

Cerebellum and Fourth Ventricle

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The posterior cranial fossa, the largest and deepest of the three cranial fossae, contains the most complex intracranial anatomy. Here, in approximately one-eighth the intracranial space, are found the pathways regulating consciousness, vital autonomic functions, and motor activities and sensory reception for the head, body, and extremities, in addition to the centers for controlling balance and gait. Only 2 of the 12 pairs of cranial nerves are located entirely outside the posterior fossa; the 10 other pairs have a segment within the posterior fossa (22, 25) (*Fig. 1.1*). The posterior fossa is strategically situated at the outlet of the cerebrospinal fluid flow from the ventricular system. The arterial relationships are especially complex, with the vertebral and basilar arteries having relatively inaccessible segments deep in front of the brainstem and the major cerebellar arteries coursing in relation to multiple sets of cranial nerves before reaching the cerebellum (9, 10, 18, 19).

The posterior fossa extends from the tentorial incisura, through which it communicates with the supratentorial space, to the foramen magnum, through which it communicates with the spinal canal. It is surrounded by the occipital, temporal, parietal, and sphenoid bones (*Fig. 1.1*). It is bounded in front by the dorsum sellae, the posterior part of the sphenoid body, and the clival part of the occipital bone; behind by the lower portion of the squamosal part of the occipital bone; and on each side by the petrous and mastoid parts of the temporal bone, the lateral part of the occipital bone, and above and behind by a small part of the mastoid angle of the parietal bone. Its intracranial surface is penetrated by the jugular foramen, internal acoustic meatus, hypoglossal canal, the vestibular and cochlear aqueducts, and several venous emissary foramina, all of which will be explored in greater detail. The upper surface of the cerebellum is separated from the supratentorial space by the tentorium cerebelli. Optimizing an operative approach to the posterior fossa requires an understanding of the relationships of the cerebellum, cranial nerves, brainstem, the cerebellar arteries, veins, and peduncles, and the complex fissures between the cerebellum and brainstem. The relationships of the fourth ventricle to the cerebellar surfaces and the fissures through which the ventricle is approached surgically are among the most complex in the brain.

This section on the cerebellum and fourth ventricle will begin at the cerebellar surfaces and progress to the deeper neural structures.

CEREBELLAR SURFACES

The cortical surfaces are divided on the basis of the structures they face, or along which they may be exposed, to make this description more readily applicable to the operative setting (*Fig. 1.2*). The first surface, the tentorial surface, faces the tentorium and is retracted in a supracerebellar approach; the second surface, the suboccipital surface, is located below and between the lateral and sigmoid sinuses and is exposed in a suboccipital craniectomy; and the third surface, the petrosal surface, faces forward toward the posterior surface of the petrous bone and is retracted to expose the cerebellopontine angle. Each of the surfaces has the vermis in the midline and the hemispheres laterally and is divided by a major fissure named on the basis of the surface that it divides. The hemispheric lobules forming each of the three surfaces commonly overlap onto and form a part of the adjacent surfaces (22). The fissures dividing the three cortical surfaces are to be distinguished from the fissures between the cerebellum and the brainstem.

Tentorial surface

The tentorial surface faces and conforms to the lower surface of the tentorium (*Figs. 1.2–1.4*). The anteromedial part of this surface, the apex, formed by the anterior vermis, is the highest point on the cerebellum. This surface slopes downward from its anteromedial to its posterolateral edge. On the tentorial surface, the transition from the vermis to the hemispheres is smooth and not marked by the deep fissures on the suboccipital surface between the vermis and hemispheres. Deep notches, the anterior and posterior cerebellar incisurae, groove the anterior and posterior edges of the tentorial surface in the midline. The brainstem fits into the anterior cerebellar incisura and the falx cerebelli fits into the posterior incisura (*Fig. 1.2*).

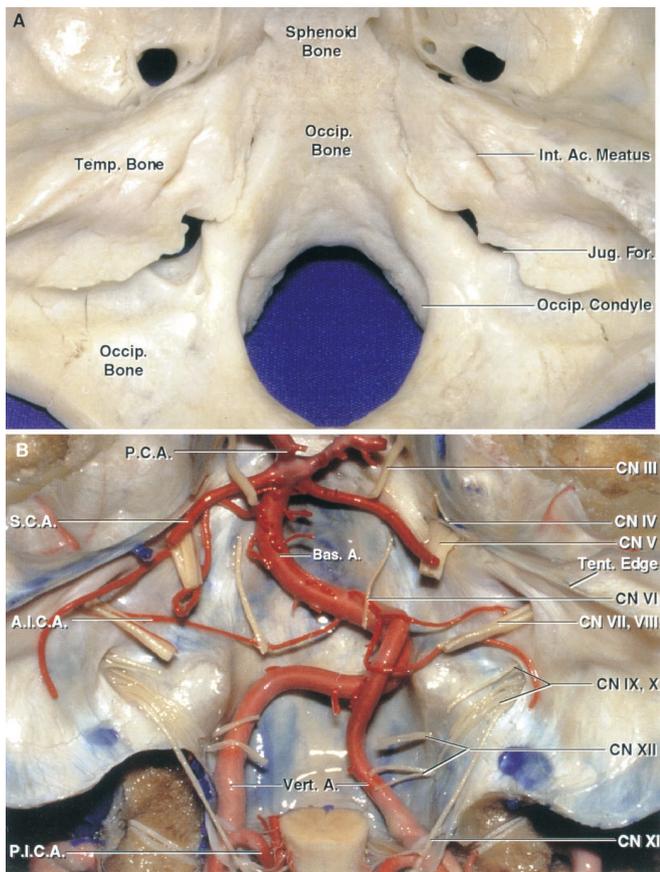


FIGURE 1.1. *A*, superior view of the posterior cranial fossa. The osseous walls of the posterior fossa are formed by the occipital, temporal, and sphenoid bones. The fossa is bounded in front by the dorsum sellae and posterior part of the sphenoid bone and the clival part of the occipital bone; behind by the lower portion of the squamosal part of the occipital bone; and on each side by the petrous and mastoid parts of the temporal bone, and the lateral part of the occipital bone. One small part above the temporal bone is formed by the inferior angle of the parietal bone. *B*, nerves and arteries of the posterior fossa. Only 2 of the 12 pairs of cranial nerves course entirely outside the posterior fossa. The tentorium, which is attached along the petrous ridges, roofs the posterior fossa. *A.*, artery; *Ac.*, acoustic; *A.I.C.A.*, antero-inferior cerebellar artery; *Bas.*, basilar; *CN*, cranial nerve; *For.*, foramen; *Int.*, internal; *Jug.*, jugular; *Occip.*, occipital; *P.C.A.*, posterior cerebral artery; *P.I.C.A.*, posteroinferior cerebellar artery; *S.C.A.*, superior cerebellar artery; *Temp.*, temporal; *Tent.*, tentorial; *Vert.*, vertebral.

The anterior border, separating the tentorial and petrosal surfaces, has a lateral part (the anterolateral margin) that is parallel to the superior petrosal sinus and separates the hemispheric part of the tentorial and petrosal surfaces, and a medial part (the anteromedial margin) that faces the midbrain and forms the posterior border of the fissure between the midbrain and cerebellum. The anterior angle formed by the junction of the anterolateral and anteromedial margins is

directed anteriorly above the origin of the posterior root of the trigeminal nerve. The posterior border between the tentorial and the suboccipital surfaces also has a lateral and a medial part. The lateral part (the posterolateral margin) is parallel and adjacent to the lateral sinus and separates the hemispheric part of the suboccipital and tentorial surfaces, and the short medial part (the posteromedial margin) faces the posterior cerebellar incisura and separates the vermian part of the two surfaces. The lateral angle, formed by the junction of the anterolateral and posterolateral margins, is located at the junction of sigmoid, lateral, and superior petrosal sinuses. Veins often converge on the anterior and lateral angles.

The hemispheric part of the tentorial surface includes the quadrangular, simple, and superior semilunar lobules, and the vermian part includes the culmen, declive, and folium. The vermian and the related hemispheric parts from above to below in sequence are the culmen and the quadrangular lobule, the declive and the simple lobule, and the folium and the superior semilunar lobule. The tentorial surface is divided at the site of its major fissure, the tentorial fissure, into anterior and posterior parts. This fissure, located between the quadrangular and the simple lobules on the hemisphere and the culmen and the declive on the vermis, has also been called the primary fissure. The postclival fissure separates the simple and the superior semilunar lobules. The interfolial fissures on this surface pass anterolaterally from the midline and are continuous with the fissures on the superior half of the petrosal surface.

Suboccipital surface

The suboccipital surface, located below and between the lateral and sigmoid sinuses, is the most complex of the three surfaces (*Figs. 1.2 and 1.5*). Operative approaches to the fourth ventricle and most cerebellar tumors are commonly directed around or through this surface. It has a deep vertical depression, the posterior cerebellar incisura, which contains a fold of dura, the falx cerebelli. The vermis is folded into and forms the cortical surface within this incisura. The lateral walls of the incisura are formed by the medial aspects of the cerebellar hemispheres. Deep clefts, the vermohemispheric fissures, separate the vermis from the hemispheres. The vermian surface within the incisura has a diamond shape. The upper half of the diamond-shaped formation has a pyramidal shape and is called the pyramid. The folium and the tuber, superior to the pyramid, form the apex of the suboccipital part of the vermis. The lower half of the diamond-shaped formation, the uvula, projects downward between the tonsils, thus mimicking the situation in the oropharynx. The rostromedial margin of the tonsils borders the tapering edges of the uvula. The nodule, the lowermost subdivision of the vermis, is hidden deep to the uvula. The strip of vermis within the incisura is broadest at the junction of the pyramid and uvula. Inferiorly, the posterior cerebellar incisura is continuous with the vallecula cerebelli, a cleft between the tonsils that leads through the foramen of Magendie into the fourth ventricle.

The hemispheric portion of the suboccipital surface is formed by the superior and inferior semilunar and biventral

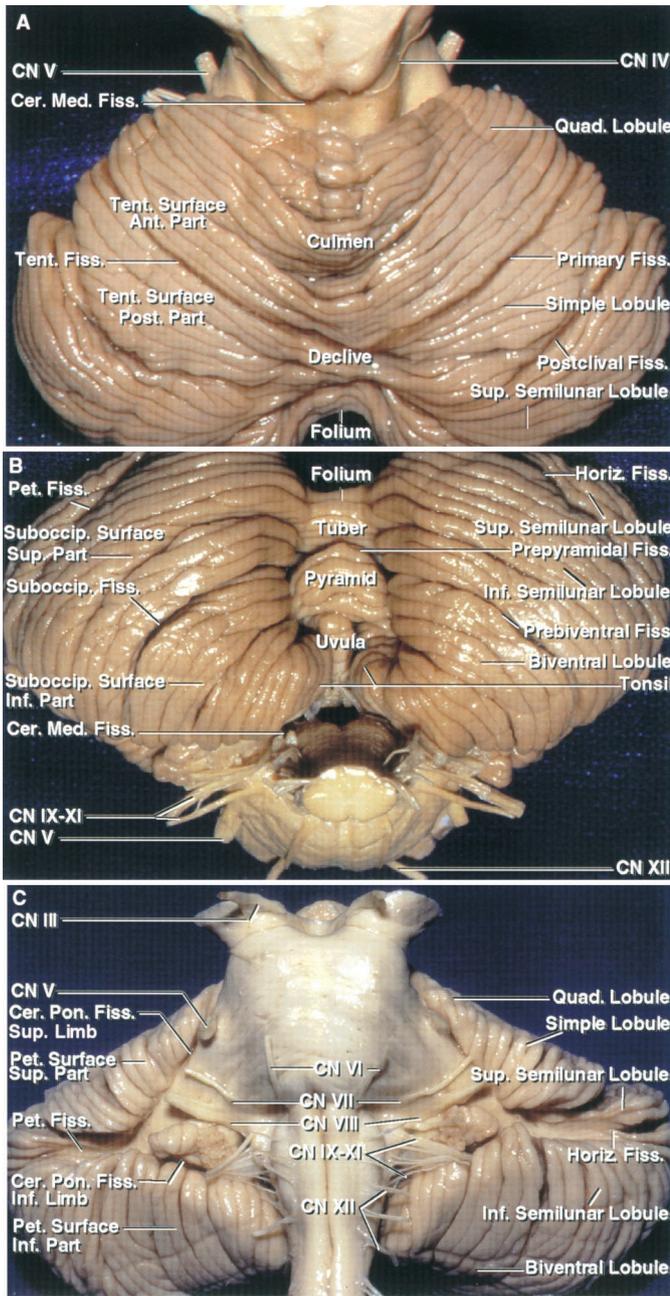


FIGURE 1.2. Tentorial, suboccipital, and petrosal cerebellar surfaces. *A*, the tentorial surface faces the lower surface of the tentorium. The anterior vermis is the most superior part of the tentorial surface. This surface slopes downward to its posterior and lateral margins. The vermian subdivisions of this surface are superior to their corresponding hemispheric parts. The classical nomenclature applied to the vermian and hemispheric subdivisions of the tentorial surface is listed on the *right*, and our simplified nomenclature is listed on the *left*. The culmen and quadrangular lobules correspond to the anterior part of the tentorial surface, and the declive, simple lobules, and part of the superior semilunar lobules correspond to the posterior part of the tentorial surface. The fissure separating the tentorial surface into anterior and posterior parts is referred to as the tentorial fissure in our nomenclature, but is the primary fissure in older nomenclature. This fissure separates the hemispheric surface between the quadrangular and simple lobules and the vermis between the declive and culmen. The anterior part of the superior surface of the cerebellum surrounds the posterior half of the midbrain to form the cerebellomesencephalic fissure. *B*, suboccipital surface. The suboccipital surface is located below and between the sigmoid and lateral sinuses and is the surface that is exposed in a wide bilateral suboccipital craniectomy. The classical nomenclature applied to this surface is shown on the *right*, and our simplified nomenclature is on the *left*. The vermis sits in a large median depression, the posterior cerebellar incisura, between the cerebellar hemispheres. According to classical nomenclature, the portions of the vermis within the incisura from above to below are the folium, tuber, pyramid, and uvula. The parts of the hemispheric surface from above to below are the superior and inferior semilunar and biventral lobules and the tonsils. These lobules extend beyond the suboccipital surface to the other surfaces of the cerebellum. The prebiventral fissures between the inferior semilunar and the biventral lobules separate the hemispheres into superior and inferior parts, and the prepyramidal fissure between the pyramid and tuber separates the vermis into superior and inferior parts. We refer to the union of the prebiventral and the prepyramidal fissures that divide the suboccipital surface into superior and inferior parts as the suboccipital fissure. From below to above the corresponding vermian and hemispheric parts are the uvula and the tonsils, the pyramid and the biventral lobules, the tuber and inferior semilunar lobules, and the folium and the superior semilunar lobules. The petrosal (horizontal) fissure, the most prominent fissure on the petrosal surface, extends onto the suboccipital surface and divides the superior half of the suboccipital surface between the superior and inferior semilunar lobules. The cerebellomedullary fissure extends superiorly between the cerebellum and medulla. *C*, petrosal surface. The petrosal surface faces forward toward the petrous temporal bone and is the surface that is retracted to surgically expose the cerebellopontine angle. The classical nomenclature applied to this surface is shown on the *right*, and our simplified nomenclature is on the *left*. The petrosal fissure divides the petrosal surface into superior and inferior parts. The superior part is formed by the quadrangular, simple, and a small part of the superior semilunar lobules. The inferior part is formed by the inferior semilunar and biventral lobules and the tonsil. The cerebellopontine fissures are V-shaped fissures formed where the cerebellum wraps around the pons and the middle cerebellar peduncles. These fissures have a superior and an inferior limb, which meet at a lateral apex. The petrosal fissure extends laterally from the apex of the cerebellopontine fissures. *Ant.*, anterior; *Cer.Med.*, cerebellomedullary; *Cer.Pon.*, cerebellopontine; *CN*, cranial nerve; *Fiss.*, fissure; *Horiz.*, horizontal; *Inf.*, inferior; *Pet.*, petrosal; *Post.*, posterior; *Quad.*, quadrangular; *Suboccip.*, suboccipital; *Sup.*, superior; *Tent.*, tentorial.

