The Lateral and Third Ventricles

Albert L. Rhoton, Jr., M.D.
Department of Neurological Surgery, University of Florida, Gainesville, Florida

Correspondence:
Albert L. Rhoton, Jr., M.D., Department of Neurological Surgery, University of Florida McKnight Brain Institute, P.O. Box 100265, 100 South Newell Drive, Building 59, L2-100, Gainesville, FL 32610-0265.
Email: rhoton@neurosurgery.ufl.edu

KEY WORDS: Cerebral arteries, Cerebral veins, Cerebrum, Choroid plexus, Choroidal fissure, Colloid cyst, Intraventricular tumors, Lateral ventricle, Microsurgical anatomy, Operative approaches, Third ventricle

Neurosurgery 51[Suppl 1]:207–271, 2002 DOI: 10.1227/01.NEU.0000028161.91504.4F www.neurosurgery-online.com

Operative approaches to the lateral and third ventricles are made challenging by their deep position near the center of intracranial space, complete encasement in neural tissue, curved shape within the cerebrum, variable shape and size in the different lobes, narrow communicating orifices making them susceptible to obstruction, expansile nature allowing them to act as mass lesions, and walls containing important motor, sensory, and visual pathways and vital autonomic and endocrine centers. The lateral ventricles provide deep cavities through which the third ventricle and basal cisterns may be approached. In this chapter, the neural and vascular relationships that provide the basis for optimizing the results obtained with intraventricular operations are reviewed before the individual operative approaches are described. Many of the structures that form part of the walls of the lateral ventricle are also seen in the third ventricle. Both the lateral and third ventricles are intimately related to the deep venous system, and numerous arteries supply the walls of both the lateral and third ventricles.

LATERAL VENTRICLE

Neural Relationships

Each lateral ventricle is a C-shaped cavity that wraps around the thalamus and is situated deep within the cerebrum (*Fig. 5.1*). Each lateral ventricle has five parts: the frontal, temporal, and occipital horns, the body, and the atrium. Each of these five parts has medial and lateral walls, a roof, and a floor. In addition, the frontal and temporal horns and the atrium have anterior walls. These walls are formed predominantly by the thalamus, septum pellucidum, deep cerebral white matter, corpus callosum, and two C-shaped structures, the caudate nucleus and the fornix, that wrap around the thalamus.

Thalamus

The thalamus is located in the center of the lateral ventricle. Each lateral ventricle wraps around the superior, inferior, and posterior surfaces of the thalamus (*Fig. 5.1A*). The body of the lateral ventricle is above the thalamus, the atrium and occipital horn are posterior to the thalamus, and the temporal horn is inferolateral to the thalamus. The superior surface of the thalamus forms the floor of the body, the posterior surface of the pulvinar of the thalamus forms the anterior wall of the atrium, and the inferior surface of the thalamus is situated at the medial edge of the roof of the temporal horn.

Caudate Nucleus

The caudate nucleus is an arched, C-shaped, cellular mass that wraps around the thalamus and constitutes an important part of the wall of the lateral ventricle (*Fig. 5.1B*). It has a head, body, and tail. The head bulges into the lateral wall of the frontal horn and body of the lateral ventricle. The body forms part of the lateral wall of the atrium, and the tail extends from the atrium into the roof of the temporal horn and is continuous with the amygdaloid nucleus near the anterior tip of the temporal horn. In the body of the lateral ventricle, the caudate nucleus is superolateral to the thalamus; in the atrium, it is posterolateral to the thalamus; and in the temporal horn, it is inferolateral to the thalamus. The stria terminalis, a fiber tract that runs parallel and deep to the thalamostriate vein, arises in the amygdaloid nucleus and courses along the border between the caudate nucleus and the thalamus in the wall of the ventricle from the temporal horn to the body.

Fornix

The fornix is another C-shaped structure that wraps around the thalamus in the wall of the ventricle (*Fig. 5.1A*). The fornix consists mainly of hippocampomamillary tract fibers that originate from the hippocampus, subiculum, and dentate gyrus of the temporal lobe. The fimbria arises in the floor of the temporal horn on the ventricular surface of the hippocampal formation and passes posteriorly to become the crus of the fornix. The crus wraps around the posterior surface of the pulvinar of the thalamus and arches superomedially toward the lower surface of the splenium of the corpus callosum. At the junction of the atrium and the body of the lateral ventricle, the paired crura meet to form the body of the fornix, which runs forward along the superomedial border of the thalami in the medial wall of the body of the lateral ventricle. The body of the fornix separates the roof of the third ventricle from the floor of the bodies of the lateral ventricles. At the anterior margin of the thalamus, the body of the fornix separates into two columns that arch along the superior and anterior margins of the foramen of Monro in their course toward the mamillary bodies. In the area below the

