at the level of the pontomedullary sulcus and ascends just lateral to the anterior pontine membrane. The facial and vestibulocochlear nerves arise in the inferior part of the cerebellopontine cistern just above the lateral pontomedullary membrane. The outer arachnoid membrane extends into the internal auditory canal and surrounds the intracanalicular segment of the facial and vestibulocochlear nerves. The flocculus projects into the cerebellopontine cistern behind the facial and vestibulocochlear nerves.

The SCA and AICA course through the cerebellopontine cistern (5, 14). The SCA enters the cerebellopontine cistern by passing through the junction of the anterior pontine membrane and the oculomotor nerve. It courses below the trochlear nerve and the lateral pontomesencephalic membrane, and above the trigeminal nerve in its passage through this cistern. The bifurcation of the SCA into rostral and caudal trunks may be situated in either the prepontine or the cerebellopontine cisterns. The AICA enters the lower part of the cerebellopontine cisterns by passing through or below the anterior pontine membrane. It commonly bifurcates into its rostral and caudal trunks within this cistern. The veins in this cistern converge on the area around the trigeminal nerve, where they unite to form the superior petrosal veins, which empty into the superior petrosal sinus (16).

Premedullary Cistern

The premedullary cistern lies between the anterior surface of the medulla and the arachnoid membrane covering the lower part of the clivus (Figs. 10.1, 10.2, and 10.4) (2). Its upper border is located at the junction of the pons and medulla. It is separated from the prepontine cistern by the medial pontomedullary membrane. Laterally, its border with the cerebellomedullary cistern is located at the dorsal margin of the inferior olive in front of the glossopharyngeal, vagus, and accessory nerves, at the site where the density of the arachnoid trabeculae crossing the subarachnoid space increases (1). Inferiorly, the premedullary cistern is continuous (without obstruction) with the anterior spinal cistern. The rootlets forming the hypoglossal nerves arise in the posterior wall of this cistern between the medullary pyramids and the inferior olives.

The vertebral arteries enter this cistern by ascending through the foramen magnum. They ascend obliquely through this cistern and join at the junction of the premedullary and prepontine cisterns. The paired anterior spinal arteries arise from the vertebral arteries and join to form a single trunk that courses in the midline on the anterior surface of spinal cord.