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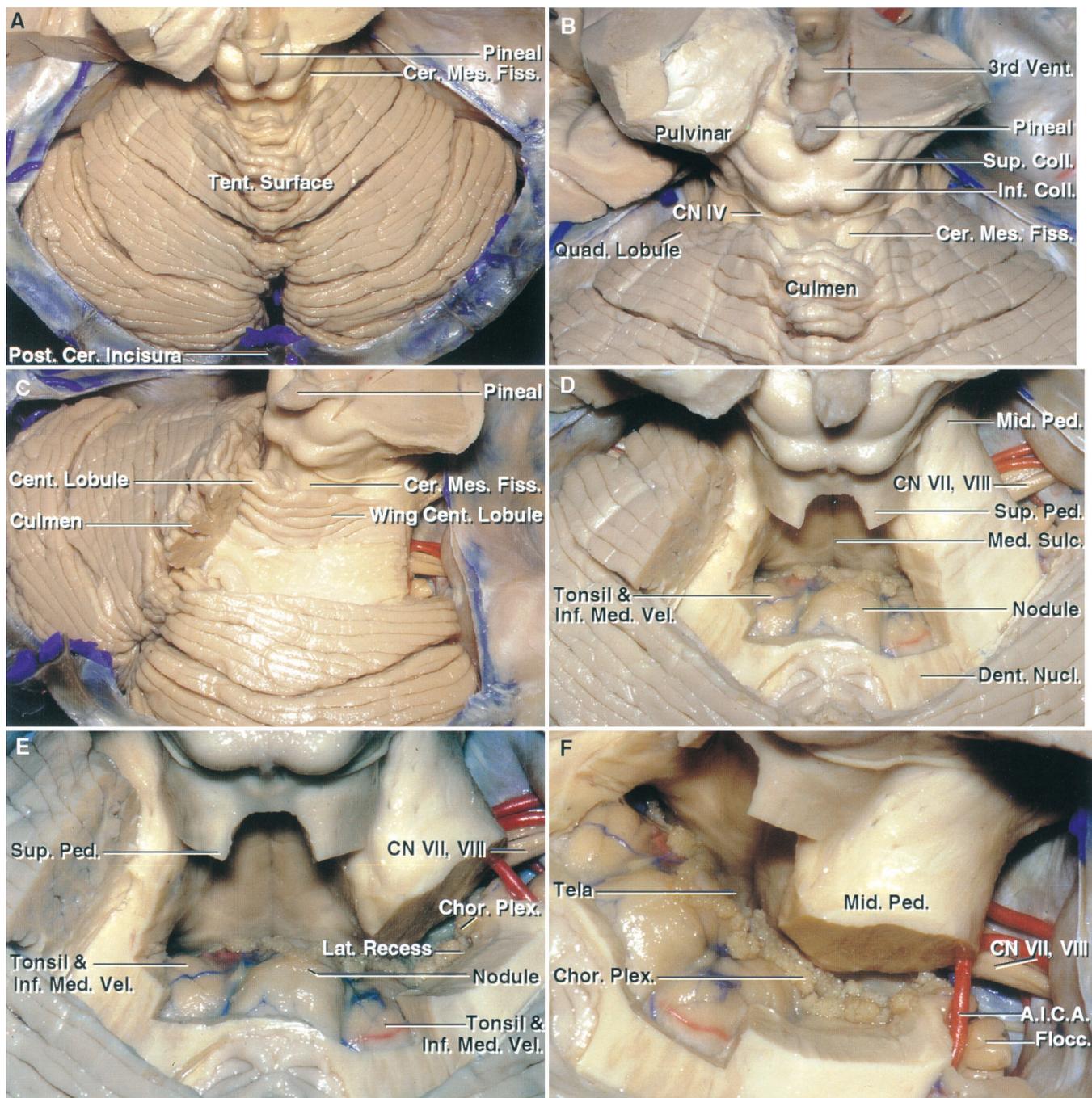


FIGURE 1.3. Tentorial surface and cerebellomesencephalic fissure. *A*, the tentorial surface faces the tentorium, which has been removed. The surface slopes downward from the apex to the posterior and lateral margins. The upper part of the tentorial surface surrounds the posterior half of the midbrain and forms the posterior lip of the cerebellomesencephalic fissure. The anterior cerebellar incisura, the notch where the brainstem fits into the anterior part of the tentorial surface, is located anteriorly and the posterior cerebellar incisura, the notch where the falx cerebelli fits into the cerebellum, is located posteriorly. *B*, enlarged view of the cerebellomesencephalic fissure, which extends downward between the midbrain and the cerebellum. The superficial part of the posterior lip is formed by the culmen in the midline and the quadrangular lobule laterally. The quadrigeminal cistern extends caudally from the pineal into the cerebellomesencephalic fissure. *C*, the culmen has been removed to expose the central lobule and its wings, which form part of the posterior lip of the cerebellomesencephalic fissure. *D*, the central lobule and its wings, the lingula, the superior medullary velum, and medial part of the superior cerebellar peduncles have been removed to expose the fourth ventricle. The lower half of the roof is formed in the midline by the

lobules and the tonsils, and the vermic portion is formed by the folium, tuber, pyramid, and uvula. The vermian and the related hemispheric parts from above to below are the folium and the superior semilunar lobules, the tuber and the inferior semilunar lobules, the pyramid and the biventral lobules, and the uvula and the tonsils.

The suboccipital surface is divided at its major fissure, the suboccipital fissure, into superior and inferior parts. The suboccipital fissure has a vermian and a hemispheric part. The vermian part of this fissure, the prepyramidal fissure, separates the tuber and the pyramid, and the hemispheric part, the prebiventral fissure, separates the biventral and the inferior semilunar lobules. The prebiventral and prepyramidal fissures are continuous at the vermohemispheric junction, and together they form the suboccipital fissure. The petrosal fissure, the major fissure on the petrosal surface, extends from the petrosal surface onto the suboccipital surface, and separates the superior and inferior semilunar lobules laterally and the folium and the tuber medially. The tonsillobiventral fissure separates the tonsil and the biventral lobule.

The tonsils, the most prominent structure blocking access to the caudal part of the fourth ventricle, are a hemispheric component (Figs. 1.5 and 1.6). Each tonsil is an ovoid structure in the inferomedial part of the suboccipital surface that is attached to the remainder of the cerebellum along its superolateral border by a white matter bundle called the tonsillar peduncle. The remaining tonsillar surfaces are free surfaces. The inferior pole and posterior surface face the cisterna magna and are visible inferomedial to the remainder of the suboccipital surface. The lateral surface of each tonsil is covered by, but is separated from, the biventral lobule by a narrow cleft, except superiorly at the level of the tonsillar peduncle. The medial, anterior, and superior surfaces all face other neural structures, but are separated from them by narrow fissures. The anterior surface of each tonsil faces and is separated from the posterior surface of the medulla by the cerebellomedullary fissure. The medial surfaces of the tonsils face each other across a narrow cleft, the vallecula, which leads into the fourth ventricle. The ventral aspect of the superior pole of each tonsil faces the three structures (tela choroidea, inferior medullary velum, and nodule) forming the lower half of the roof of the fourth ventricle. The superior pole is separated from the surrounding structures by a posterior extension of the cerebellomedullary fissure, called either the telovelotonsillar or supratonsillar cleft. The posterior aspect of

the superior pole faces the uvula medially and the biventral lobule laterally.

Petrosal surface

The petrosal or anterior surface faces the posterior surface of the petrous bones, the brainstem, and the fourth ventricle (Figs. 1.2 and 1.7). The lateral or hemispheric part of the petrosal surface rests against the petrous bone and is retracted to expose the cerebellopontine angle. The median or vermian part of the petrosal surface has a deep longitudinal furrow, the anterior cerebellar incisura, that wraps around the posterior surface of the brainstem and fourth ventricle. The right and left halves of the petrosal surfaces are not connected from side to side by a continuous strip of vermis, as are the suboccipital and tentorial surfaces, because of the interposition of the fourth ventricle between the superior and inferior part of the vermis. The vermal components rostral to the fourth ventricle are the lingula, the central lobule, and the culmen, and those caudal to the fourth ventricle are the nodule and the uvula. The hemispheric surfaces are formed by the wings of the central lobule and the anterior surfaces of the quadrangular, simple, biventral, and superior and inferior semilunar lobules, the tonsils, and the flocculi. The vermian and related hemispheric parts are the central lobule and the wings of the central lobule, the culmen and the quadrangular lobules, the nodule and the flocculi, and the uvula and the tonsils. The major fissure on this surface, the petrosal fissure, also called the horizontal fissure, splits the petrosal surface into superior and inferior parts and extends onto the suboccipital surface between the superior and inferior semilunar lobules.

THE FOURTH VENTRICLE AND THE CEREBELLAR-BRAINSTEM FISSURES

Fourth ventricle

The fourth ventricle is a broad, tent-shaped midline cavity located between the cerebellum and the brainstem. It is connected rostrally through the aqueduct with the third ventricle, caudally through the foramen of Magendie with the cisterna magna, and laterally through the foramina of Luschka with the cerebellopontine angles. Most of the cranial nerves arise near its floor. It has a roof, a floor, and two lateral recesses. It is ventral to the cerebellum, dorsal to the pons and medulla, and medial to the cerebellar peduncles.

← nodule and laterally by the inferior medullary velum, which passes laterally above, but is separated from the rostral pole of the tonsils by the cerebellomedullary fissure. *E*, some of the middle peduncle has been removed to expose the choroid plexus extending through the lateral recess into the cerebellopontine angle below the facial and vestibulocochlear nerves. *F*, oblique view of the lower half of the roof formed by the inferior medullary velum and the tela choroidea in which the choroid plexus arises. The inferior medullary velum arises on the surface of the nodule and extends laterally to blend into the flocculus and, with the flocculus and nodule, forms the flocculonodular lobe of the cerebellum. *A.I.C.A.*, anteroinferior cerebellar artery; *Cent.*, central; *Cer.*, cerebellar; *Cer.Mes.*, cerebellomesencephalic; *Chor.*, choroid; *CN*, cranial nerve; *Coll.*, colliculus; *Dent.*, dentate; *Fiss.*, fissure; *Flocc.*, flocculus; *Inf.*, inferior; *Lat.*, lateral; *Mid.*, middle; *Med.*, median, medullary; *Nucl.*, nucleus; *Ped.*, peduncle; *Plex.*, plexus; *Post.*, posterior; *Quad.*, quadrangular; *Sulc.*, sulcus; *Sup.*, superior; *Tent.*, tentorial; *Vel.*, velum; *Vent.*, ventricle.