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

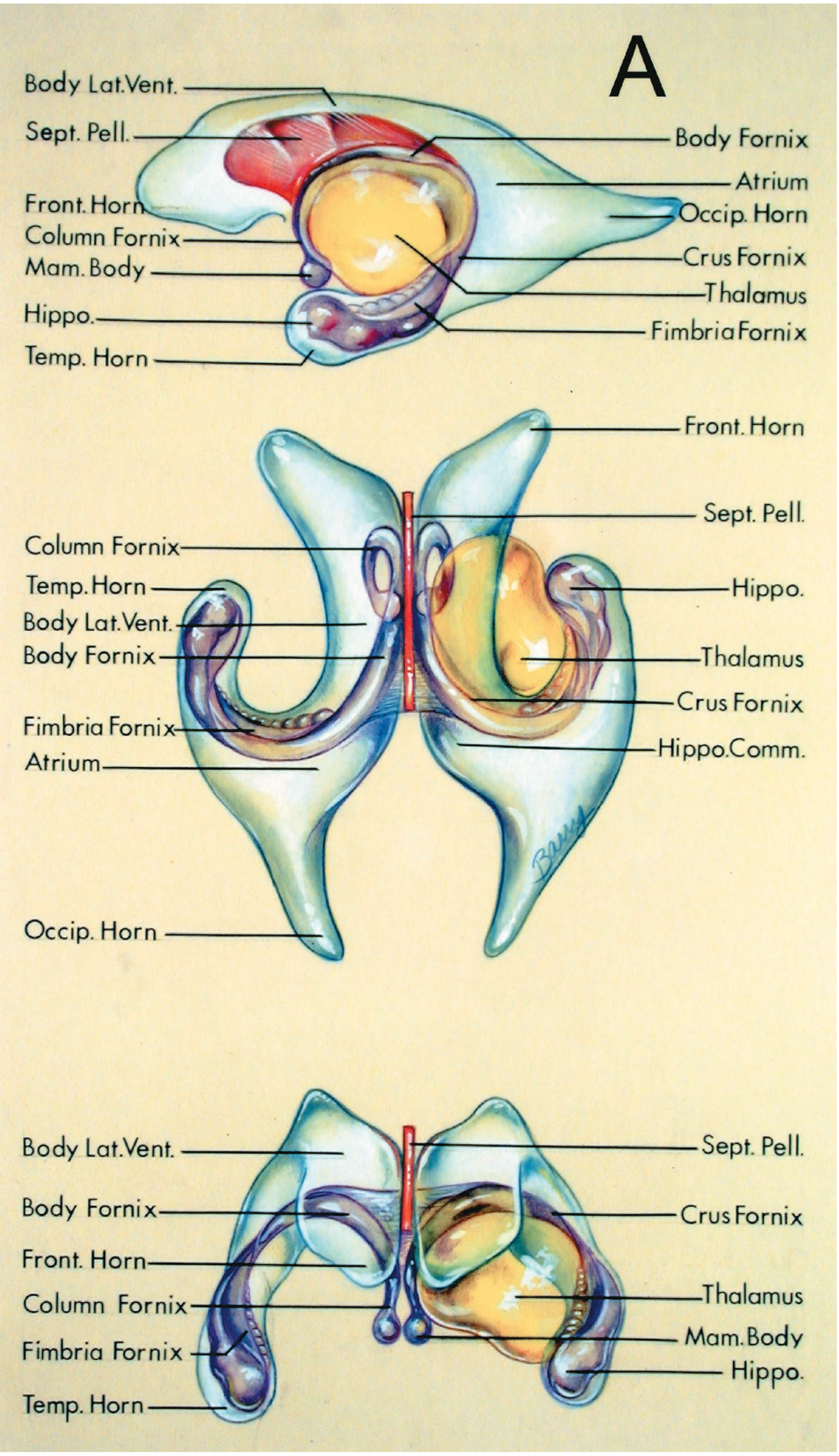


FIGURE 5.1. *Neural relationships.* A, *relationship of the septum pellucidum (*orange*), thalamus (*yellow*), and hippocampal formation and fornix (*purple*) to the lateral ventricles.* Top, *lateral view;* middle, *superior view;* bottom, *anterior view. Each lateral ventricle wraps around the thalamus. The frontal horn is anterior to the thalamus, the body is above the thalamus, the atrium and occipital horn are behind the thalamus, and the temporal horn is below and lateral to the thalamus. The septum pellucidum is in the medial wall of the frontal horn and body of the lateral ventricle. The hippocampal formation is in the floor of the temporal horn. The fornix arises in the hippocampal formation and wraps around the thalamus in the medial part of the temporal horn, atrium, and body. The fimbria of the fornix arises on the surface of the hippocampal formation in the temporal horn. The crus of the fornix is posterior to the thalamus in the wall of the atrium. The body of the fornix passes above the thalamus in the lower part of the medial wall of the body. The columns of the fornix are formed at the level of the foramen of Monro and pass inferior to the mamillary bodies. The crura of the fornix are connected across the midline in the roof of the third ventricle by the hippocampal commissure. The septum pellucidum, which separates the frontal horns in the midline, does not extend to the anterior tip of the frontal horn in the lateral view because the frontal horn is directed forward and laterally from the anterior margin of the septum pellucidum.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

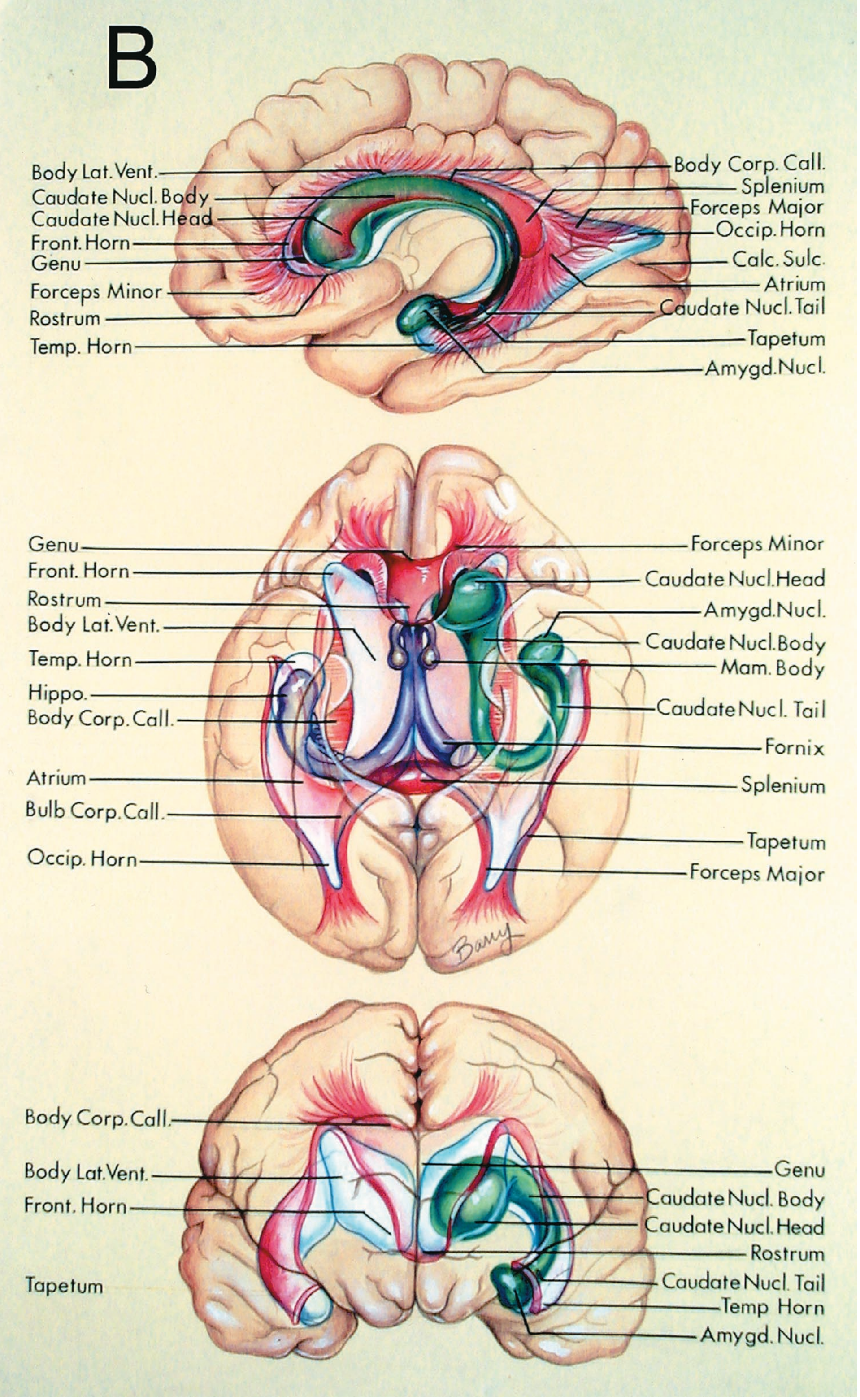


FIGURE 5.1. *Continued*
B, *relationship of the corpus callosum (*red*), caudate nucleus (*green*), and fornix and hippocampal formation (*purple*) to the lateral ventricles.* Top, *view through medial surface of the hemisphere;* middle, *view through inferior surface of the hemisphere;* bottom, *view through the anterior surface of the hemisphere. The head and body of the caudate nucleus form the lateral wall of the frontal horn and body of the lateral ventricle. The tail of the caudate nucleus extends into the anterior part of the lateral wall of the atrium and into the medial part of the roof of the temporal horn to the level of the amygdaloid nucleus, which is in the anterior wall of the temporal horn. The corpus callosum is made up of the rostrum (which is in the floor of the frontal horn), the genu (which forms the anterior wall and roof of the frontal horn), the body (which forms the roof of the body of the lateral ventricle), and the splenium (which gives rise to the fiber bundles making up the forceps major, which forms a prominence in the medial wall of the atrium called the bulb of the corpus callosum). The genu of the corpus callosum gives rise to a fiber bundle called the forceps minor, which forms the anterior wall of the frontal horn. The body and splenium give rise to a fiber bundle called the tapetum, which sweeps downward to form the roof and lateral wall of the atrium and temporal horn. The relationship of the hippocampal formation, fornix, and mamillary bodies to these structures is shown in the* middle *figure. A prominence in the medial wall of the atrium, called the calcar avis, overlies the calcarine sulcus.* Amygd., *amygdaloid;* Calc., *calcarine;* Comm., *commissure;* Corp., *corpus;* Front., *frontal;* Hippo., *hippocampal, hippocampus;* Lat., *lateral;* Mam., *mamillary;* Nucl., *nucleus;* Occip., *occipital;* Pell., *pellucidum;* Sept., *septum;* Sulc., *sulcus;* Temp., *temporal;* Vent., *ventricle.*