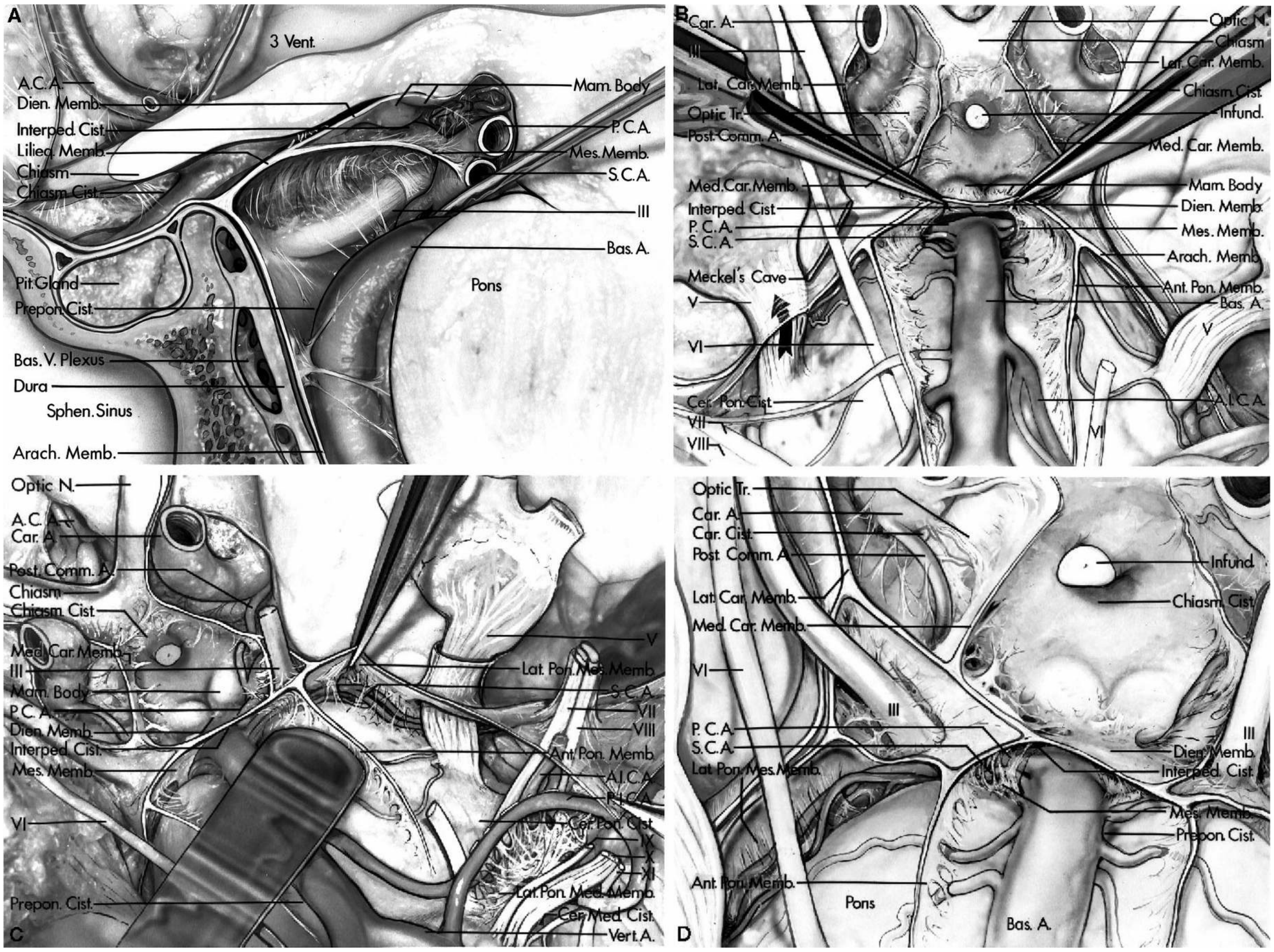


FIGURE 10.3. Liliequist's membrane and the cisterns and membranes intersecting the oculomotor nerve. A, parasagittal section to the left of the midline. Liliequist's membrane arises from the part of the outer arachnoid membrane that rests against the dorsum sellae and splits into

the diencephalic and mesencephalic membranes. The diencephalic membrane is a complete membrane that attaches to the maxillary bodies and separates the chiasmatic and interpeduncular cisterns. The mesencephalic membrane, which attaches along the junction of the midbrain and pons, forms an incomplete wall between the interpeduncular and prepontine cisterns with an opening through which the basilar artery ascends. B–D, cisterns and membranes intersecting the oculomotor nerves. B, the ventral arachnoidal wall of the chiasmatic, carotid, interpeduncular, prepontine, and cerebellopontine cisterns has been removed. The lateral carotid membrane forms the lateral wall of the carotid cistern. The medial carotid membrane separates the carotid and the chiasmatic cisterns. The interpeduncular cistern is situated behind the mamillary bodies and the diencephalic membrane. The cerebellopontine cistern opens into Meckel's cave (arrow). The anterior pontine membrane separates the prepontine and cerebellopontine cisterns. C, the arachnoid membrane covering the cerebellopontine cistern has been stretched laterally to show the lateral pontomesencephalic membrane. The lateral pontomedullary membrane separates the cerebellomedullary and cerebellopontine cisterns. D, the arachnoidal cuff around the right oculomotor nerve has been opened. The medial and lateral carotid, mesencephalic, diencephalic, lateral pontomesencephalic, and anterior pontine membranes converge on and form a cuff around the oculomotor nerve. A., artery; A.C.A., anterior cerebral artery; Ant., anterior; Arach., arachnoid; Bas., basilar; Car., carotid; Cer. Med., cerebellomedullary; Cer. Pon., cerebellopontine; Cist., cistern; Comm., communicating; Dien., diencephalic; Infund., infundibulum; Interped., interpeduncular; Lat., lateral; Mam., mamillary; Med., medial; Memb., membrane; Mes., mesencephalic; N., nerve; P.C.A., posterior cerebral artery; P.I.C.A., posteroinferior cerebellar artery; Pit., pituitary; Pon., pontine; Post., posterior; Prepon., prepontine; S.C.A., superior cerebellar artery; Sphen., sphenoid; Tr., trunk; V., vein, venous; Vent., ventricle.