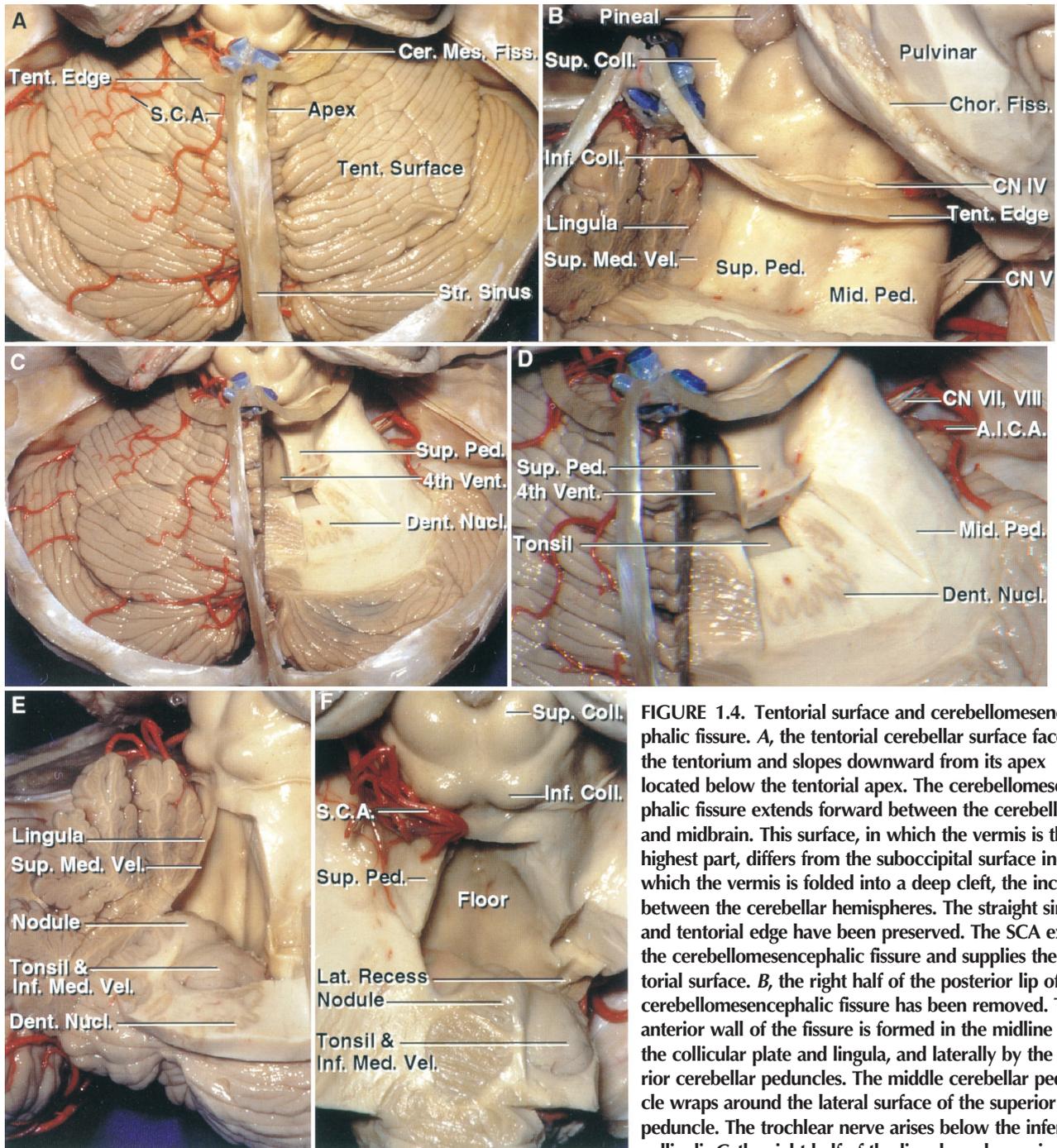


FIGURE 1.4. Tentorial surface and cerebellomesencephalic fissure. *A*, the tentorial cerebellar surface faces the tentorium and slopes downward from its apex located below the tentorial apex. The cerebellomesencephalic fissure extends forward between the cerebellum and midbrain. This surface, in which the vermis is the highest part, differs from the suboccipital surface in which the vermis is folded into a deep cleft, the incisura, between the cerebellar hemispheres. The straight sinus and tentorial edge have been preserved. The SCA exits the cerebellomesencephalic fissure and supplies the tentorial surface. *B*, the right half of the posterior lip of the cerebellomesencephalic fissure has been removed. The anterior wall of the fissure is formed in the midline by the collicular plate and lingula, and laterally by the superior cerebellar peduncles. The middle cerebellar peduncle wraps around the lateral surface of the superior peduncle. The trochlear nerve arises below the inferior colliculi. *C*, the right half of the lingula and superior peduncle have been removed to expose the fourth ventricle. Additional white matter has been removed below the right superior peduncle to expose the dentate nucleus in which the superior peduncular fibers arise. *D*, enlarged view. The dentate nucleus appears to wrap around the rostral pole of the tonsil. *E*, oblique view into the fourth ventricle. Additional cerebellum has been removed to expose the nodule and rostral pole of the tonsil. The dentate nucleus wraps around the rostral pole of the tonsil. The upper half of the roof is formed by the superior medullary velum, which has the lingula layered on its outer surface. The upper part of the lower half of the roof is formed by the nodule in the midline and by the inferior medullary velum laterally. The inferior medullary velum, an almost transparent membrane, stretches laterally across the upper pole of the tonsil. *F*, the left half of the upper part of the roof has been removed. The velum arises on the nodule and sweeps laterally above both tonsils. The SCA courses within the cerebellomesencephalic fissure. *A.I.C.A.*, anteroinferior cerebellar artery; *Cer.Mes.*, cerebellomesencephalic; *Chor.*, choroidal; *CN*, cranial nerve; *Coll.*, colliculus; *Dent.*, dentate; *Fiss.*, fissure; *Inf.*, inferior; *Lat.*, lateral; *Med.*, medullary; *Mid.*, middle; *Nucl.*, nucleus; *Ped.*, peduncle; *S.C.A.*, superior cerebellar artery; *Str.*, straight; *Sup.*, superior; *Tent.*, tentorial; *Vel.*, velum; *Vent.*, ventricle.

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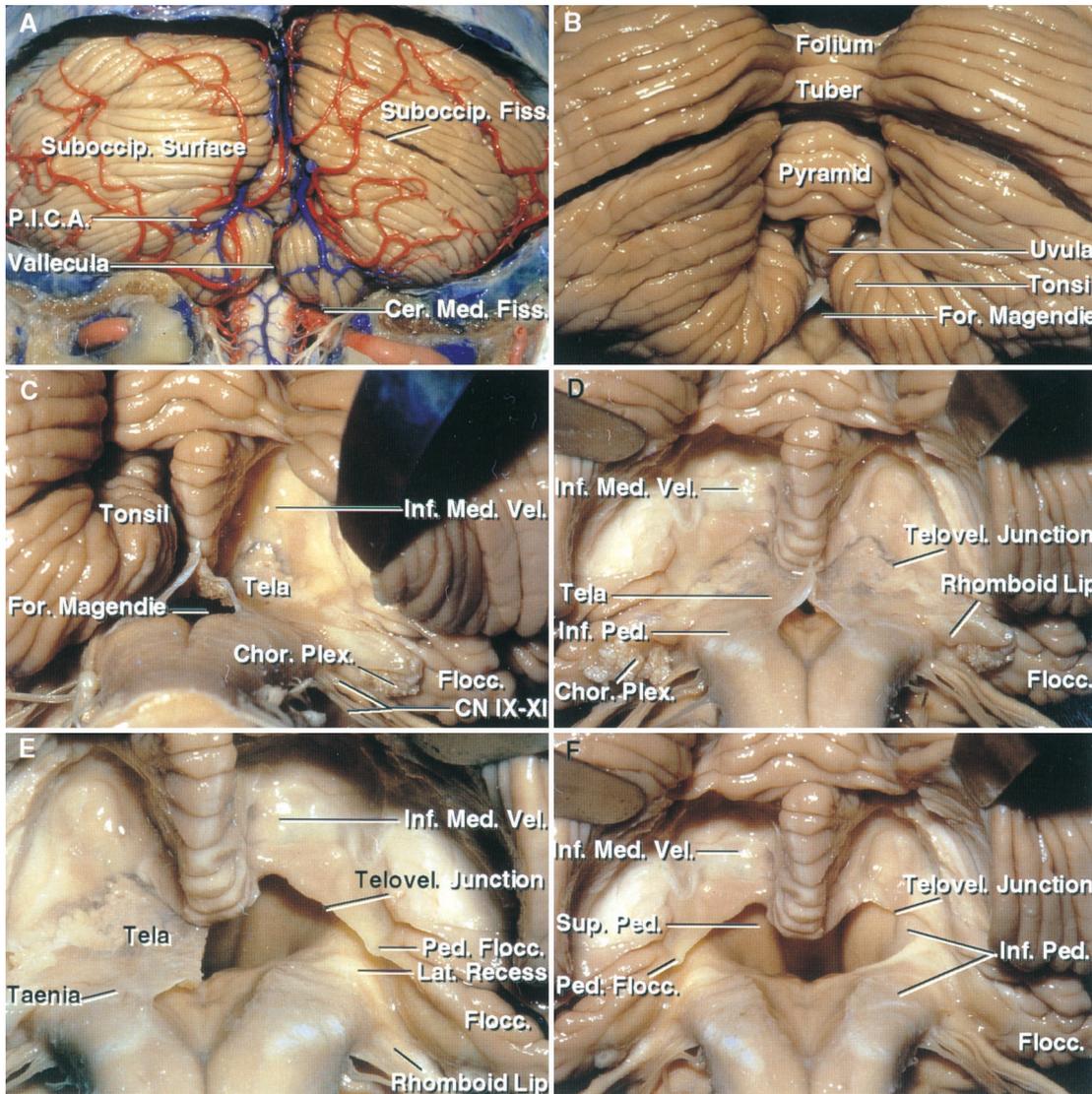


FIGURE 1.5. Suboccipital surface of the cerebellum and the cerebellomedullary fissure. *A*, the suboccipital surface is located below and between the sigmoid and lateral sinuses and is the surface that is exposed in a wide suboccipital craniectomy. The vermis sits in a depression, the posterior cerebellar incisura, between the hemispheres. The cerebellomedullary fissure extends superiorly between the cerebellum and medulla along the inferior half of the ventricular roof. The valleculla extends upward between the tonsils and communicates through the foramen of Magendie with the fourth ventricle. The PICA supplies the suboccipital surface. *B*,

enlarged view. The lower parts of the vermis behind the ventricle are the pyramid and uvula. *C*, the right tonsil has been removed to expose the lower part of the roof formed by the inferior medullary velum and tela choroidea. The nodule on which the velum arises is hidden in front of the uvula. The uvula hangs downward between the tonsils, thus mimicking the situation in the oropharynx. The choroid plexus arises on the inner surface of the tela and extends through the foramen of Luschka behind the glossopharyngeal and vagus nerve. The inferior medullary velum arises on the surface of the nodule, drapes across the superior pole of the tonsil, and blends into the flocculus laterally. *D*, both tonsils have been removed to expose the inferior medullary velum and tela choroidea bilaterally. The telovelar junction is the junction between the velum and tela. The cerebellomedullary fissure extends upward between the rostral pole of the tonsil on one side and the tela choroidea and inferior medullary velum on the opposite side. The segment of the PICA passing through this cleft is called the telovelotonsillar segment. The rhomboid lip is a sheet-like layer of neural tissue attached to the lateral margin of the ventricular floor, which extends posterior to the glossopharyngeal and vagus nerves and joins the tela choroidea to form a pouch at the outer extremity of the lateral recess. *E*, the right half of the tela has been removed to expose the ventricle and the lateral recess. The inferior medullary velum extends laterally to form a peduncle, the peduncle of the flocculus, which blends into the flocculus at the outer margin of the lateral recess. *F*, the tela has been removed on both sides. The lateral wall of the upper half of the ventricle is formed by the superior cerebellar peduncles. The inferior cerebellar peduncles ascend along the dorsolateral medulla and form the anterior and rostral margins of the lateral recess. *Cer.Med.*, cerebellomedullary; *Chor.*, choroid; *CN*, cranial nerve; *Fiss.*, fissure; *Floc.*, flocculus; *For.*, foramen; *Inf.*, inferior; *Lat.*, lateral; *Med.*, medullary; *Ped.*, peduncle; *P.I.C.A.*, posteroinferior cerebellar artery; *Plex.*, plexus; *Suboccip.*, suboccipital; *Sup.*, superior; *Telovel.*, telovelar; *Vel.*, velum.

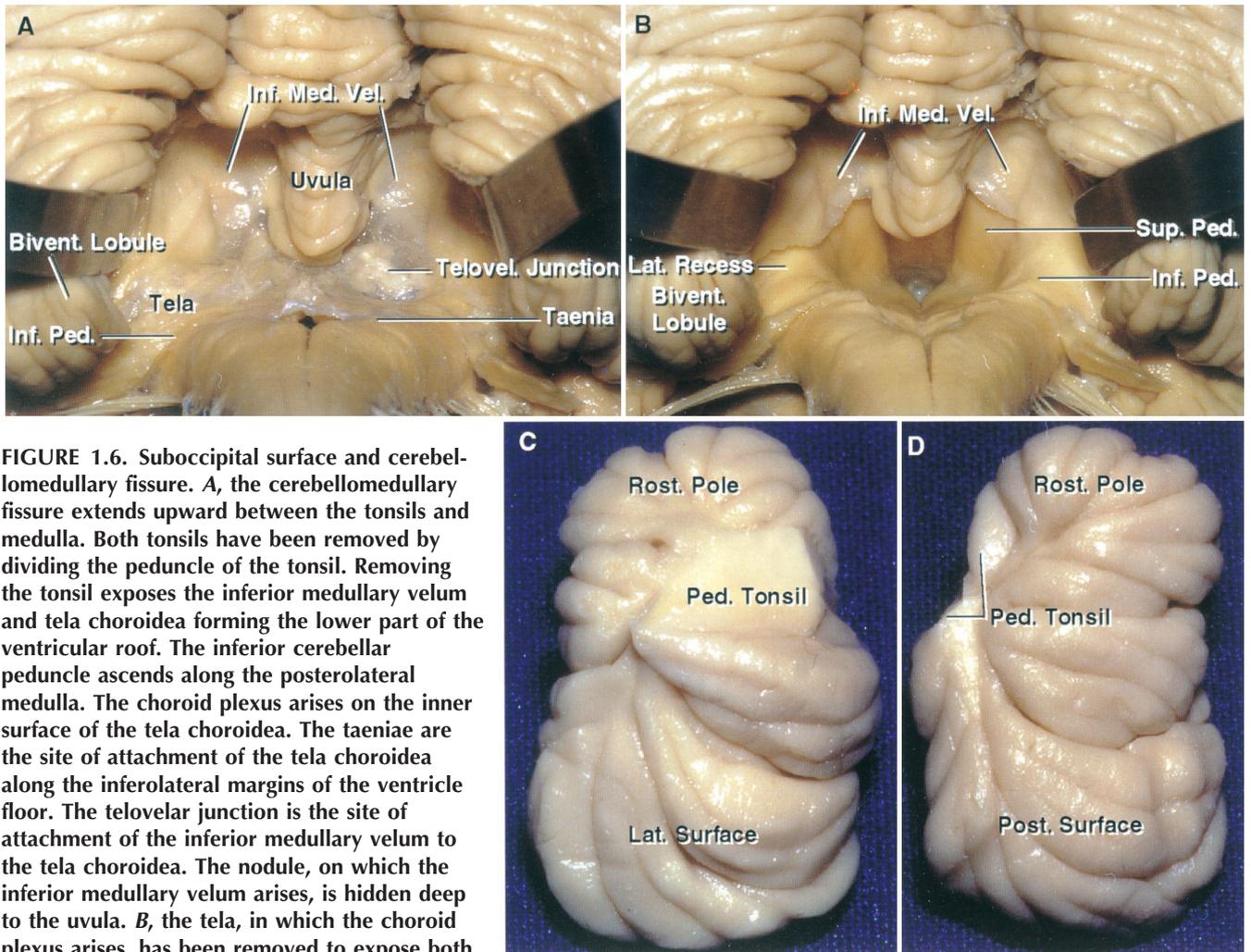


FIGURE 1.6. Suboccipital surface and cerebellomedullary fissure. *A*, the cerebellomedullary fissure extends upward between the tonsils and medulla. Both tonsils have been removed by dividing the peduncle of the tonsil. Removing the tonsil exposes the inferior medullary velum and tela choroidea forming the lower part of the ventricular roof. The inferior cerebellar peduncle ascends along the posterolateral medulla. The choroid plexus arises on the inner surface of the tela choroidea. The taeniae are the site of attachment of the tela choroidea along the inferolateral margins of the ventricle floor. The telovelar junction is the site of attachment of the inferior medullary velum to the tela choroidea. The nodule, on which the inferior medullary velum arises, is hidden deep to the uvula. *B*, the tela, in which the choroid plexus arises, has been removed to expose both lateral recesses. The superior cerebellar peduncle forms the lateral wall of the upper half of the ventricle. The inferior cerebellar peduncle forms the anterior and upper margin of the lateral recess. The middle cerebellar peduncle, which forms a large prominence on the lateral surface of the pons, is separated from the ventricular surface by the superior and inferior cerebellar peduncles. *C*, lateral surface of the left tonsil. All of the tonsillar surfaces, except at the superolateral margin, are free surfaces. The peduncle of the tonsil, located along the superolateral margin of the tonsil, attaches the tonsil to the remainder of the cerebellum. The posterior surface of the tonsil faces the cisterna magna. The medial surface faces the other tonsil. The anterior surface faces the posterior medulla. The rostral pole faces the inferior medullary velum and tela choroidea. The lateral surface below the peduncle of the tonsil faces the biventral lobule. *D*, posterior view of the left tonsil. The peduncle of the tonsil is located along the superolateral margin. Dividing the narrow peduncle allows the tonsil to be separated from the remaining cerebellum. *Bivent.*, biventral; *Inf.*, inferior; *Lat.*, lateral; *Med.*, medullary; *Ped.*, peduncle; *Post.*, posterior; *Rost.*, rostral; *Sup.*, superior; *Telovel.*, telovelar; *Vel.*, velum.