splenium, a thin sheet of fibers interconnects the medial margins of the crura to form the hippocampal commissure. In the body of the lateral ventricle, the body of the fornix is in the lower part of the medial wall; in the atrium, the crus of the fornix is in the medial part of the anterior wall; and in the temporal horn, the fimbria of the fornix is in the medial part of the floor.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

The body of the fornix crosses the thalamus approximately midway between the medial and lateral edge of the superior surface of the thalamus. The part of the thalamus lateral to the body of the fornix forms the floor of the body of the lateral ventricle, and the part medial to the fornix forms part of the lateral wall of the velum interpositum and third ventricle. The crus of the fornix crosses the pulvinar approximately midway between the medial and lateral edge of the pulvinar. The part of the pulvinar lateral to the crus of the fornix forms part of the anterior wall of the atrium, and the part medial to the fornix forms part of the anterior wall of the quadrigeminal cistern. The fimbria of the fornix passes below the inferolateral part of the thalamus just lateral to the medial and lateral geniculate bodies. The part of the thalamus medial to the fimbria forms the roof of the ambient cistern.

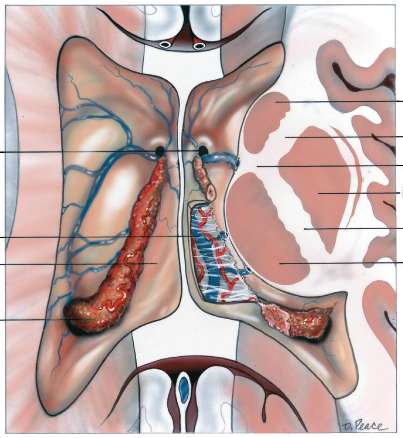


FIGURE 5.2. *Relationship of the internal capsule to the right lateral ventricle. The anterior limb of the internal capsule is separated from the lateral ventricle by the caudate nucleus, and the posterior limb is separated from the ventricle by the thalamus. The genu comes directly to the ventricular surface in the area lateral to the foramen of Monro in the interval between the caudate nucleus and thalamus. The right half of the body of the fornix has been removed to expose the internal cerebral veins in the roof of the third ventricle.*

Corpus Callosum

The corpus callosum, which forms the largest part of the ventricular walls, contributes to the wall of each of the five parts of the lateral ventricle (*Fig. 5.1B*). The corpus callosum has two anterior parts, the rostrum and genu, a central part, the body, and a posterior part, the splenium. The rostrum is situated below and forms the floor of the frontal horn. The genu has a large bundle of fibers, the forceps minor, that forms the anterior wall of the frontal horn as it sweeps obliquely forward and lateral to connect the frontal lobes. The genu and the body of the corpus callosum form the roof of both the frontal horn and the body of the lateral ventricle. The splenium contains a large fiber tract, the forceps major, that forms a prominence, called the bulb, in the upper part of the medial wall of the atrium and occipital horn as it sweeps posteriorly to connect the occipital lobes. Another fiber tract, the tapetum, which arises in the posterior part of the body and splenium of the corpus callosum, sweeps laterally and inferiorly to form the roof and lateral wall of the atrium and the temporal and occipital horns. The tapetum separates the fibers of the optic radiations from the temporal horn.

FIGURE 5.3. *Stepwise dissection used during our microsurgery courses to expose the lateral and third ventricles and the choroidal fissure.* A, *the dissection is begun by examining the relationships in the anterior transcallosal approach to the third ventricle. The right frontal lobe, between the large middle and posterior frontal bridging veins, has been retracted away from the falx to expose the anterior cerebral arteries coursing on the upper surface of the corpus callosum. The* inset *shows the relationship to the coronal suture. There is usually an area just in front of the coronal suture that is relatively devoid of bridging veins entering the superior sagittal sinus. The bone flap for the transcallosal approach is placed two-thirds in front and one-third behind the coronal suture.* B, *enlarged view. The falx and frontal lobe have been retracted to expose the anterior cerebral arteries above the corpus callosum. The veins draining the medial surface of the hemisphere often join the veins from the lateral surface to form large bridging veins that empty into the sagittal sinus.* C, *the corpus callosum has been opened to expose the fornix coursing anterior and superior to the foramen of Monro. The transcallosal opening has been completed without sacrificing a bridging vein.* D, *enlarged view. The anterior caudate and superior choroidal veins join the anterior end of the thalamostriate vein. The column of the fornix passes anterior and superior to the foramen of Monro. The choroidal fissure begins at the posterior edge of the foramen of Monro where the choroid plexus is attached by the tenia fimbria and tenia thalami to the fornix and thalamus. The floor of the frontal horn is formed by the rostrum of the corpus callosum, the medial wall by the septum pellucidum, and the lateral wall by the caudate nucleus.* E, *lateral view of the hemisphere. In the next step, the sulci and gyri on the lateral surface are examined (*Fig. 1.1*). The central sulcus ascends between the pre- and postcentral gyri. The precentral gyrus is located behind the pars opercularis. The postcentral gyrus is located in front of the anterior part of the supramarginal gyrus. To expose the ventricles for the dissection in the laboratory, an axial cut through the hemisphere is completed 1 cm above the posterior end of the long axis of the sylvian fissure (*broken line*).* F, *the same hemisphere after removal of the arteries and veins. The site of the cut (*broken line*) to expose the ventricles crosses the inferior frontal gyrus, the lower part of the central sulcus, and the supramarginal gyrus.* G, *superior view into the lateral ventricles. The caudate nucleus forms the lateral wall and the septum pellucidum forms the medial wall of the frontal horn and body of the lateral ventricle. The rostrum of the corpus callosum forms the floor of the frontal horn. The thalamus is in the floor of the body of the lateral ventricle. The third ventricle is located below the body of the fornix. The choroid plexus is attached along the choroidal fissure located between the fornix and thalamus.* H, *the frontoparietal operculum has been removed to expose the insula lateral to the frontal horn and body of the lateral ventricle. Branches of the middle cerebral artery cross the insula and the plana temporale and polare.* I, *superolateral view. The middle cerebral artery enters the operculoinsular compartment of the sylvian fissure by crossing the limen insula at the anteroinferior margin of the insula. The anterior part of the circular sulcus is separated from the frontal horn by the anterior isthmus of the central core of the hemisphere, and the posterior part of the circular sulcus is separated from the atrium by the posterior isthmus.* J, *enlarged view of the middle cerebral branches coursing along the insula. The upper temporal surface is formed posteriorly by the planum temporale where the transverse temporal gyri are located and anteriorly by the planum polare, an area free of gyri, which contains a shallow trough along which the middle cerebral artery courses. The lower part of the circular sulcus is located medial to the planum polare and temporale above the roof of the temporal horn.* *(Legend continues on page S1-215.)*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