Cerebellomedullary Cistern

The cerebellomedullary cistern lies caudal to the junction of the pons and medulla (Figs. 10.1, 10.2, and 10.4). It is separated from the cerebellopontine cistern by the lateral pontomedullary membrane and from the premedullary cistern by the trabeculae in front of the glossopharyngeal, vagus, and accessory nerves. Its inferior border is located at the level of the foramen magnum. The cistern extends backward from the dorsal margin of the inferior olive around the dorsolateral medulla to the biventral lobule of the cerebellum.

The glossopharyngeal and vagus nerves and the medullary portion of the accessory nerve arise within and course through this cistern to reach the jugular foramen. The spinal portion of the accessory nerve ascends from the posterior spinal cistern to reach the cerebellomedullary cistern. The lateral recess of the fourth ventricle communicates with this cistern through the foramen of Luschka. The choroid plexus that projects from the foramen of Luschka sits on the posterior surface of the glossopharyngeal and vagus nerves.

The vertebral artery enters the dura mater at the lower border of this cistern and immediately leaves it to enter the premedullary cistern. The posteroinferior cerebellar artery (PICA) enters this cistern by reaching the anterior surface of the rootlets of the glossopharyngeal, vagus, and accessory nerves (13). From here, the artery passes dorsally between the rootlets of these nerves and pursues a posterior course around the medulla to enter the cisterna magna.

Cisterna Magna

The cisterna magna lies dorsal to the medulla and cerebellar vermis (Fig. 10.1). Its posterior wall is formed by the arachnoid membrane that conforms to the inner surface of the occipital bone above the foramen magnum. A characteristic feature of the cisterna magna is the dense, mesh-like trabeculated arachnoid that extends from the cerebellar tonsils to the medulla and the margin of the foramen of Magendie.

The lower part of the cisterna magna is situated behind the medulla (17). Superiorly, the cisterna magna projects both anterior and posterior to the cerebellar vermis. Anteriorly, it opens into the cerebellomedullary fissure.

The cisterna magna also opens behind the vermis into the posterior cerebellar incisura. The arachnoid membrane covering the incisura is reflected around the falx cerebelli. The upper limit of the extension behind the vermis is the tentorium. If the falx cerebelli is absent or small, the upper part of the cistern may be quite large. A median sheet of arachnoid may extend from the dorsal surface of the medulla to the outer arachnoid membrane to divide the cistern into sagittal halves. Inferiorly, the cisterna magna communicates without obstruction with the posterior spinal cistern.

The PICAs pass posteriorly around the medulla. They enter the cisterna magna near the point where they commonly divide into a lateral trunk, which supplies the hemisphere and tonsil, and a medial trunk, which supplies the vermis (3, 13).

Quadrigeminal Cistern

The quadrigeminal cistern encloses a space that corresponds to the pineal region (Fig. 10.1) (18, 19, 22, 26). The quadrigeminal plate is located at the center of the anterior wall of the cistern. In the midline, the anterior wall rostral to the colliculi is formed by the pineal gland. The suprapineal recess of the third ventricle bulges into the cistern above the gland. Laterally, the anterior wall is formed by the part of the pulvinar that lies medial to where the crus of the fornix wraps around the pulvinar. The fornix crosses the pulvinar midway between the medial and lateral edges of the pulvinar. The medial half of the pulvinar forms the anterior wall of the cistern and the lateral half of the pulvinar forms the anterior wall of the atrium of the lateral ventricle.

Each lateral wall of the cistern has an anterior and a posterior part. The anterior part is formed by the segment of the crus of the fornix that wraps around the pulvinar. The posterior part is formed by the part of the occipital cortex located below the splenium. Below the colliculi, the cistern extends into the cerebellomesencephalic fissure.

The roof of the cistern is formed by the lower surface of the splenium and the broad membranous envelope that surrounds the great vein and its tributaries. This envelope is applied to the lower surface of the splenium and is continuous anteriorly with the tela choroidea surrounding the velum interpositum. It is within this envelope in the superomedial part of the cistern that the intracisternal venous structures are found in the greatest density (16). The superomedial location of the veins contrasts with the location of the arteries, which are found in the greatest density in the inferolateral part of the cistern.

The quadrigeminal cistern communicates with the posterior pericallosal cistern, which extends around the splenium. It opens inferolaterally below the pulvinars into the ambient cisterns, which are located between the midbrain and the temporal lobes. It may communicate with the velum interpositum. The trochlear nerves arise in the quadrigeminal cistern just below the inferior colliculi and course forward around the midbrain and below the pulvinars to enter the ambient cisterns.