The ventricular roof is tent-shaped (Figs. 1.8 and 1.9). The roof expands laterally and posteriorly from its narrow rostral end just below the aqueduct to the level of the fastigium and lateral recess, the site of its greatest height and width, and from there it tapers to a narrow caudal apex at the level of the foramen of Magendie. The apex of the roof, the fastigium, divides it into superior and inferior parts. The superior part is distinctly different from the inferior part, in that the inferior

part is formed largely by thin membranous layers and the superior part is formed by thicker neural structures.

The external or cisternal surfaces of the structures forming the roof are intimately related to the fissures between the cerebellum and brainstem. The three fissures formed by the embryological folding of the cerebellum around the brainstem are the cerebellomesencephalic fissure, which extends inferiorly between the cerebellum and mesencephalon and is inti-

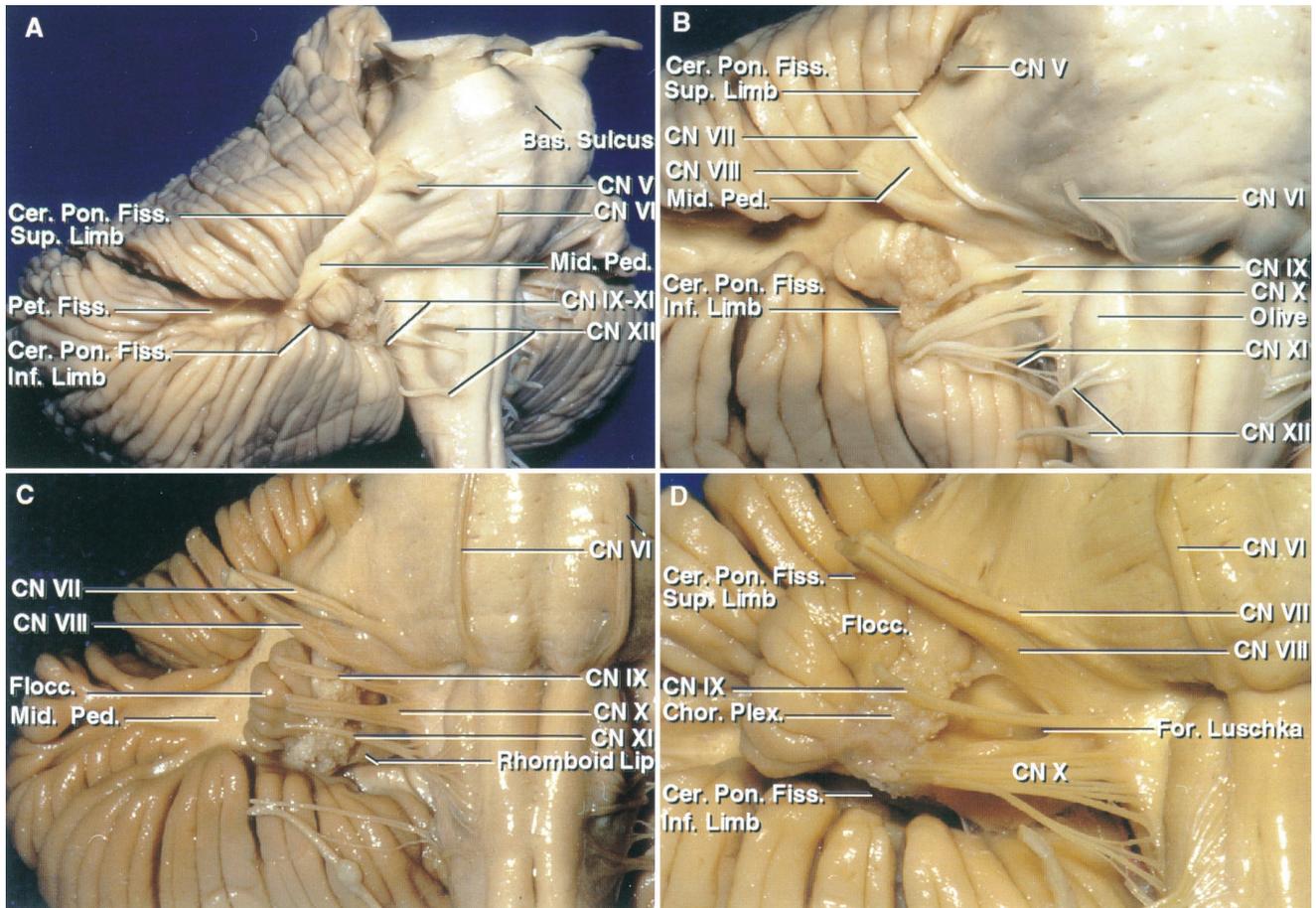


FIGURE 1.7. Brainstem, petrosal surface, and cerebellopontine fissure. *A*, oblique view. The petrosal surfaces of the cerebellum face forward toward the petrous bone and is the surface that is retracted to expose the cerebellopontine angle. The cerebellopontine fissure, which might also be referred to as the cerebellopontine angle, is a V-shaped fissure formed where the cerebellum wraps around the pons and middle cerebellar peduncle. The superior and inferior limbs meet laterally at the apex located at the anterior end of the petrosal fissure that divides the petrosal surface into superior and inferior parts. Cranial nerves V through XI arise within the margins of the cerebellopontine fissure. The flocculus and choroid plexus extend laterally from the foramen of Magendie above the lower limb of the fissure. The basilar sulcus is a shallow longitudinal groove on the anterior surface of the pons, which accommodates the basilar artery. *B*, enlarged view. The petrosal fissure extends laterally from the apex of the cerebellopontine fissure. The abducens nerve arises in the medial part of the pontomedullary sulcus rostral to the medullary pyramids. The facial and vestibulocochlear nerves arise just rostral to the foramen of Luschka near the flocculus at the lateral end of the pontomedullary sulcus. The hypoglossal nerves arise anterior to and the glossopharyngeal, vagus, and accessory nerves arise posterior to the olives. Choroid plexus protrudes from the foramen of Luschka behind the glossopharyngeal and vagus nerves. *C*, enlarged view of another brainstem. The facial and vestibulocochlear nerves join the brainstem 2 or 3 mm rostral to the glossopharyngeal nerve on a line drawn dorsal to the olive along the origin of the rootlets of the glossopharyngeal, vagus, and accessory rootlets. The rhomboid lip, a thin neural membrane in the ventral margin of the lateral recess, extends laterally behind the glossopharyngeal, vagus, and accessory nerves with the choroid plexus. *D*, enlarged view of another cerebellopontine fissure. The cerebellopontine angle is the area situated between the superior and inferior limbs of the cerebellopontine fissure. The glossopharyngeal, vagus, and accessory nerves arise near the inferior limb, dorsal to the olive, and anterior to the choroid plexus protruding from the foramen of Luschka. The facial and vestibulocochlear nerves arise in the midportion of the fissure and the trigeminal nerve near the superior limb of the fissure. The hypoglossal rootlets arise in front of the olive and the cranial rootlets of the accessory nerve. *Bas.*, basilar; *Cer.Pon.*, cerebellopontine; *Chor.*, choroid; *CN*, cranial nerve; *Fiss.*, fissure; *Flocc.*, flocculus; *For.*, foramen; *Inf.*, inferior; *Mid.*, middle; *Ped.*, peduncle; *Pet.*, petrosal; *Plex.*, plexus; *Sup.*, superior.

mately related to the superior half of the roof (Figs. 1.3 and 1.4); the cerebellopontine fissures, which are formed by the folding of the cerebellum around the lateral sides of the pons and are intimately related to the lateral recesses (Figs.

1.7 and 1.8); and the cerebellomedullary fissure, which extends superiorly between the cerebellum and the medulla and is intimately related to the inferior half of the roof (Figs. 1.5 and 1.6).

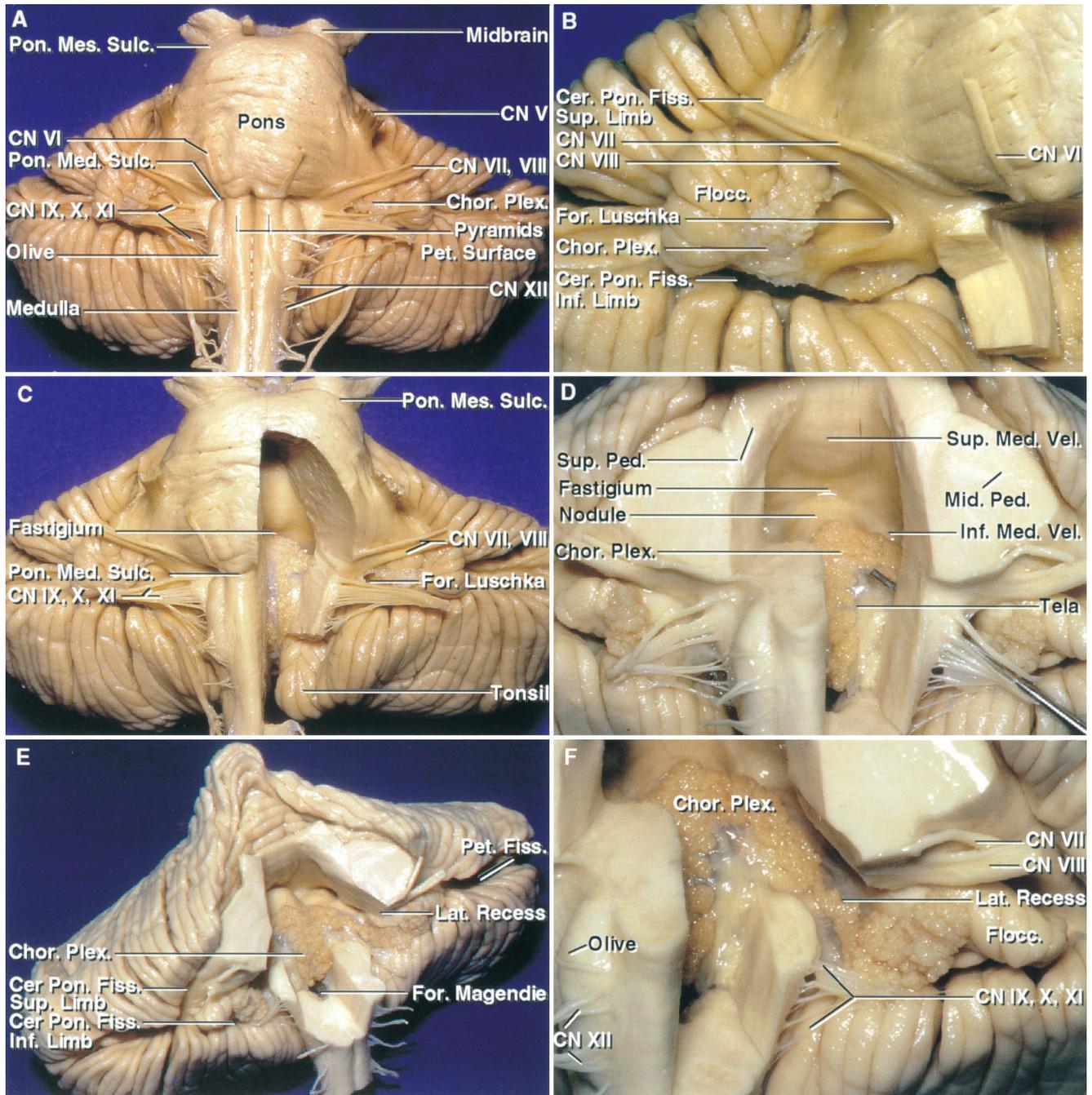


FIGURE 1.8. A–F. Brainstem, fourth ventricle, and petrosal cerebellar surface. Stepwise anterior exposure. *A*, the petrosal surface faces forward toward the posterior surface of the temporal bone. The fourth ventricle is located behind the pons and medulla. The midbrain and pons are separated by the pontomesencephalic sulcus and the pons and medulla by the pontomedullary sulcus. The trigeminal nerves arise from the midpons. The abducens nerve arises in the medial part of the pontomedullary sulcus, rostral to the medullary pyramids. The facial and vestibulocochlear nerves arise at the lateral end of the pontomedullary sulcus immediately rostral to the foramen of Luschka. The hypoglossal nerves arise anterior to the olives and the glossopharyngeal, vagus, and accessory nerves arise posterior to the olives. Choroid plexus protrudes from the foramen of Luschka behind to the glossopharyngeal and vagus nerves. *B*, right cerebellopontine angle following removal of some of the medulla. The foramen of Luschka opens into the cerebellopontine angle below the junction of the facial and vestibulocochlear nerves with the lateral end of the pontomedullary sulcus. Choroid plexus protrudes from the lateral recess and foramen of Luschka behind the glossopharyngeal, vagus, and accessory nerves. The cerebellopontine fissure, a V-shaped fissure formed by the cerebellum wrapping around the pons and middle cerebellar peduncle, has a superior and inferior limb that