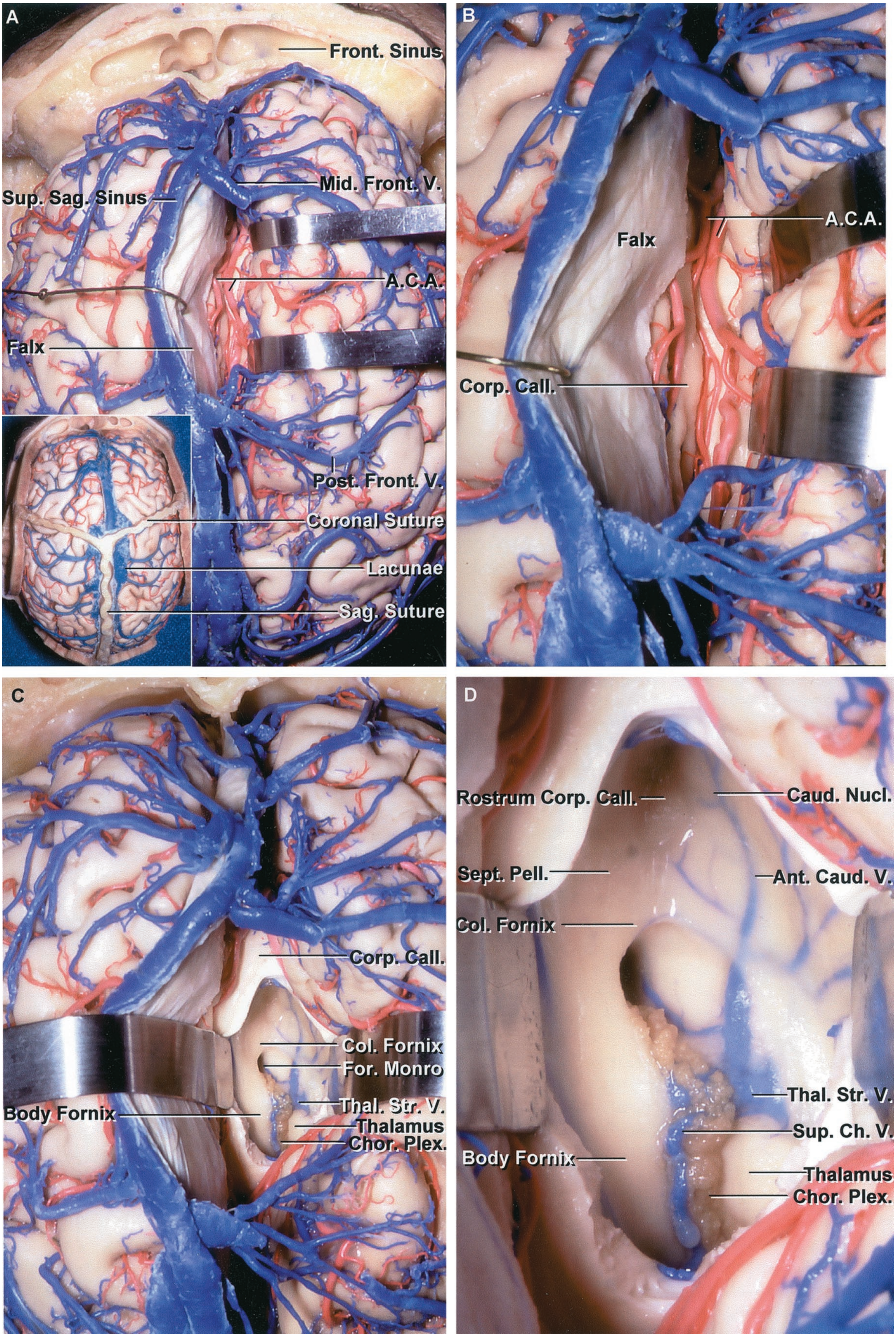


FIGURE 5.3.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

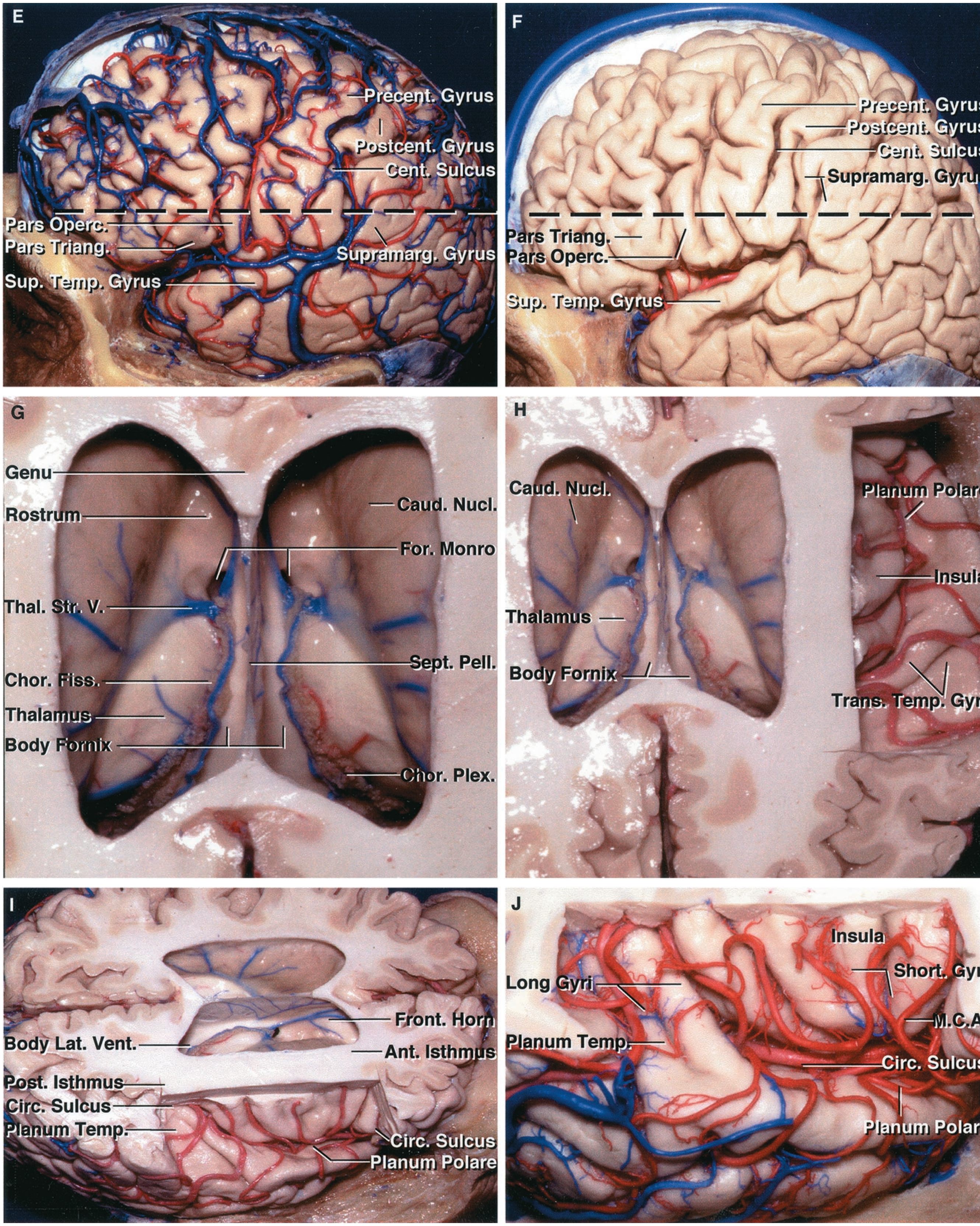


FIGURE 