The trunks and branches of the PCA and SCA enter the lower-anterior part of the cistern and course below and lateral to the arachnoidal envelope around the vein of Galen and its tributaries (5, 16, 29). The PCAs commonly bifurcate into their calcarine and parieto-occipital branches within the cistern. Some of the lateral posterior choroidal arteries arise from the PCAs within this cistern (4). The medial posterior choroidal arteries arise from the PCAs in front of the midbrain and encircle the brainstem to enter the quadrigeminal cistern, where they turn forward beside the pineal body to reach the velum interpositum. The SCAs course through the part of the cistern that extends into the cerebellomesencephalic fissure. The perforating branches of the PCAs supply the walls of the cistern situated above the shallow groove separating the superior and inferior colliculi, and the SCAs supply the walls of the cistern below this groove.

The venous relationships in the cistern are the most complex in the cranium because the cistern is the site of convergence of the internal cerebral and basal veins and multiple other tributaries of the vein of Galen (18, 19). The internal cerebral veins exit the velum interpositum and the basal veins exit the ambient cisterns to reach the quadrigeminal cistern, where they join the vein of Galen. The latter vein passes below the splenium to enter the straight sinus at the tentorial apex. The veins that converge on the cistern to empty into the great, basal, or internal cerebral veins include the posterior pericallosal veins, which course around the splenium; the atrial veins, which drain the walls of the atria; the internal occipital veins, which originate on or near the calcarine and parietooccipital sulci; and the vein of the cerebellomesencephalic fissure, which originates on the superior cerebellar peduncles and terminates with the superior vermian vein in the great vein.

FIGURE 10.4. A, prepontine, cerebellopontine, cerebellomedullary, and premedullary cisterns. The arachnoid membrane that forms the anterior wall of the cerebellopontine, cerebellomedullary, prepontine, and

premedullary cisterns has been removed. The lateral pontomedullary membrane separates the cerebellopontine and cerebellomedullary cisterns. The thick arachnoid trabeculae around the junction of the vertebral arteries form the median pontomedullary membrane that separates the premedullary and prepontine cisterns. The anterior pontine membrane separates the prepontine and cerebellopontine cisterns. The premedullary cistern extends backward to the anterior surface of the glossopharyngeal, vagus, and accessory nerves. B, the anterior pontine membrane, which separates the prepontine and cerebellopontine cisterns, passes forward from the pons to the clivus. The lateral pontomesencephalic membrane, which forms the floor of the ambient cistern and the roof of the cerebellopontine cistern, stretches across the interval between the PCA and SCA. A small flap of dura has been elevated to expose the trigeminal nerve in Meckel's cave. C, posterior view. The arachnoid membrane forming the posterior wall of the cerebellopontine and cerebellomedullary cisterns has been opened. The lateral pontomedullary membrane separates the cerebellopontine and cerebellomedullary cisterns. The PICA and hypoglossal nerves arise in the premedullary cistern. Choroid plexus protrudes into the junction of the cerebellomedullary and cerebellopontine cisterns. D, anterior view. The lateral pontomedullary membrane separates the cerebellopontine and cerebellomedullary cisterns. The anterior pontine membrane separates the prepontine and cerebellopontine cisterns. A., artery; A.I.C.A., anteroinferior cerebellar artery; Ant., anterior; Arach., arachnoid; Bas., basilar; Car., carotid; Cav., cavernous; Cer. Med., cerebellomedullary; Cer. Pon., cerebellopontine; Chor. Plex., choroid plexus; Cist., cistern; Comm., communicating; F., foramen; For., foramen; Infund., infundibulum; Jug., jugular; Lat., lateral; Med., medial, medullary; Memb., membrane; N., nerve; P.C.A., posterior cerebral artery; Pet., petrosal; P.I.C.A., posteroinferior cerebellar artery; Pon., pontine; Pon. Mes., pontomesencephalic; Post., posterior; Premed., premedullary; Prepon., prepontine; S.C.A., superior cerebellar artery; Sulc., sulcus; Temp., temporal; Trans., transverse; V., vein; Vert., vertebral.

Superior Cerebellar Cistern

This cistern is situated between the superior part of the vermis and the arachnoid membrane that rests against the lower border of the straight sinus. Anteriorly, it opens into the quadrigeminal cistern (Fig. 10.1). Posteriorly, it communicates below the torcular with the cisterna magna. Laterally, it blends into the subarachnoid space over the cerebellar hemispheres. The cistern contains the median and paramedian branches of the SCAs and the superior vermian vein.