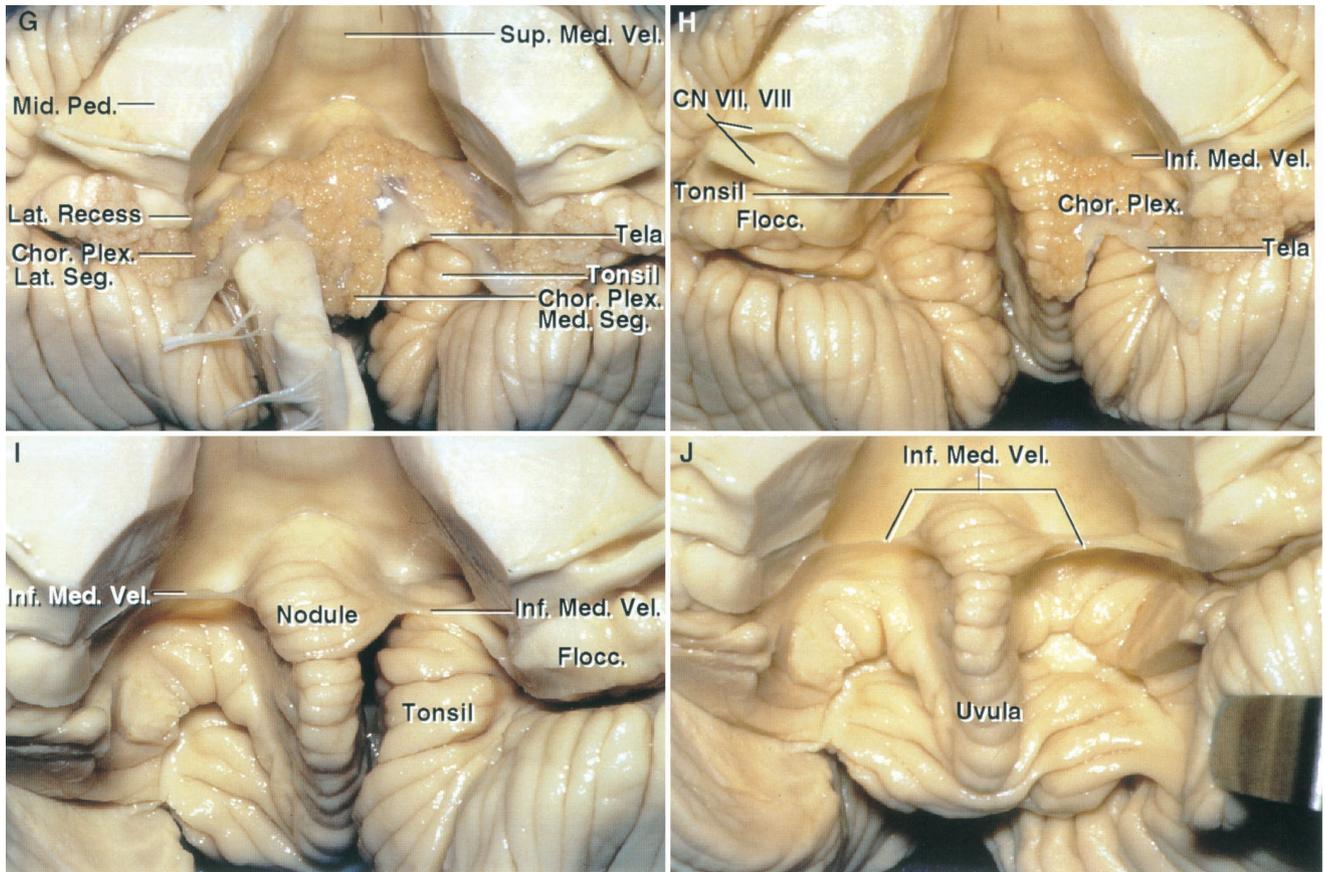


FIGURE 1.8. *G–J.* Brainstem, fourth ventricle, and petrosal cerebellar surface. *G*, the left half of the medulla has been removed. The superior half of the roof is formed by the superior medullary velum, which has the lingula of the vermis layered on its outer surface. The lower half of the roof is formed by the inferior medullary velum, which arises on the surface of the nodule, and the tela choroidea in which the choroid plexus arises. The choroid plexus is composed of paired L-shaped fringes, which have medial and lateral segments. The lateral segments extend laterally through the foramen of Luschka and the medial segments extend longitudinally through the foramen of Magendie. *H*, the right half of the tela choroidea and choroid plexus have been removed to expose the upper pole of right tonsil. *I*, the right cerebellar tonsil has been removed. All of the surfaces of the tonsils are free surfaces except the superolateral margin, the site of the tonsillar peduncle, a bundle of white matter, which attaches the tonsil to the remainder of the cerebellum. The inferior medullary velum is a thin membranous layer of neural tissue that arises on the nodule and extends laterally above the rostral pole of the tonsil to blend into the flocculus and form the flocculonodular lobe of the cerebellum. The cranial loop of the PICA courses between the rostral pole of the tonsil and the inferior medullary velum. *J*, both tonsils have been removed. The inferior medullary velum sweeps laterally from the surface of the nodule.

define the margins of the cerebellopontine angle. The superior limb extends above the trigeminal nerve and the inferior limb passes below the flocculus and the nerves that pass to the jugular foramen. *C*, the part of the pons and medulla forming the left half of the floor of the ventricle has been removed to expose the fastigium, which divides the ventricular roof into superior and inferior parts. *D*, the right half of the pons has been removed to expose the upper half of the roof. The superior part of the roof is formed by the superior medullary velum. The rostral part of the lower half of the roof is formed by the nodule and inferior medullary velum and the caudal part is formed by the tela choroidea, a thin arachnoid-like membrane, in which the choroid plexus arises. *E*, the cerebellopontine fissure has upper and lower limbs, which meet at a later apex located at the medial end of the petrosal fissure, also called the horizontal fissure, which divides the petrosal surface into upper and lower halves. The junction of the pons and medulla, which forms the anterior wall of the left lateral recess, has been removed to expose the choroid plexus protruding through the lateral recess into the cerebellopontine angles. *F*, enlarged view. The choroid plexus protrudes laterally through the foramen of Luschka into the cerebellopontine angle below the flocculus. *Cer.Pon.*, cerebellopontine; *Chor.*, choroid; *CN*, cranial nerve; *Fiss.*, fissure; *Flocc.*, flocculus; *For.*, foramen; *Inf.*, inferior; *Lat.*, lateral; *Med.*, medial, medullary; *Mid.*, middle; *Ped.*, peduncle; *Pet.*, petrosal; *Plex.*, plexus; *Pon.Med.*, pontomedullary; *Pon.Mes.*, pontomesencephalic; *Seg.*, segment; *Sulc.*, sulcus; *Sup.*, superior; *Vel.*, velum.

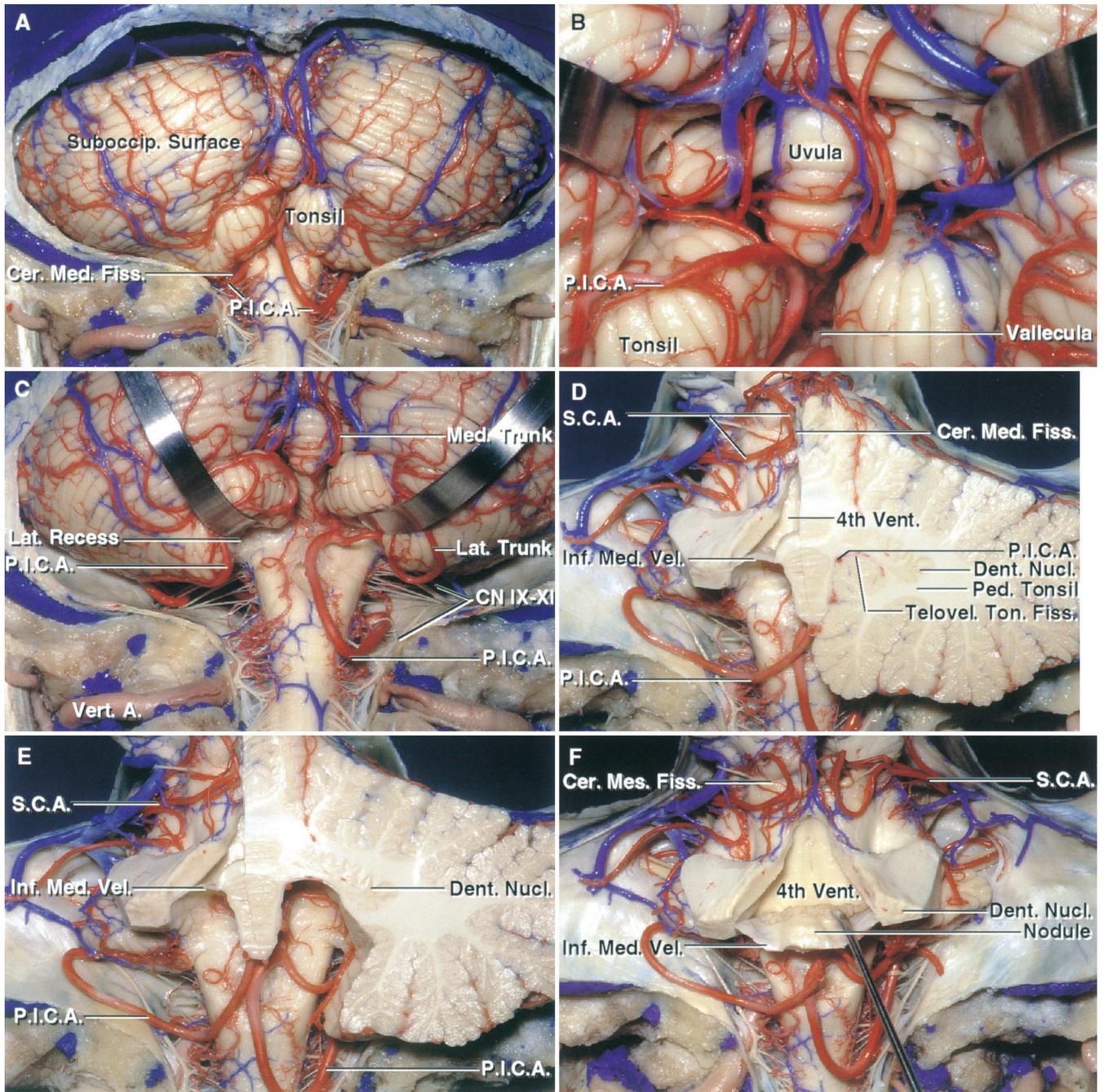


FIGURE 1.9. A–F. Posterior views. Stepwise dissection examining the relationships of the inferior medullary velum, dentate nucleus, tonsil, and the cerebellomedullary and cerebellomesencephalic fissures. A, the PICAs pass around the posterior medulla to reach the lower margin of the cerebellomedullary fissure. The left PICA courses around the lower pole of the tonsil. The right PICA descends well below the tonsil to the level of the foramen magnum before ascending along the medial tonsillar surface. B, the PICAs ascend between the tonsils and medulla to reach the interval between the tonsil and uvula and to supply the suboccipital surface. C, the posterior medullary segment of the right PICA divides into a medial trunk supplying the vermis and paravermian area and a lateral trunk supplying the hemisphere. D, the cerebellum has been sectioned in an oblique coronal plane to show the relationship of the rostral pole of the tonsil to the inferior medullary velum and dentate nucleus. The dentate nucleus is located above the posterolateral part of the ventricular roof, near the fastigium, where it wraps around, and is separated from, the rostral pole of the tonsil by the inferior medullary velum. The left tonsil has been removed while preserving the left half of the inferior medullary velum. The SCAs course in the cerebellomesencephalic fissure. The PICA passes between the walls of the cerebellomedullary fissure formed above by the inferior medullary velum and

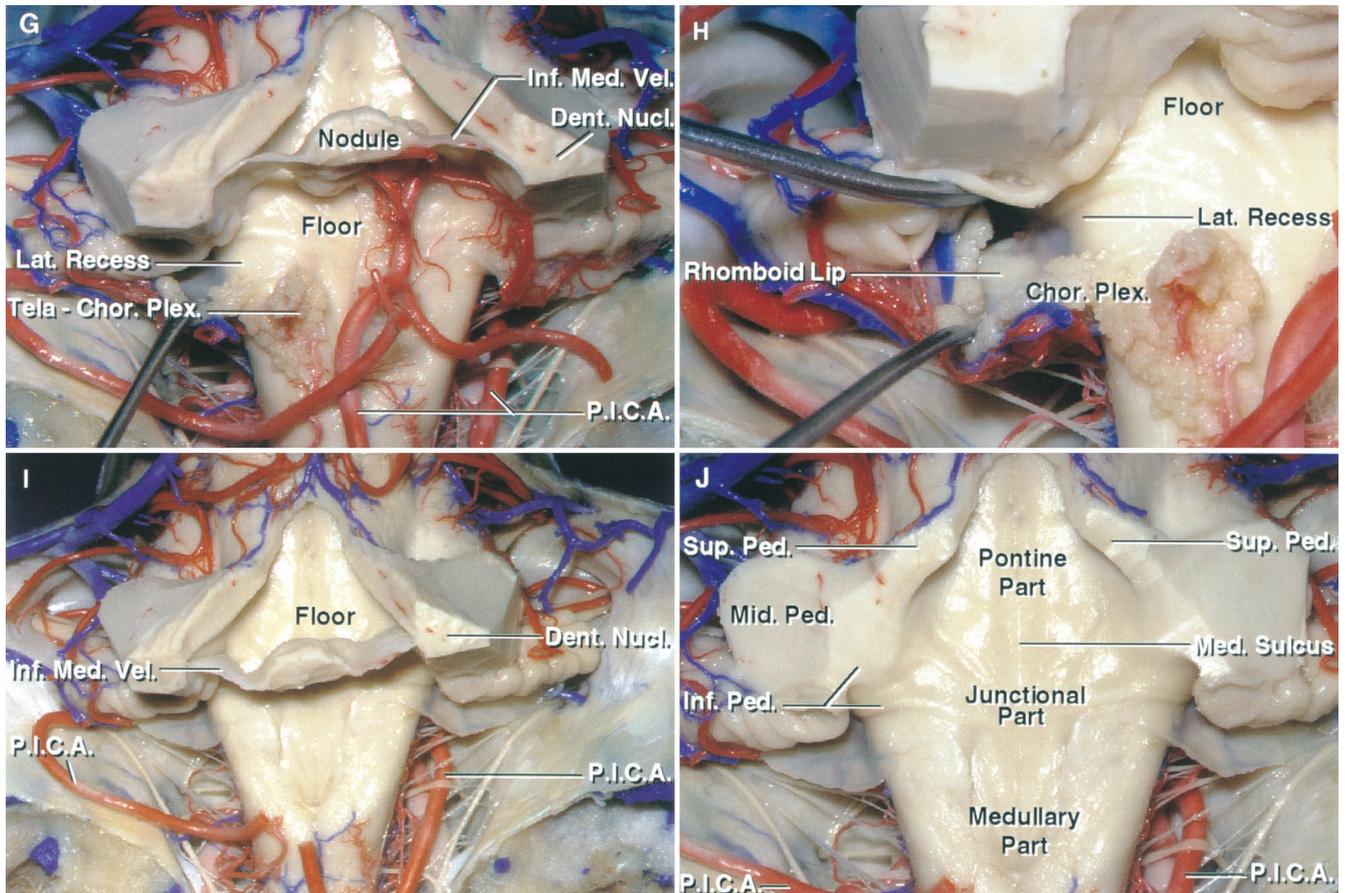


FIGURE 1.9. *G–J.* Posterior views. *G*, the tela choroidea, in which the choroid plexus arises, has been folded downward to expose the lower part of the floor. *H*, enlarged view of the left lateral recess and the foramen of Luschka. The rhomboid lip is a thin layer of neural tissue, which extends laterally from the anterior margin of the lateral recess and, with the tela choroidea, forms a pouch at the outer edge of the lateral recess. Choroid plexus extends through the lateral recess and foramen of Luschka into the cerebellopontine angle. *I*, the tela has been removed to expose the parts of the floor located above and below the nodule and inferior medullary velum. *J*, the nodule and the inferior medullary velum have been removed to expose the full length of the floor, which is divided in the midline by the median sulcus and craniocaudally into pontine, junctional, and medullary parts. The superior and inferior peduncles face the ventricular surface. The middle cerebellar peduncle is separated from the ventricular surface by the superior and inferior peduncles. *Chor.*, choroid; *Dent.*, dentate; *Inf.*, inferior; *Lat.*, lateral; *Med.*, median, medullary; *Mid.*, middle; *Nucl.*, nucleus; *P.I.C.A.*, posteroinferior cerebellar artery; *Ped.*, peduncle; *Plex.*, plexus; *Sup.*, superior; *Vel.*, velum.