5.3. *Continued*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

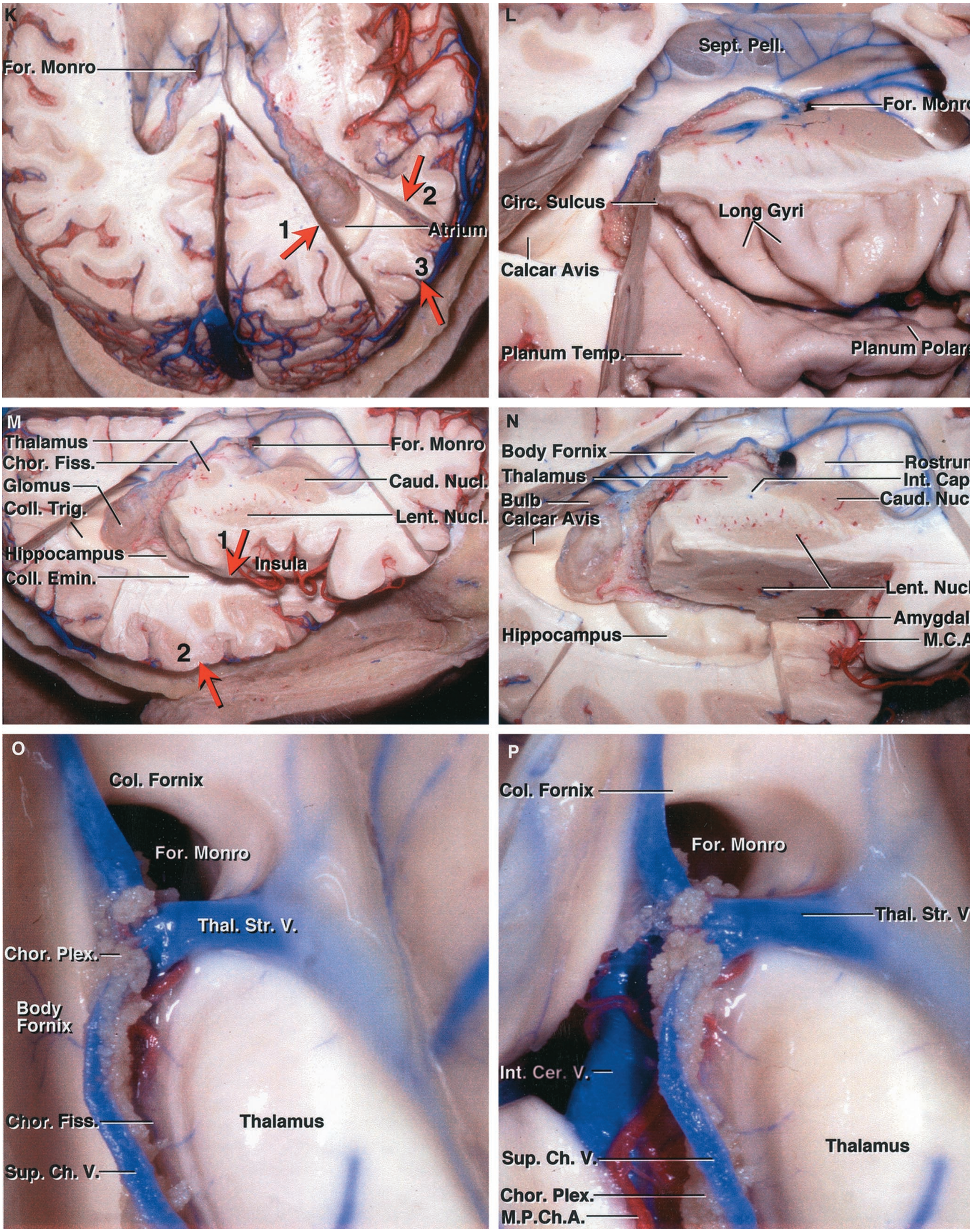


FIGURE 5.3. *Continued*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