Discussion

Key and Retzius's excellent illustrations in 1875 accurately display the anterior pontine, medial and lateral pontomedullary, and lateral pontomesencephalic membranes and the membrane now called Liliequist's membrane (9). Liliequist noted that the membrane bearing his name, in pneumograms, is often seen as a fine line with a forward convexity extending from the dorsum sellae to the mamillary bodies (11, 12). In our study, this membrane was found to have two leaves: an upper leaf, called the diencephalic membrane, which attaches to the posterior edge of the mamillary bodies, and a caudal leaf, called the mesencephalic membrane, which attaches to the junction of the pons and the midbrain. The completeness and position of the diencephalic membrane favor its definition after lumbar subarachnoid injections of air, whereas a membrane like the mesencephalic membrane would not be seen on air studies because the large perforation in it, through which the basilar artery ascends, does not block the passage of air.

The oculomotor nerve is the site of intersection of multiple arachnoidal membranes (9). Six arachnoid membranes converge on the oculomotor nerve: the diencephalic, mesencephalic, anterior pontine, lateral pontomesencephalic, and medial and lateral carotid membranes. The medial carotid membrane separates the chiasmatic and carotid cisterns. The lateral carotid membrane, which is situated lateral to the carotid artery, extends from the optic to the oculomotor nerve (10, 25).

The three sites in the posterior fossa where the normal arachnoidal trabeculae and membranes present the greatest obstacle at operation are the interpeduncular and quadrigeminal and the cisterna magna. The multiple membranes that converge on the walls of the interpeduncular cistern make the operative exposure of lesions in this cistern more difficult. The tendency for the arachnoidal membranes and the nerves and arteries to which they attach to retract away from the site of an arachnoidal incision can be utilized to aid in exposing lesions in the interpeduncular cistern and also at other sites. If the arachnoid membrane is opened below the oculomotor nerve, the intact arachnoid membrane above the nerve will draw the nerve upward. After opening the arachnoid membrane below the oculomotor nerve, elevating the temporal lobe will elevate the oculomotor nerve and aid in exposing the structures below the nerve because the arachnoid above the oculomotor nerve is tethered to the temporal lobe. Opening the arachnoid above the nerve will allow the nerve to retract inferiorly and facilitate the exposure of structures above the nerve.

The second site at which the arachnoid trabeculae are especially dense is in the superomedial part of the quadrigeminal cistern, where the dense arachnoidal envelope surrounding the vein of Galen and its tributaries blends with the tela choroidea forming the walls of the velum interpositum. The part of the cistern situated below the vein of Galen that contains the PCA and SCA is less densely trabeculated.

The third site where the arachnoidal web is especially dense is in the cisterna magna, where the trabeculae bind the medulla and cerebellar tonsils to the branches of the PICA. It is commonly necessary to divide numerous trabeculae to remove a cerebellar tonsil and to expose and mobilize the infratonsillar loop of the PICA.

Opening a cisternal wall, with the resultant escape of cerebrospinal fluid, facilitates the approach to lesions in front of the brainstem and cerebellum. Allowing cerebrospinal fluid to escape from the cisterna magna during posterior fossa operations facilitates the exposure of lesions in the cerebellopontine, cerebellomedullary, prepontine, and premedullary cisterns. In some operations in which excessive retraction would be necessary to reach a cistern, opening the arachnoid over several surface folia and applying suction through a cottonoid laid over the arachnoidal opening will remove enough cerebrospinal fluid to relax the cerebellum and allow the operation to proceed.

Pathological processes in the subarachnoid space may conform to cisternal boundaries. The arachnoid septa and trabeculae separating the cisterns may prevent the spread of blood to adjacent cisterns after aneurysm rupture. The resulting location of the blood, as seen on computed tomographic scans and magnetic resonance imaging, often provides information pinpointing the site of a ruptured aneurysm. The thickening and staining of the arachnoid membranes that follow subarachnoid hemorrhage may make the approach to an aneurysm more difficult. Yasargil notes that aneurysms may become invested with the arachnoidal walls of the cisterns and that tension on the arachnoid membranes may be transmitted to the fundus of the aneurysm, even when dissection is being carried out some distance away (27, 28). In dissecting an aneurysm, it is helpful to know which membranes may be attached to the aneurysm. Aneurysms arising at the basilar apex and at the origin of the SCA may project into the leaves of Liliequist's membrane; aneurysms arising at the origin of the AICA may have the anterior pontine membrane stretched around their surface; aneurysms arising at the origin of the PICA from the vertebral artery may project upward into the lateral pontomedullary membrane; and aneurysms arising at the junction of the vertebral with the basilar arteries may be enmeshed in the thick trabeculae that form the medial pontomedullary membrane (21).