A major cerebellar artery and vein course in each fissure. The superior cerebellar artery (SCA) and the vein of the cerebellomesencephalic fissure course within the cerebellomesencephalic fissure, the anteroinferior cerebellar artery (AICA) and the vein of the cerebellopontine fissure are related to the cerebellopontine fissure, and the posteroinferior cerebellar artery (PICA) and the vein of the cerebellomedullary

fissure are intimately related to the cerebellomedullary fissure. These arteries and veins will be reviewed in the next two chapters on the cerebellar arteries and posterior fossa veins (10, 18, 19).

Each fissure communicates with the adjacent fissure. The cerebellopontine fissures are continuous around the rostral surface of the middle cerebellar peduncles with the caudal

below by the upper pole of the tonsil. *E*, both tonsils have been removed. The PICAs ascend through the cleft between the inferior medullary velum and rostral pole of the tonsil. *F*, the superior part of the ventricular roof has been removed and the nodule and the inferior medullary velum has been folded downward to expose the floor. *A.*, artery; *Cer. Med.*, cerebellomedullary; *Cer. Mes.*, cerebellomesencephalic; *CN*, cranial nerve; *Dent.*, dentate; *Fiss.*, fissure; *Inf.*, inferior; *Lat.*, lateral; *Med.*, medial, medullary; *Nucl.*, nucleus; *Ped.*, peduncle; *P.I.C.A.*, posteroinferior cerebellar artery; *S.C.A.*, superior cerebellar artery; *Suboccip.*, suboccipital; *Telovel. Ton.*, telovelotonsillar; *Vel.*, velum; *Vent.*, ventricle; *Vert.*, vertebral.

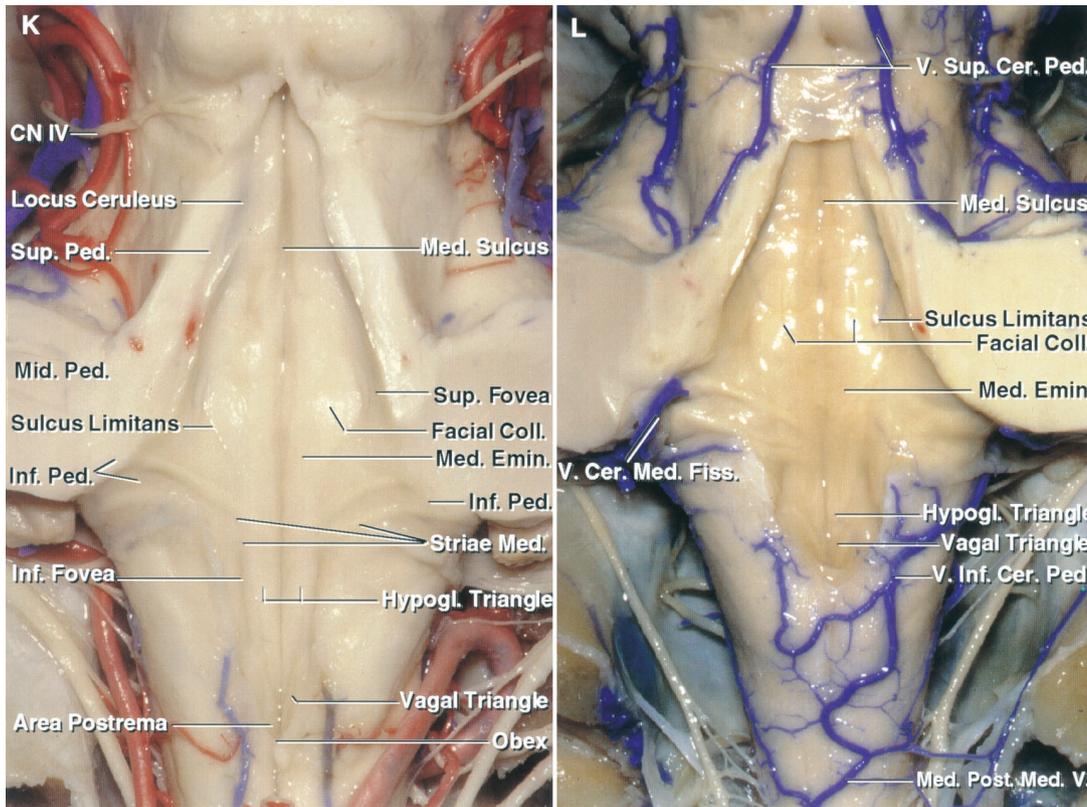


FIGURE 1.9. K and L. Posterior views. *K*, enlarged view of the floor of the fourth ventricle. The median sulcus divides the floor longitudinally in the midline. Each half of the floor is divided longitudinally by an irregular sulcus, the sulcus limitans, which deepens lateral to the facial colliculus and hypoglossal triangles to form the superior and inferior foveae. A darkened area of cells, the locus ceruleus, is located at the rostral end of the sulcus limitans. The stria medullaris crosses the floor at the level of the lateral recess. The hypoglossal and vagal nuclei and the area postrema are stacked

one above the other in the lower part of the floor to give the configuration of a pen nib and, thus, the area is referred to as the calamus scriptorius. *L*, another fourth ventricular floor. The paired veins of the superior cerebellar peduncle course on the outer surface of the superior peduncles and join superiorly to form the vein of the cerebellomesencephalic fissure. The median posterior medullary vein ascends on the medulla and splits into the paired veins of the inferior cerebellar peduncle at the caudal margin of the floor. That left vein is hypoplastic. The left vein of the cerebellomedullary fissure passes along the lateral recess and ascends to join the petrosal group of veins in the cerebellopontine angle. *Cer.Med.*, cerebellomedullary; *Cer.*, cerebellar; *CN*, cranial nerve; *Coll.*, colliculus; *Emin.*, eminence; *Fiss.*, fissure; *Hypogl.*, hypoglossal; *Inf.*, inferior; *Med.*, median, medullary; *Mid.*, middle; *Ped.*, peduncle; *Post.*, posterior; *Striae Med.*, Stria medullaris; *Sup.*, superior; *V.*, vein.

edges of the cerebellomesencephalic fissure and around the caudal margin of the middle cerebellar peduncles with the rostral limits of the cerebellomedullary fissure. These fissures will be reviewed in greater detail in the discussion of the roof and lateral recesses of the fourth ventricle.

Upper ventricular roof and the cerebellomesencephalic fissure

The ventricular surface of the superior part of the roof of the fourth ventricle is divided into a single median and two lateral parts (*Figs. 1.3 and 1.4*). The median part is formed by the superior medullary velum, and the lateral parts (also referred to as the lateral walls) are formed by the inner surface of the cerebellar peduncles. The superior medullary velum is a thin lamina of white matter that spans the interval between the superior cerebellar peduncles and has the lingula, the uppermost division of the vermis, on its outer surface. It is continuous at the fastigium with the inferior medullary velum. The rostral portion of the ventricular surface of each lateral wall is formed by the

medial surface of the superior cerebellar peduncle, and the caudal part is formed by the inferior cerebellar peduncle.

The middle cerebellar peduncle, although it is the largest component of the fiber bundle formed by the union of the three cerebellar peduncles, is separated from the ventricular surface by the fibers of the inferior and superior peduncles on its medial surface (*Fig. 1.9*). The fibers of the inferior cerebellar peduncle ascend in the posterolateral medulla and turn posteriorly in the inferomedial part of the fiber bundle formed by the union of the three peduncles to line the ventricular surface of the superior margin of the lateral recess and the inferior part of the lateral wall. The fibers of the superior cerebellar peduncle arise in the dentate nucleus and ascend on the medial side of the middle cerebellar peduncle to form the ventricular surface of the superior part of the lateral wall.

The cisternal (external) surface of the structures forming the superior part of the roof also form the anterior wall of the cerebellomesencephalic fissure. This fissure, which extends inferiorly between the cerebellum and midbrain, is V-shaped

when viewed from superiorly (Figs. 1.3 and 1.4). This fissure has also been referred to as the precentral cerebellar fissure. The dorsal half of the midbrain sits within the limbs of the V-shaped notch, and the cerebellum forms the outer margin, with the apex being posterior. The inner wall of the fissure, which forms the outer surface of the superior part of the roof, is composed of the lingula, the dorsal surface of the superior cerebellar peduncles, and the rostral surface of the middle cerebellar peduncles. The lingula, a thin, narrow tongue of vermis, sits on the outer surface of the superior medullary velum. The superior cerebellar peduncles form smooth longitudinal prominences on each side of the lingula before disappearing into the midbrain beneath the colliculi. The rostral surface of the middle cerebellar peduncles appear to wrap around the caudal margin of the superior cerebellar peduncles. A shallow groove, the interpeduncular sulcus, marks the junction of the superior and the middle cerebellar peduncles. The interpeduncular sulcus is continuous anteriorly with the pontomesencephalic sulcus, a transverse groove between the pons and midbrain, and superiorly with the lateral mesencephalic sulcus, a longitudinal fissure dorsal to the cerebral peduncle. The trochlear nerves arise in the cerebellomesencephalic fissure below the inferior colliculi and pass anterolateral to exit the anterior part of the fissure. The outer wall of the cerebellomesencephalic fissure is formed by the culmen and the central lobule and its wings.

The neural structures separating the ventricular and cisternal surfaces of the superior part of the roof are thinnest in the area of the superior medullary velum and lingula and thickest in the area of the cerebellar peduncles. The rostral portion of each lateral wall, formed by only the superior cerebellar peduncle, is thinner than the caudal portion, which is formed by the three cerebellar peduncles after they have united.

Lower roof and cerebellomedullary fissure

The inferior portion of the roof slopes sharply ventral and slightly caudal from the fastigium to its attachment to the inferolateral borders of the floor (Figs. 1.3–1.6). The ventricular and cisternal surfaces are formed by the same structures, the tela choroidea and the inferior medullary velum, except in the rostral midline, where the ventricular surface is formed by the nodule and the cisternal surface is formed by the uvula. The choroid plexus is attached to the ventricular surface of the tela choroidea.

The ventricular surface is divided into a cranial part formed by the nodule and the inferior medullary velum and a caudal part formed by the tela choroidea. The inferior medullary velum is a membranous layer and is all that remains of the connection between the nodule and the flocculi that form the flocculonodular lobe of the primitive cerebellum (14) (Figs. 1.8 and 1.9). It is a thin bilateral semitranslucent butterfly-shaped sheet of neural tissue that blends into the ventricular surface of the nodule medially and stretches laterally across, but is separated from, the superior pole of the tonsil by a narrow, rostral extension of the cerebellomedullary fissure. It blends into the dorsal margin of each lateral recess and forms the peduncle of each flocculus. The inferior medullary velum is continuous at the level of the fastigium with the superior medullary velum. Caudally it is attached to the tela choroidea.

The tela choroidea forms the caudal part of the inferior portion of the roof and the inferior wall of each lateral recess (Figs. 1.5, 1.6, and 1.9). It consists of two thin, semitransparent membranes, each having a thickness comparable to arachnoid, between which is sandwiched a vascular layer composed of the choroidal arteries and veins. The choroid plexus projects from the ventricular surface of the tela choroidea into the fourth ventricle. The line of attachment of the inferior medullary velum to the tela choroidea, the telovelar junction, extends from the nodule into each lateral recess. The tela choroidea sweeps inferiorly from the telovelar junction around the superior pole of each tonsil to its attachment to the inferolateral edges of the floor along narrow white ridges, the taeniae, which meet at the obex. Cranially, the taeniae turn laterally over the inferior cerebellar peduncles and pass horizontally along the inferior borders of the lateral recesses. The tela choroidea does not completely enclose the inferior half of the fourth ventricle, but has three openings into the subarachnoid space: the paired foramina of Luschka located at the outer margin of the lateral recesses and the foramen of Magendie located at the caudal tip of the fourth ventricle.

The cisternal (external) surface of the caudal half of the roof faces and is intimately related to the cerebellomedullary fissure (Figs. 1.6, 1.8, and 1.9). This fissure is one of the most complex fissures in the brain. The ventral wall of the fissure is formed by the posterior surface of the medulla, the inferior medullary velum, and the tela choroidea. The dorsal wall of the fissure is formed by the uvula in the midline and the tonsils and biventral lobules laterally. It extends superiorly to the level of the lateral recesses and communicates around the superior poles of the tonsils with the cisterna magna, through the foramen of Magendie with the fourth ventricle, and around the foramina of Luschka with the cerebellopontine fissures. The rostral pole of the tonsils faces the inferior medullary velum, the tela choroidea, and the peritonsillar part of the uvula and the biventral lobule in the superior part of the fissure (Figs. 1.3–1.6). The portion of the fissure between the tonsil, the tela choroidea, and the inferior medullary velum is called the telovelotonsillar cleft, and the superior extension of this cleft over the superior pole of the tonsil has been called the supratonsillar cleft.

LATERAL RECESS AND CEREBELLOPONTINE FISSURE

The lateral recesses are narrow, curved pouches formed by the union of the roof and the floor. They extend laterally below the cerebellar peduncles and open through the foramina of Luschka into the cerebellopontine angles (Figs. 1.3, 1.5, 1.6, and 1.8). The ventral wall of each lateral recess is formed by the junctional part of the floor and the rhomboid lip, a sheetlike layer of neural tissue that extends laterally from the floor and unites with the tela choroidea to form a pouch at the outer extremity of the lateral recess. The rostral wall of each lateral recess is formed by the caudal margin of the cerebellar peduncles. The inferior cerebellar peduncle courses upward in the floor ventral to the lateral recess and turns posteriorly at the lower part of the pons to form the ventricular surface

of the rostral wall. The peduncle of the flocculus interconnecting the inferior medullary velum and the flocculus crosses in the dorsal margin of the lateral recess. The caudal wall is formed by the tela choroidea that stretches from the lateral part of the taenia to the peduncle of the flocculus. The biventral lobule is dorsal to the lateral recess. The flocculus is superior to the outer extremity of the lateral recess. The rootlets of the glossopharyngeal and vagus nerves arise ventral to and the facial nerve arises rostral to the lateral recess. The fibers of the vestibulocochlear nerve cross the floor of the recess.

Each lateral recess opens into the cerebellopontine angle along the cerebellopontine fissure (*Fig. 1.7*). This V-shaped fissure is formed by the folding of the cerebellar hemisphere around the lateral side of the pons and the middle cerebellar peduncle. It has a superior limb between the rostral half of the middle cerebellar peduncle and the superior part of the petrosal surface and an inferior limb between the caudal half of the middle cerebellar peduncle and the inferior part of the petrosal surface. The middle cerebellar peduncle fills the interval between the two limbs. The apex of the fissure is located laterally where the superior and inferior limbs meet. The petrosal fissure extends laterally from the apex. The lateral recess and the foramen of Luschka open into the medial part of the inferior limb. Other structures located along the inferior limb are the flocculus, the rhomboid lip, the choroid plexus protruding from the foramen of Luschka, and the facial, vestibulocochlear, glossopharyngeal, and vagus nerves. The trigeminal nerve arises from the pons along the superior limb of the fissure.