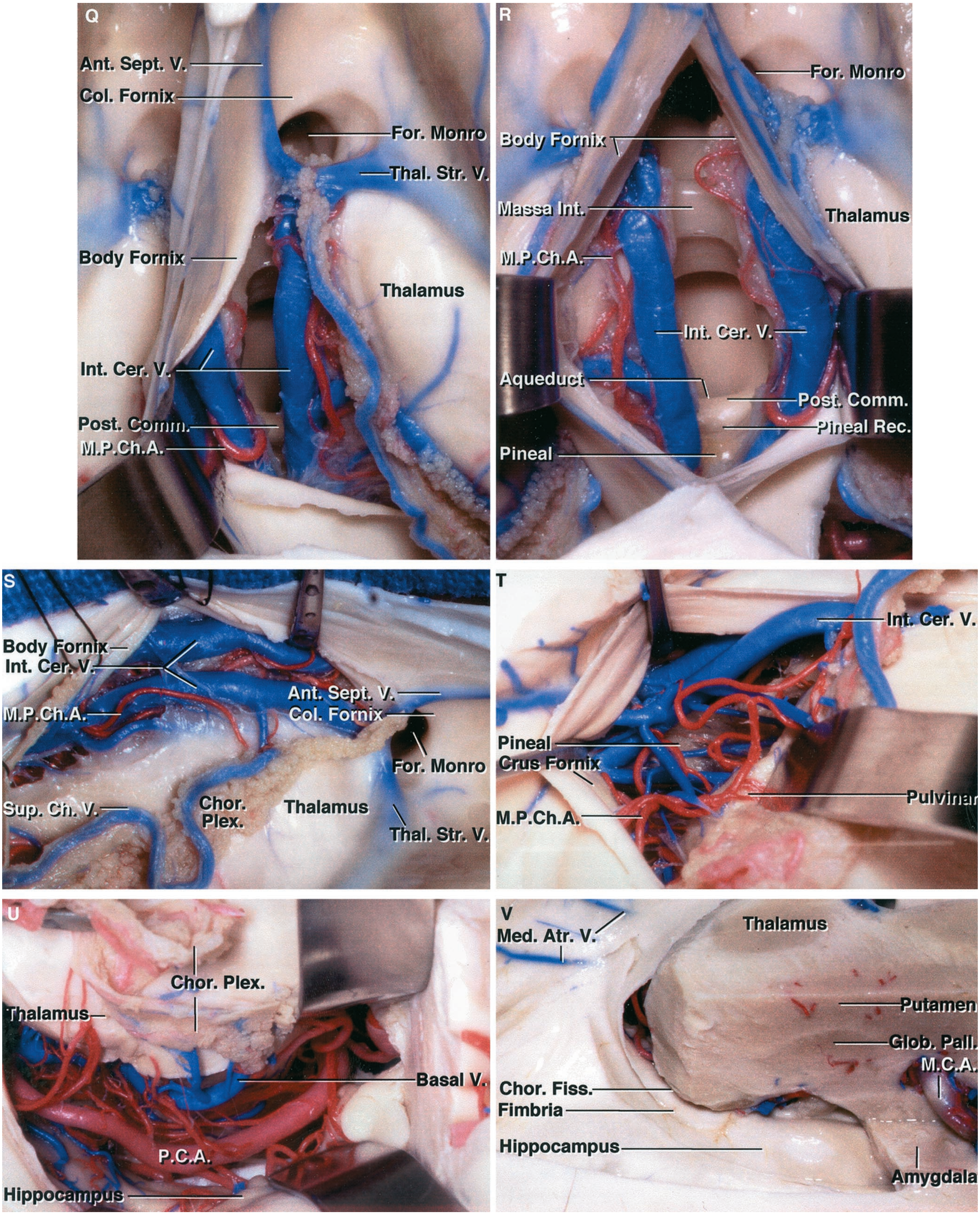


FIGURE 5.3. *Continued*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

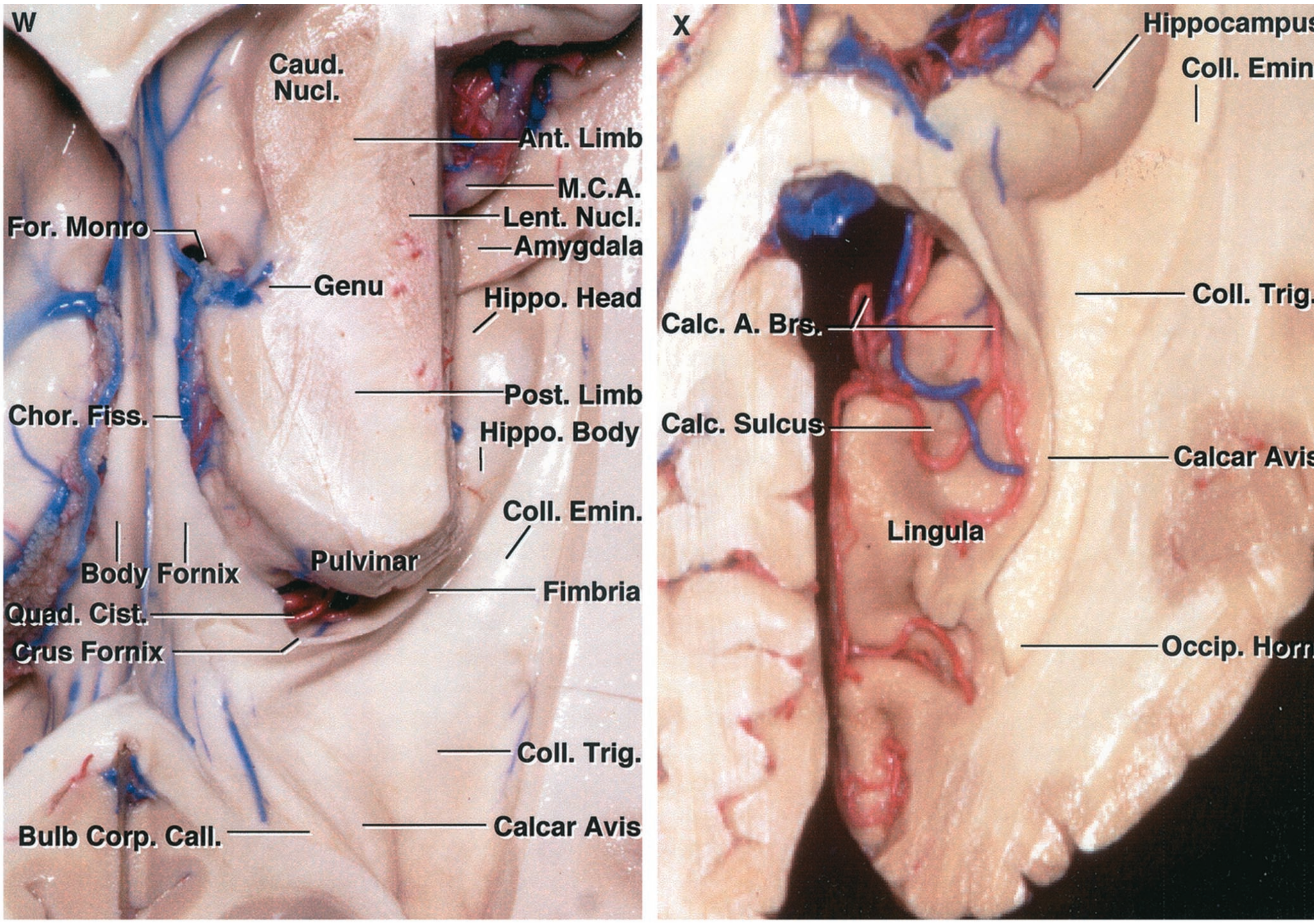
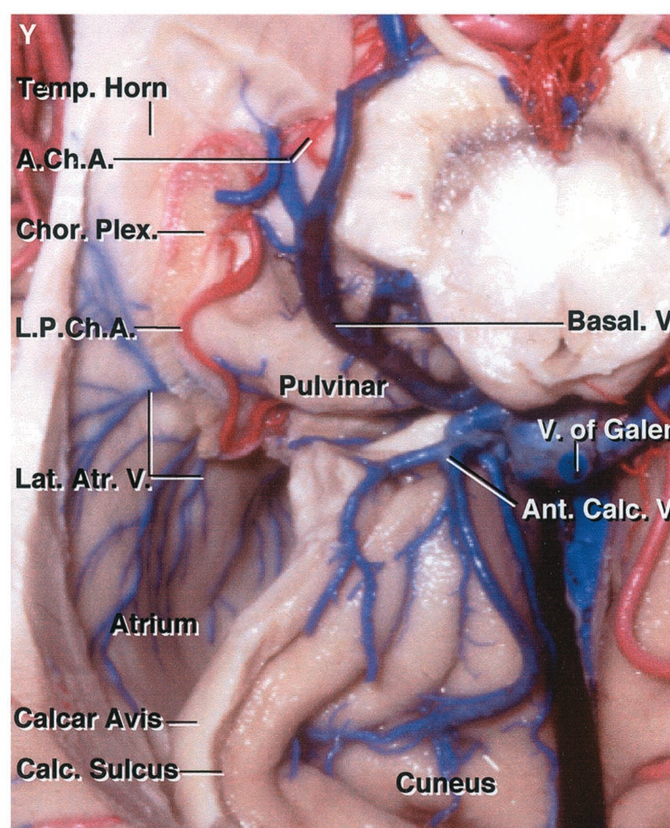