An understanding of the arachnoidal membranes is especially important in dealing with aneurysms pointing in the direction of the oculomotor nerves. Traction on any of the membranes converging on the oculomotor nerve may rupture these aneurysms. The outer surface of the arachnoidal membranes that are adherent to an aneurysm may provide a plane of dissection that allows easier separation of the aneurysm from adjacent structures. It may be necessary to leave some of the arachnoid membrane attached to the fundus and wall of the aneurysm to prevent rupture of the aneurysm before a clip is applied.

A knowledge of the anatomy of the cistern will aid in dissecting some tumors. The arachnoidal walls of a cistern containing a tumor may protect the neural and vascular structures in adjacent cisterns from operative injury. Tumors may be classified into five categories on the basis of their relationship to the cisterns. These are: 1) growth within a single cistern; 2) growth within one cistern with compression of adjacent cisterns; 3) growth within multiple cisterns; 4) growth in adjacent structures with extension into the cisterns; and 5) growth in adjacent structures with compression of, but not extension into, the adjacent cisterns. A small pinealoma or acoustic neurinoma will be situated entirely within a single cistern. As it enlarges, it will stretch the arachnoidal walls of the cistern around its borders. Epidermoid tumors grow within multiple cisterns. These tumors, when situated in the posterior fossa, commonly involve the cerebellopontine, cerebellomedullary, and prepontine cisterns, and they may spread into the premedullary, interpeduncular, ambient, and quadrigeminal cisterns. Choroid plexus papillomas and ependymomas of the fourth ventricle may extend through the foramen of Magendie into the cisterna magna or through the foramen of Luschka into the cerebellomedullary cistern. Some gliomas of the cerebellum and brainstem may develop exophytic extensions into the cisterns. Meningiomas commonly arise external to and compress the cisterns without extending directly into them.

Acoustic neurinomas may stretch the anterior pontine, lateral pontomedullary, and lateral pontomesencephalic membranes around their borders (23). Preserving the arachnoid membrane that lies posterior to the tumor and extends into the internal acoustic meatus during removal of the posterior meatal wall with a drill will prevent bone dust from entering the subarachnoid space. A large tumor will displace the abducens nerve and anterior pontine membrane toward the midline. The lateral pontomedullary membrane crosses the interval between the tumor and the glossopharyngeal and vagus nerves and provides some protection for these nerves during tumor removal. Meningiomas may be removed without opening the outer arachnoid membrane. These tumors frequently displace the arachnoid membrane around their inner surface. The arachnoid membrane provides a barrier to injury of adjacent arteries and nerves during the removal of these tumors.

The arachnoid membranes surrounding the cerebellopontine and cerebellomedullary cisterns are best seen in decompression operations on the cranial nerves (6–8, 20). During these operations, the membranes are commonly found to be displaced by tortuous arteries. When one exposes the trigeminal nerve by the retrosigmoid route, the trochlear nerve is usually seen just above the trigeminal nerve. Placing the arachnoidal incision to expose the trigeminal nerve below the caudal edge of the trochlear nerve will allow the arachnoidal trabeculae inserting on the upper edge of the trochlear nerve to draw it upward, away from the operative site. After the outer arachnoidal membrane beside the trigeminal nerve is opened, the lateral pontomesencephalic membrane will come into view in the interval above the SCA. To complete a decompression operation on the trigeminal nerve, one rarely must expose the SCA as far medial as the point where it penetrates the anterior pontine membrane.

In completing an operation at the junction of the cerebellopontine and cerebellomedullary cisterns for hemifacial spasm, one sees the lateral pontomedullary membrane in the interval between the glossopharyngeal nerve and the nerves entering the internal acoustic meatus. One of the more common findings in hemifacial spasm is that the PICA has looped upward to compress the caudal surface of the facial nerve. This loop commonly pushes the lateral pontomedullary membrane ahead of it.

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