The superior limb of the cerebellopontine fissure communicates above the trigeminal nerve with the lateral part of the cerebellomesencephalic fissure, and the inferior limb communicates with the lateral part of the cerebellomedullary fissure at the level of the lateral recess. The flocculus projects into the cerebellopontine angle at the confluence of the cerebellopontine and cerebellomedullary fissures. The vestibulocochlear and facial nerves enter the brainstem anterosuperior to the flocculus, and the fila of the glossopharyngeal and the vagal nerves cross anteroinferiorly to it.

CHOROID PLEXUS

The choroid plexus of the posterior fossa is composed of two inverted L-shaped fringes that arise on the ventricular surface of the tela choroidea and are located on each side of the midline (7) (*Figs. 1.3 and 1.8*). The paired longitudinal limbs bordering the median plane are the medial segments. The transverse limbs that originate from the rostral ends of the medial segments are the lateral segments. The entire structure presents the form of a letter T, the vertical limb of which, however, is double.

The medial segments are located in the roof near the midline, and the lateral segments extend through the lateral recesses and the foramina of Luschka into the cerebellopontine angles. The medial segments stretch from the level of the nodule anterior to the tonsils to the level of the foramen of Magendie. Each medial segment is subdivided into a rostral or nodular part and a caudal or tonsillar part. The nodular

parts are widest at their junction with the lateral segments. The tonsillar parts are anterior to the tonsils and extend inferiorly through the foramen of Magendie. The rostral and caudal ends of the medial segments are often fused.

The lateral segments form a transversely oriented fringe that attach to the rostral part of the medial segments and extend parallel to the telovelar junction through the lateral recesses into the cerebellopontine angles. Each lateral segment is subdivided into a medial or peduncular part and a lateral or floccular part. The peduncular part forms a narrow fringe that is continuous with the rostral part of the medial segment and is attached to the tela choroidea covering the lateral recess inferior to the cerebellar peduncles. The floccular part is continuous with the peduncular part at the lateral margin of the cerebellar peduncles and protrudes through the foramen of Luschka into the cerebellopontine angle below the flocculus.

BRAINSTEM AND FLOOR

Brainstem

The brainstem and ventricle floor are considered together because the brainstem forms the fourth ventricular floor. The brainstem in the posterior fossa is composed of the mesencephalon, pons, and medulla (*Figs. 1.7–1.9*). The mesencephalon consists of the cerebral peduncles, the tegmentum, and the tectum. It is demarcated superiorly from the diencephalon by the sulcus between the optic tracts and the cerebral peduncles, and inferiorly from the pons by the pontomesencephalic sulcus. The interpeduncular fossa, a wedge-shaped depression between the cerebral peduncles, has the posterior perforated substance in its floor. The rootlets of the oculomotor nerves arise in the depths of the interpeduncular fossa and form the fossa's walls lateral to the posterior perforated substance. A small depression, the superior foramen cecum, is located in the caudal part of the interpeduncular fossa. The pontomesencephalic sulcus runs from the superior foramen cecum around the cerebral peduncles to join the lateral mesencephalic sulcus, a vertical sulcus between the tegmentum and the cerebral peduncle.

The belly of the pons is convex from side to side, as well as from top to bottom, and is continuous on each side with the middle cerebellar peduncles. It has a shallow midline groove, the basilar sulcus, which extends from its superior to its inferior border. The posterior root of the trigeminal nerve emerges from the upper portion of the middle cerebellar peduncle just below the anterior angle of the cerebellum. The pons is demarcated inferiorly from the medulla by the pontomedullary sulcus, which extends laterally from the inferior foramen cecum (a midline dimple) to the supraolivary fossette (a depression located rostral to the olive). The rootlets of the facial and the vestibulocochlear nerves arise superior to this fossette and the rootlets of the glossopharyngeal and the vagal nerves originate dorsal to it.

The anterior surface of the medulla is formed by the medullary pyramids, which face the clivus, the anterior edge of the foramen magnum, and the rostral part of the odontoid

process (Figs. 1.7 and 1.8). The anteromedian sulcus divides the upper medulla in the anterior midline between the pyramids and disappears on the lower medulla at the level of the decussation of the pyramids, but it reappears below the decussation and is continuous caudally with the anteromedian fissure of the spinal cord. The lateral surface of the medulla is formed predominantly by the inferior olives, which are situated lateral to and separated from the pyramids by the anterolateral (preolivary) sulcus. The rootlets of the hypoglossal nerves arise in the anterolateral sulcus. The lateral surface is demarcated posteriorly by the exits of the rootlets of the glossopharyngeal, vagus, and accessory nerves just dorsal to the posterolateral (postolivary) sulcus, which courses along the dorsal margin of the olive and is continuous below with the posterolateral sulcus of the spinal cord. The abducens nerves emerge from the pontomedullary sulcus rostral to the pyramids. The posterior surface of the medulla is divided into superior and inferior parts. The superior part is composed in the midline of the inferior half of the floor of the fourth ventricle and laterally by the inferior cerebellar peduncles. The inferior part of the posterior surface is divided into two halves in the midline by the posteromedian sulcus, and each half is composed of the gracile fasciculus and tubercle medially, and the cuneate fasciculus and tubercle laterally. The posteromedian sulcus of the medulla, which separates the paired gracile fasciculi in the midline, ends superiorly at the obex of the fourth ventricle and is continuous inferiorly with the posteromedian sulcus of the spinal cord. The posterior intermediate sulcus, which separates the gracile and cuneate fasciculi, is continuous inferiorly with the posterior intermediate sulcus of the spinal cord. The lower medulla blends indistinguishably into the upper spinal cord at the level of the C1 nerve roots (Figs. 1.5–1.7).

Floor

The floor has a rhomboid shape (Fig. 1.9). The rostral two-thirds of the floor is posterior to the pons and the caudal one-third is posterior to the medulla. Its cranial apex is at the level of the cerebral aqueduct; its caudal tip, the obex, is located at the rostral end of the remnant of the spinal canal, anterior to the foramen of Magendie; and its lateral angles open through the lateral recesses and foramina of Luschka into the cerebellopontine angles. A line connecting the orifices of the lateral recesses is located at the level of the junction of the caudal and the middle third of the length of the floor and also at the level of the junction of the pons and the medulla.

The floor is divided into three parts: a superior or pontine part, an intermediate or junctional part, and an inferior or medullary part. The superior part has a triangular shape: its apex is at the cerebral aqueduct, its base is represented by an imaginary line connecting the lower margin of the cerebellar peduncles, and its lateral limbs are formed by the medial surfaces of the cerebral peduncles. The intermediate part is the strip between the lower margin of the cerebellar peduncles and the site of attachment of the tela choroidea to the taeniae just below the lateral recesses. The intermediate part extends into the lateral recesses. The inferior part has a triangular shape and is limited laterally by the taeniae marking the

inferolateral margins of the floor. Its caudal tip, the obex, is anterior to the foramen of Magendie.

The floor is divided longitudinally from the rostral apex to the caudal tip into symmetrical halves by the median sulcus. The sulcus limitans, another longitudinal sulcus, divides each half of the floor into a raised median strip, called the median eminence, that borders the midline and a lateral region called the vestibular area.

Each median eminence, the strip between the sulcus limitans and the median sulcus, from above to below contains the facial colliculus, a rounded prominence related to the facial nerve, and three triangular areas overlying the hypoglossal and vagus nuclei and the area postrema. The three triangular areas are paired and are stacked along the median sulcus to give the caudal part of the floor a feather or pen nib configuration; thus, the area is called the calamus scriptorius. At the pontine level the median eminence has a width equal to that of the full half of the floor and thus the sulcus limitans corresponds with the lateral limit of this part of the floor.

The sulcus limitans is discontinuous and is most prominent in the pontine and medullary portions of the floor, where it deepens at two points to form dimples called foveae, and is least distinct in the junctional part of the floor. One of the two dimples, the superior fovea, is located in the pontine portion of the floor and the other, the inferior fovea, is located in the medullary part of the floor. At the level of the superior fovea, the median eminence forms an elongated swelling, the facial colliculus, which overlies the nucleus of the abducens nerve and the ascending section of the root of the facial nerve. At the rostral tip of each sulcus limitans in the lateral margin of the floor is a bluish gray area, the locus ceruleus, which owes its color to a group of pigmented nerve cells. The hypoglossal triangle is medial to the inferior fovea and overlies the nucleus of the hypoglossal nerve. Caudal to the inferior fovea and between the hypoglossal triangle and the lower part of the vestibular area is a triangular dark field, the vagal triangle, that overlies the dorsal nucleus of the vagus nerve. A translucent ridge, the funiculus separans, crosses the lower part of the vagal triangle. The area postrema forms a small tongue-shaped area between the funiculus separans and the gracile tubercle in the lower limit of the median eminence immediately rostral to the obex.

The vestibular area, the portion of the floor lateral to the median eminence and sulcus limitans, is widest in the intermediate part of the floor, where it forms a rounded elevation that extends into the lateral recess. White strands, the striae medullaris, course transversely from the region of the lateral recess across the inferior cerebellar peduncles above the hypoglossal triangles toward the midline and disappear in the median sulcus. The vestibular nuclei lie beneath the vestibular area. The auditory tubercle produced by the underlying dorsal cochlear nucleus and the cochlear part of the vestibulocochlear nerve forms a prominence in the lateral part of the vestibular area.

VASCULAR RELATIONSHIPS

Each wall of the fourth ventricle has surgically important arterial relationships: the SCA is intimately related to the supe-

rior half of the roof; the PICA is intimately related to the inferior half of the roof; the AICA is intimately related to the lateral recess and the foramen of Luschka; and the basilar and vertebral arteries give rise to many perforating branches that reach the floor of the fourth ventricle (5, 7, 9, 10, 18, 19) (Figs. 1.9 and 1.10). The choroidal branches of the AICA supply the portion of the choroid plexus in the cerebellopontine angle and the adjacent part of the lateral recess, and the PICA supplies the choroid plexus in the roof and the medial part of the lateral recess (7).

There are no major veins within the cavity of the fourth ventricle. The veins most intimately related to the fourth ventricle are those in the fissures between the cerebellum and the brainstem and on the cerebellar peduncle (21). The veins of the cerebellomesencephalic fissure and the superior cerebellar

peduncle course on the superior part of the roof, the veins of the cerebellomedullary fissure and the inferior cerebellar peduncle drain the inferior half of the roof, and the veins of the cerebellopontine fissure and the middle cerebellar peduncle drain the lateral wall and the cerebellopontine angle around the lateral recess. These vascular relationships will be explored in greater detail in the next two chapters on the cerebellar arteries and posterior fossa veins.

DISCUSSION

Effects of neural injury

The operative approaches to the cerebellum and fourth ventricle may require splitting of the vermis, resection of part

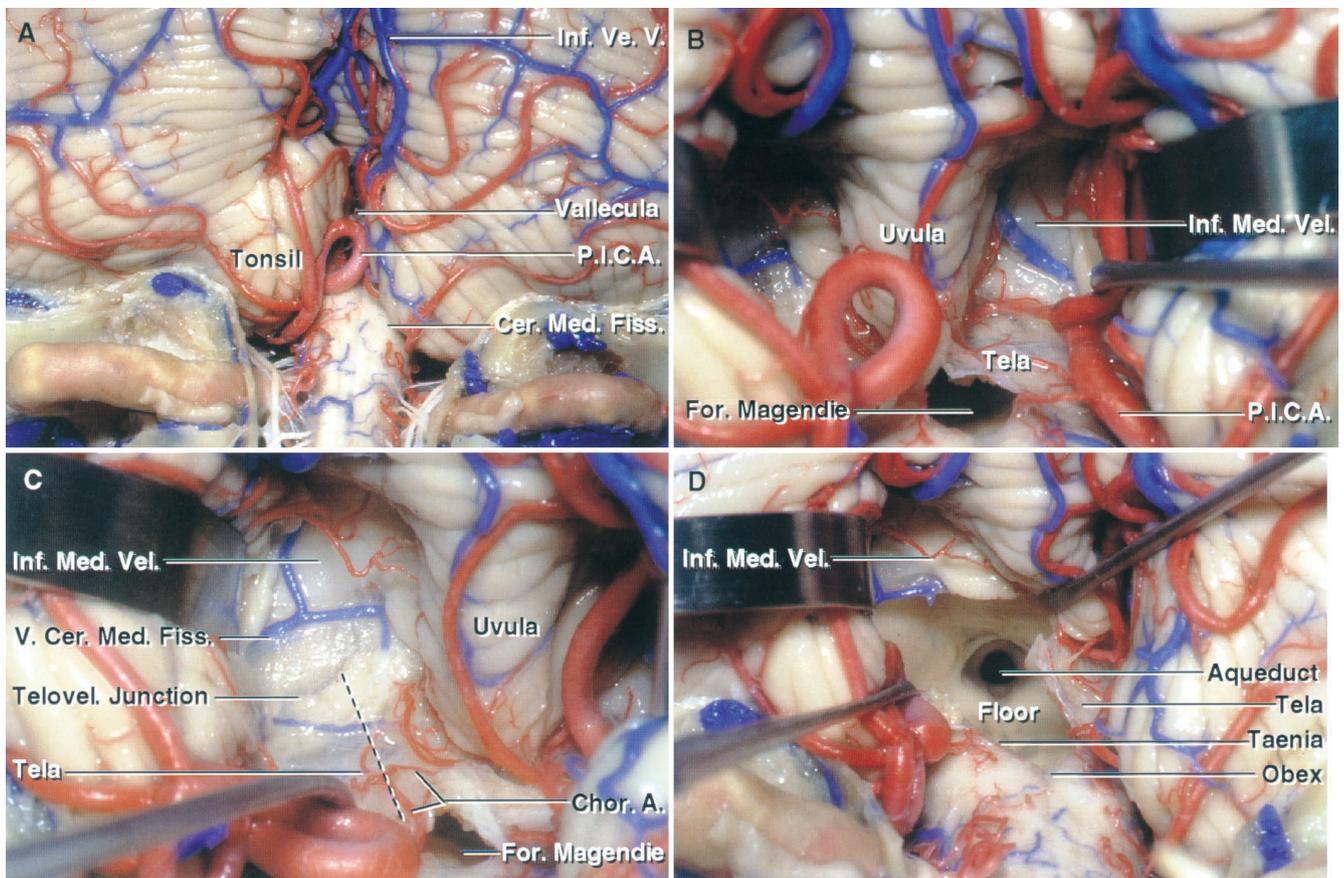


FIGURE 1.10. A–D. Telovelar approach to the fourth ventricle. *A*, the cerebellomedullary fissure extends upward between the tonsils posteriorly and the medulla anteriorly. The vallecule opens between the tonsils into the fourth ventricle. *B*, both tonsils have been retracted laterally to expose the inferior medullary velum and tela choroidea that form the lower part of the ventricular roof. The nodule of the vermis, on which the inferior medullary arises, is hidden deep to the uvula. *C*, enlarged view of the left half of the cerebellomedullary fissure. The choroidal arteries course along the tela choroidea from which the choroid plexus projects into the roof of the fourth ventricle. The vein of the cerebellomedullary fissure, which crosses the inferior medullary velum, is the largest vein in the cerebellomedullary fissure. The interrupted line shows the site of the incision in the tela to provide the exposure seen in the next step. The telovelar junction is the line of attachment of the tela to the velum. *D*, the tela choroidea has been opened extending from the foramen of Magendie to the junction with the inferior medullary velum. The uvula has been displaced to the right side to provide this view extending from the aqueduct to the obex. *A.*, artery; *Cer.Med.*, cerebellomedullary; *Chor.*, choroidal; *Fiss.*, fissure; *For.*, foramen; *Inf.*, inferior; *Med.*, medullary; *P.I.C.A.*, posteroinferior cerebellar artery; *Telovel.*, telovelar; *V.*, vein; *Ve.*, vermician; *Vel.*, velum.