FIGURE 5.3. *Continued*

*K, the initial cut through the hemisphere exposes the frontal horns and bodies of the lateral ventricles. Three cuts, two coronal cuts and one horizontal, are then completed to expose the atrium and posterior part of the temporal horn. The posterior coronal cut (*No. 1*) is directed obliquely forward along the medial wall of the atrium. The second coronal cut (*No. 2*) crosses the hemisphere at the anterior part of the atrium just behind the pulvinar. The horizontal cut (*No. 3*) is located at the level of the floor of the atrium. The three cuts expose the atrium from the pulvinar back to the medial wall. L, superolateral view obtained with cuts shown in K. M, the temporal horn is exposed using two cuts. One (*No. 1*) is directed through the lower margin of the circular sulcus to the temporal horn, and the second is a transverse cut (*No. 2*) located at the level of the floor of the temporal horn. Removing the block of tissue between the two cuts exposes the temporal horn. The collateral eminence overlying the deep end of the collateral sulcus is well seen, but it is difficult to see the hippocampus because it is located further medially below the insula and lentiform nucleus. N, a sagittal cut medial to the insula exposes the lentiform nucleus. The incision extends through the lentiform nucleus and amygdala. The full length of the choroidal fissure from the foramen of Monro to the inferior choroidal point, located behind the head of the hippocampus, is exposed. The bulb of the corpus callosum overlying the forceps major and the calcar avis overlying the deep end of the calcarine sulcus are exposed in the medial wall of the atrium. O, enlarged view of the foramen of Monro. The columns of the fornix pass around the superior and anterior margins of the foramen of Monro. The anterior nucleus of the thalamus sits in the posterior margin of the foramen of Monro. The thalamostriate vein passes forward between the caudate nucleus and thalamus and through the posterior margin of the foramen of Monro. The choroidal fissure in the body of the lateral ventricle is located between the body of the fornix and the thalamus. A superior choroidal vein passes along the choroid plexus. (Legend continues on next page.)*



Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

Septum Pellucidum

The septum pellucidum, which is composed of paired laminae, separates the frontal horns and bodies of the lateral ventricles in the midline (*Fig. 5.1A*). In the frontal horn, the septum pellucidum is attached to the rostrum of the corpus callosum below, the genu anteriorly, and the body above. In the body of the lateral ventricle, the septum is attached to the body of the corpus callosum above and the body of the fornix below. The septum pellucidum is tallest anteriorly and shortest posteriorly, disappearing near the junction of the body and crura of the fornix where the crura and hippocampal commissure fuse with the lower surface of the corpus callosum. The anterior-posterior length of the septum pellucidum varies from 28 to 50 mm. There may be a cavity, the cavum septum pellucidum, in the midline between the laminae of the septum pellucidum.

Internal Capsule

The close relationship of the internal capsule to the lateral wall of the frontal horn and body of the lateral ventricle is often forgotten in planning operative approaches to the ventricles (*Figs. 5.2* and *5.3*). The anterior limb of the internal capsule, which is located between the caudate and lentiform nuclei, is separated from the frontal horn by the head of the caudate nucleus, and the posterior limb, which is situated between the thalamus and the lentiform nucleus, is separated from the body of the lateral ventricle by the thalamus and body of the caudate nucleus. However, the genu of the internal capsule comes directly to the ventricular surface and touches the wall of the lateral ventricle immediately lateral to the foramen of Monro, in the interval between the caudate nucleus and the thalamus.

Lateral Ventricular Walls

Frontal Horn

The frontal horn, the part of the lateral ventricle located anterior to the foramen of Monro, has a medial wall formed by the septum pellucidum, an anterior wall and roof formed by the genu of the corpus callosum, a lateral wall composed of the head of the caudate nucleus, and a narrow floor formed by the rostrum of the corpus callosum (*Figs. 5.3–5.5*). The columns of the fornix, as they pass anterior to the foramen of Monro, are in the posteroinferior part of the medial wall.

FIGURE 5.3. *Continued*
P, *the opening in the choroidal fissure is begun by dividing the tenia fornix, the delicate membrane that attaches the lateral margin of the fornix to the choroid plexus. Opening the tenia on the thalamic side, by opening the tenia thalami, carries greater risk of damaging the thalamostriate vein than opening the forniceal side of the fissure. The internal cerebral vein and medial posterior choroidal arteries are exposed in the roof of the third ventricle.* Q, *the opening in the choroidal fissure has been extended back to the area above the posterior commissure by dividing the tenia fornix. The choroid plexus is not disturbed on the thalamic side of the choroidal fissure. Branches of the medial posterior choroidal artery course with the internal cerebral veins.* R, *an interforniceal approach, in which the body of the fornix is divided longitudinally in the midline, has been completed. The massa intermedia, aqueduct, posterior commissure, pineal recess, and pineal are exposed.* S, *superolateral view of the dissection. The velum interpositum, located between the upper and lower layers of tela and in which the internal cerebral veins and medial posterior choroidal arteries course, has been exposed. The lower layer of tela attached to the striae medullaris thalami has not been opened. Both internal cerebral veins are exposed posterior to the foramen of Monro. If a vein at the foramen of Monro is to be sacrificed, it is preferable to sacrifice the anterior septal rather than the thalamostriate vein.* T, *the exposure has been extended back to the atrium where the choroid fissure has been opened by dividing the tenia fornix along the edge of the crus of the fornix. The medial posterior choroidal arteries pass along the side of the pineal and through the quadrigeminal cistern to reach the roof of the third ventricle.* U, *the opening in the choroidal fissure has been extended to the temporal horn. The choroidal fissure has been opened by dividing the tenia on the edge of the fimbria of the fornix to expose the posterior cerebral artery and basal veins. The choroid plexus remains attached to the thalamus.* V, *the choroid plexus in the right lateral ventricle has been removed. The medial atrial vein drains into the internal cerebral veins. The amygdala is exposed below the globus pallidus and just behind the middle cerebral artery coursing in the sylvian fissure. The amygdala forms the anterior wall and anterior part of the roof of the temporal horn and superiorly blends into the lower margin of the lentiform nucleus. The middle cerebral artery courses above the amygdala in the medial part of the sylvian fissure.* W, *superior view. The choroid plexus in the right lateral ventricle has been removed after opening the choroidal fissure from the foramen of Monro to the inferior choroidal point located just behind the head of the hippocampus. The axial section through the right hemisphere extends through the internal capsule. The genu of the internal capsule comes directly to the ventricular surface in the area lateral to the foramen of Monro. The lateral part of the floor of the temporal horn is formed by the collateral eminence, and the floor of the atrium is formed by the collateral triangle. Both the collateral eminence and trigone overlie the deep end of the collateral sulcus, which courses along the basal surface of the hemisphere between the parahippocampal and occipitotemporal gyri. The calcar avis, overlying the deep end of the calcarine sulcus, and the bulb, overlying the forceps major, are exposed in the medial wall of the atrium.* X, *superior view of the temporal and occipital horns with the upper part of the hemisphere removed. The section extends through the depths of the calcarine sulcus. The cuneus, forming the upper lip of the calcarine sulcus, has been removed to expose the lingula, forming the lower lip of the fissure. The calcarine sulcus extends so deeply into the medial part of the hemisphere that it produces a prominence, the calcar avis, in the medial wall of the atrium and occipital horn.* Y, *inferior view of the calcar avis. The lingula, forming the lower lip of the calcarine sulcus, has been removed to expose the cuneus, forming the upper lip of the sulcus. The calcarine sulcus cuts so deeply into the hemisphere that it produces a prominence in the medial wall of the atrium. The lateral atrial veins cross the lateral atrial wall. The lower part of the temporal lobe has been removed to expose the roof of the temporal lobe. The choroid plexus is attached to the lower surface of the thalamus. The anterior and lateral posterior choroidal arteries course along the medial edge of the choroid plexus. The anterior calcarine vein drains the depths of the calcarine sulcus.* A.C.A., *anterior cerebral artery;* A.Ch.A., *anterior choroidal artery;* Ant., *anterior;* Atr., *atrial;* Calc., *calcarine;* Call., *callosum;* Cap., *capsule;* Caud., *caudate;* Cent., *central;* Cer., *cerebral;* Ch., *choroidal;* Chor., *choroid, choroidal;* Circ., *circular;* Cist., *cistern;* Col., *column;* Coll., *collateral;* Corp., *corpus;* Emin., *eminence;* Fiss., *fissure;* For., *foramen;* Front., *frontal;* Glob., *globus;* Hippo., *hippocampal;* Int., *intermedia, internal;* Lat., *lateral;* Lent., *lenticular;* M.C.A., *middle cerebral artery;* Med., *medial;* Mid., *middle;* M.P.Ch.A., *medial posterior choroidal artery;* Nucl., *nucleus;* Operc., *opercularis;* Pall., *pallidus;* P.C.A., *posterior cerebral artery;* Pell., *pellucidum;* Plex., *plexus;* Post., *posterior;* Postcent., *postcentral;* Precent., *precentral;* Quad., *quadrigeminal;* Rec., *recess;* Sag., *sagittal;* Sept., *septal, septum;* Sup., *superior;* Supramarg., *supramarginal;* Temp., *temporal, temporale;* Thal. Str., *thalamostriate;* Triang., *triangularis;* Trig., *trigone;* V., *vein.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