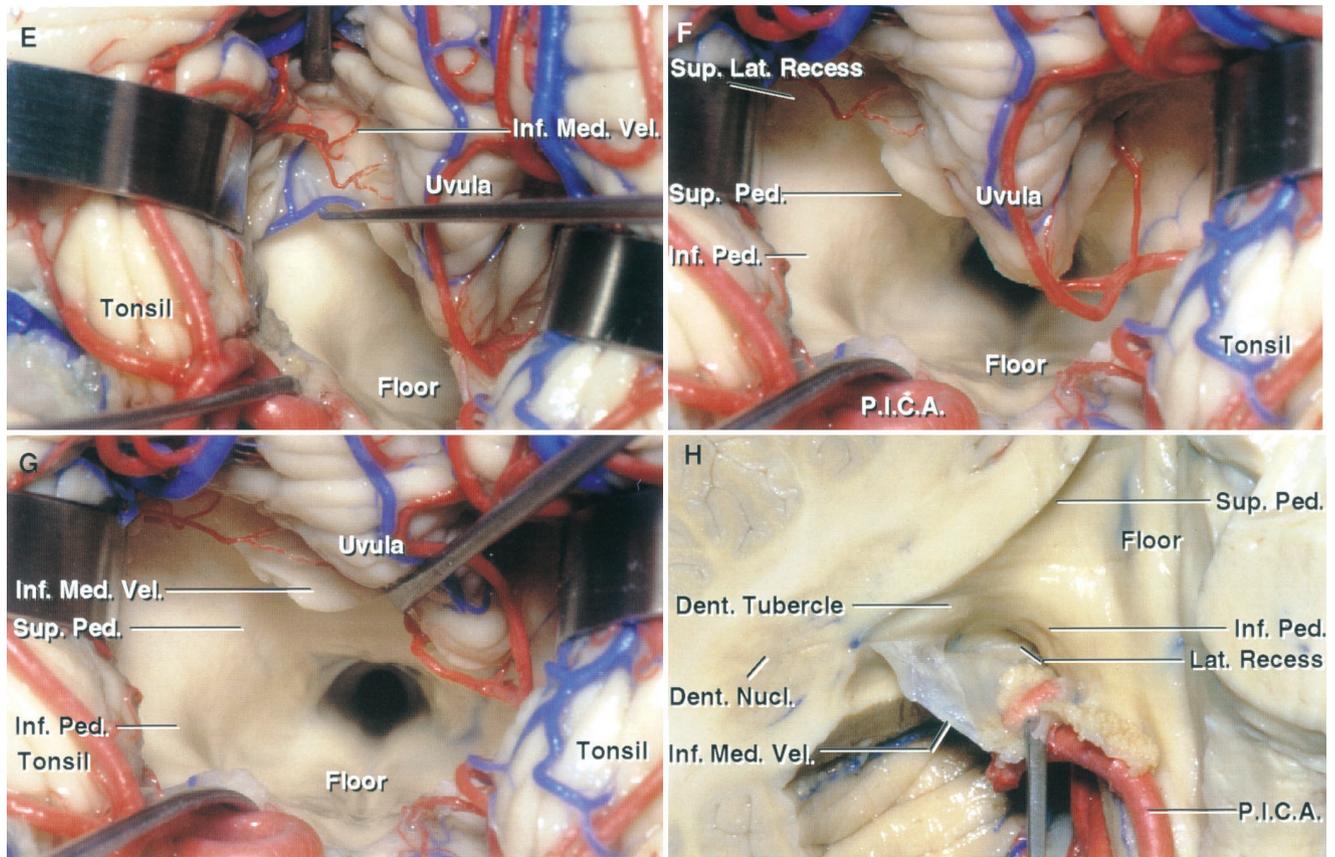


FIGURE 1.10. *E–H.* Telovelar approach to the fourth ventricle. *E*, the tip of a nerve hook placed inside the fourth ventricle is seen through the paper-thin inferior medullary velum. *F*, the left half of the inferior medullary velum has been divided to expose the superolateral recess and the ventricular surface formed by the superior and inferior peduncles. *G*, the uvula has been retracted to the right to expose all of the floor and much of the roof of the ventricle. *H*, the right half of the cerebellum was removed by dividing the vermis sagittally and the cerebellar peduncles transversely. The tonsil has been removed and the inferior medullary velum and the cranial loop of the PICA have been displaced downward to expose the opening into the lateral recess. The dentate nucleus forms a prominence, the dentate tubercle, in the superolateral recess of the roof of the fourth ventricle near the site of attachment of the inferior medullary velum. *Dent.*, dentate; *Inf.*, inferior; *Lat.*, lateral; *Med.*, medullary; *Nucl.*, nucleus; *P.I.C.A.*, posteroinferior cerebellar artery; *Ped.*, peduncle; *Sup.*, superior; *Vel.*, velum.

of the hemisphere, removal of the tonsil, opening of the inferior medullary velum, separation of tumor from the floor and roof, dissection in the region of the cerebellar peduncles and deep cerebellar nuclei, and retraction or removal of the flocculus. Horsley pointed out that large amounts of cerebellar tissue could be sacrificed with little or no demonstrable loss of function (13). A common approach to the fourth ventricle is by splitting the vermis on the suboccipital surface, as recommended by Dandy (3) and Kempe (15). Dandy stated that the vermis could be opened at its center to gain access to fourth ventricular tumors without causing a disturbance of function, provided that the operator carefully avoided the dentate nuclei (3). Small lesions in the vermis caused no symptoms or deficit, but larger lesions of the uvula, nodule, and flocculus, involving cerebellar fibers related to the vestibular system, cause equilibratory disturbances, with truncal ataxia, staggering gait, and oscillation of the head and trunk on assumption of the erect position without ataxia on voluntary movement of

the extremities (8, 11, 12, 16). Injury to the vestibular projections from the brainstem to the flocculonodular lobe also causes nystagmus that is present in all directions of gaze. Cerebellar mutism is a transient complication that may appear after removal of cerebellar tumors, usually in children, characterized by lack of speech output in the awake patient, with intact speech comprehension, sometimes associated with oropharyngeal apraxia (2, 4, 24). Although the exact anatomic substrate for the mutism remains unknown, the majority occurred after removal of midline tumors involving the vermis (2, 4, 24, 26). The inferior part of the vermis, including the pyramid, uvula, and nodule has been implicated.

Hemispheric resection may be required to reach lesions of the lateral part of the roof or the lateral recess of the fourth ventricle. Frazier resected the lateral part of the hemisphere without permanent sequelae (6). Unilateral resection of the part of the hemisphere lateral to the dentate nuclei results in ataxia of voluntary movement, hypotonia, and adiadochoki-

nesia in the ipsilateral limbs with errors in rate, range, direction, and force of movement, which are often transient (8, 11, 12, 16). If the ablation involves the dentate nucleus, these disturbances are more severe and enduring and there is, in addition, intention tremor with voluntary movement of the extremities. During an operation on the caudal part of the roof, one should remember that the dentate nuclei are located just rostral to the superior pole of the tonsils and are wrapped around the superolateral recess of the ventricle near the inferior medullary velum. Dysarthria results when resection extends into the paravermian part of the cerebellar hemisphere and occurs more frequently from left hemisphere injury than from vermal or right hemisphere injury (17). Nystagmus with hemispheric lesions is associated with an ocular rest point 10 to 30 degrees toward the unaffected side, with greater oscillation upon looking to the side of the lesion. The addition of a vermian lesion or a lesion extending to the contralateral hemisphere produces more marked symptoms than a unilateral hemispheric lesion and is associated with disturbances of standing, walking, and speech. Lesions of the anterior part of the tentorial surface result in increased tone in the muscles used for maintaining the erect posture. If the lateral half of this area is damaged, the hypertonia is predominantly in the ipsilateral extremities.

All of the cerebellar peduncles converge on the lateral wall and roof and may be damaged here. The inferior and superior cerebellar peduncles are more likely to be injured during procedures within the ventricle because they abut directly on the ventricular surface; the middle cerebellar peduncle would be more susceptible to injury in procedures near the external wall such as those in the cerebellopontine angle because it forms a major part of the cisternal surface of the ventricular wall. Lesions of the middle cerebellar peduncle cause ataxia and dysmetria during voluntary movement of the ipsilateral extremities with hypotonia similar to that produced by damage to the lateral part of the hemisphere. Lesions of the superior cerebellar peduncle cause severe ipsilateral intention tremor, dysmetria, and decomposition of movement. The syndrome is mild and subsides rapidly if there is only a partial section of the peduncle. Section of the inferior cerebellar peduncle causes disturbances of equilibrium similar to those produced by ablation of the flocculonodular lobe, with truncal ataxia and staggering gait.

The consequences of removal or gentle manipulation of tumors attached to the floor of the fourth ventricle include intraoperative blood pressure decrease, apnea, and/or respiratory rate increase and postoperative diplopia, disturbances of speech and swallowing, and poor cough reflex associated with incidental disturbances of gastrointestinal bleeding, aspiration pneumonia, and electrolyte disturbances (1).

Telovelar approach to fourth ventricle

Lesions of the fourth ventricle have posed a special challenge to neurosurgeons because of the severe deficits that may follow injury to the structures in the ventricular walls and floor. In the past, operative access to the fourth ventricle was obtained by splitting the cerebellar vermis or removing part of a cerebellar hemisphere (1, 3, 15). In examining the clefts and

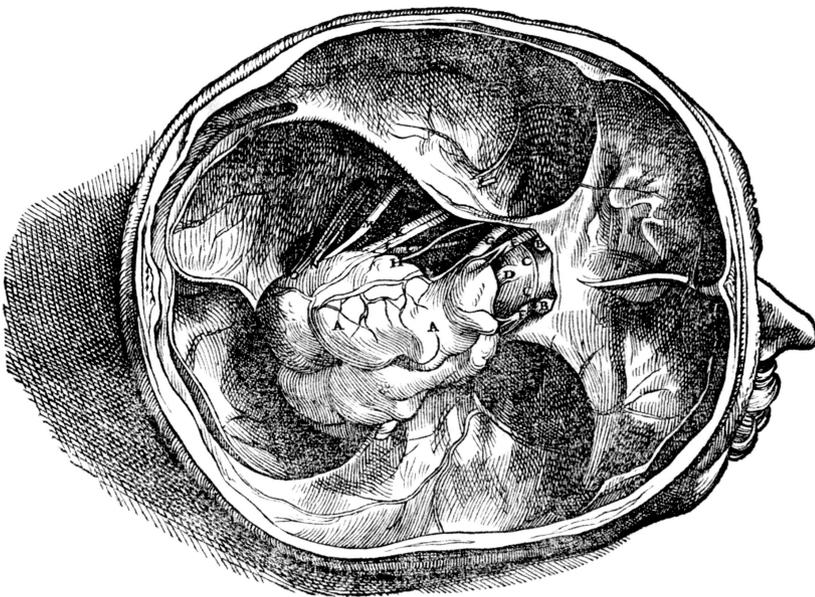
walls of the cerebellomedullary fissure, we have found that opening the tela alone will provide adequate ventricular exposure in most cases without splitting the vermis (20, 22, 23) (Fig. 1.10). The inferior medullary velum, another paper-thin layer, can also be opened if opening the tela does not provide adequate exposure. Opening the tela alone provides access to the full length of the floor and all of the ventricular cavity except, possibly, the fastigium, superolateral recess, and the superior half of the roof. Opening the inferior medullary velum accesses the latter areas and the superior half of the roof. Extending the telar opening laterally toward the foramen of Luschka opens the lateral recess and exposes the peduncular surfaces bordering the recess. Tumors in the fourth ventricle may stretch and thin these two semi-translucent membranes to a degree that one may not be aware that they are being opened in exposing a fourth ventricular tumor. There are no reports of deficits following isolate opening of the tela and velum. However, other structures exposed in the ventricle walls and at risk for producing the deficits described above include the dentate nuclei, cerebellar peduncles, floor of the fourth ventricle, and the PICA. During an operation on the caudal part of the roof, one should remember that the dentate nuclei are located just rostral to the superior pole of the tonsils underlying the dentate tubercles in the posterolateral part of the roof where they are wrapped around the superolateral recesses near the lateral edges of the inferior medullary velum (Figs. 1.9 and 1.10). All of the cerebellar peduncles converge on the lateral wall and roof where they may be damaged. The superior cerebellar peduncle is more likely to be injured during operations on lesions involving the superior part of the roof above the level of the dentate tubercles; the inferior peduncles are most susceptible to damage in exposing lesions within the lateral recess; and the middle cerebellar peduncle is susceptible to injury in procedures near the external wall of the superior half of the roof, such as those in the cerebellopontine angle, because the middle peduncle forms a major part of the cisternal surface of the ventricular wall. The consequences of removal or gentle manipulation of tumors attached to the floor of the fourth ventricle have been reviewed.

The PICA is frequently exposed in approaches directed through the tela choroidea or inferior medullary velum, but only infrequently occluded during operative approaches to the fourth ventricle. Occlusion of the branches of the PICA distal to the medullary branches at the level of roof of the fourth ventricle avoids the syndrome of medullary infarction but produces a syndrome resembling labyrinthitis, which includes rotatory dizziness, nausea, vomiting, inability to stand or walk unaided, and nystagmus without appendicular dysmetria (11). The main trunk of the AICA is infrequently exposed in opening the cerebellomedullary fissure, but it may also send choroidal branches to the tela and choroid plexus in the lateral recess.

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Cranial floor and contents of the posterior fossa. Vesalius (1514–1564) was only 28 years old when his publication was printed. The woodcuts, with their innovative landscape background, were by Jan Stephan Kalkar. From, Andreas Vesalius, *De Humani Corporis Fabrica*. Basel, Ex officina Ioannis Oporini, 1543. Courtesy, Rare Book Room, Norris Medical Library, Keck School of Medicine, Los Angeles, California. (Also see pages S68, S209, and S285.)

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