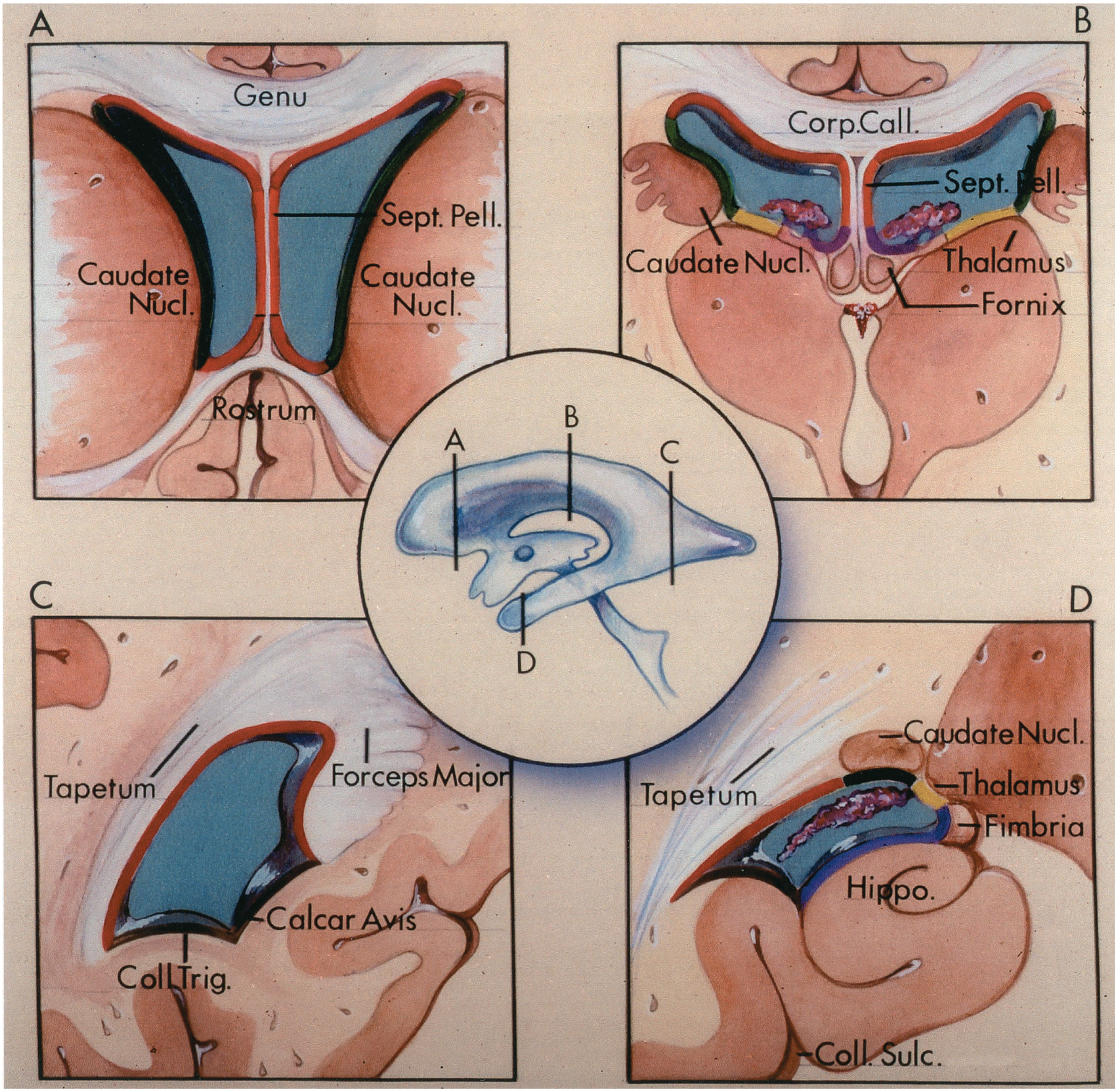


FIGURE 5.4. *Structures in the walls of the lateral ventricles. The* central *diagram shows the level of the cross sections through the frontal horn* (A)*, body* (B)*, atrium* (C)*, and temporal horn* (D)*. The ventricular surfaces formed by the various structures are shown in different colors: corpus callosum,* red*; thalamus,* yellow*; fornix and hippocampal formation,* purple*; caudate nucleus,* green*; septum pellucidum,* orange*; and the prominences overlying the collateral and calcarine sulci,* brown. A, *frontal horn. The genu of the corpus callosum is in the roof, the caudate nucleus is in the lateral wall, the rostrum of the corpus callosum is in the floor, and the septum pellucidum is in the medial wall.* B, *body of the lateral ventricle. The body of the corpus callosum is in the roof, the caudate nucleus is in the lateral wall, the thalamus is in the floor, and the septum pellucidum and fornix are in the medial wall. The choroidal fissure, the site of the attachment of the choroid plexus in the lateral ventricle, is situated between the fornix and the thalamus.* C, *atrium. The lateral wall and roof are formed by the tapetum of the corpus callosum, and the floor is formed by the collateral trigone, which overlies the collateral sulcus. The inferior part of the medial wall is formed by the calcar avis, the prominence that overlies the deep end of the calcarine sulcus, and the superior part of the medial wall is formed by the bulb of the corpus callosum, which overlies the forceps major.* D, *temporal horn. The medial part of the floor of the temporal horn is formed by the prominence overlying the hippocampal formation, and the lateral part of the floor is formed by the prominence called the collateral eminence, which overlies the deep end of the collateral sulcus. The roof is formed by the caudate nucleus and the tapetum of the corpus callosum, the lateral wall is formed by the tapetum of the corpus callosum, and the medial wall of the temporal horn is little more than the cleft between the fimbria of the fornix and the inferolateral aspect of the thalamus.* Call., *callosum;* Coll., *collateral;* Corp., *corpus;* Hippo., *hippocampus;* Nucl., *nucleus;* Pell., *pellucidum;* Sept., *septum;* Sulc., *sulcus;* Trig., *trigone.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

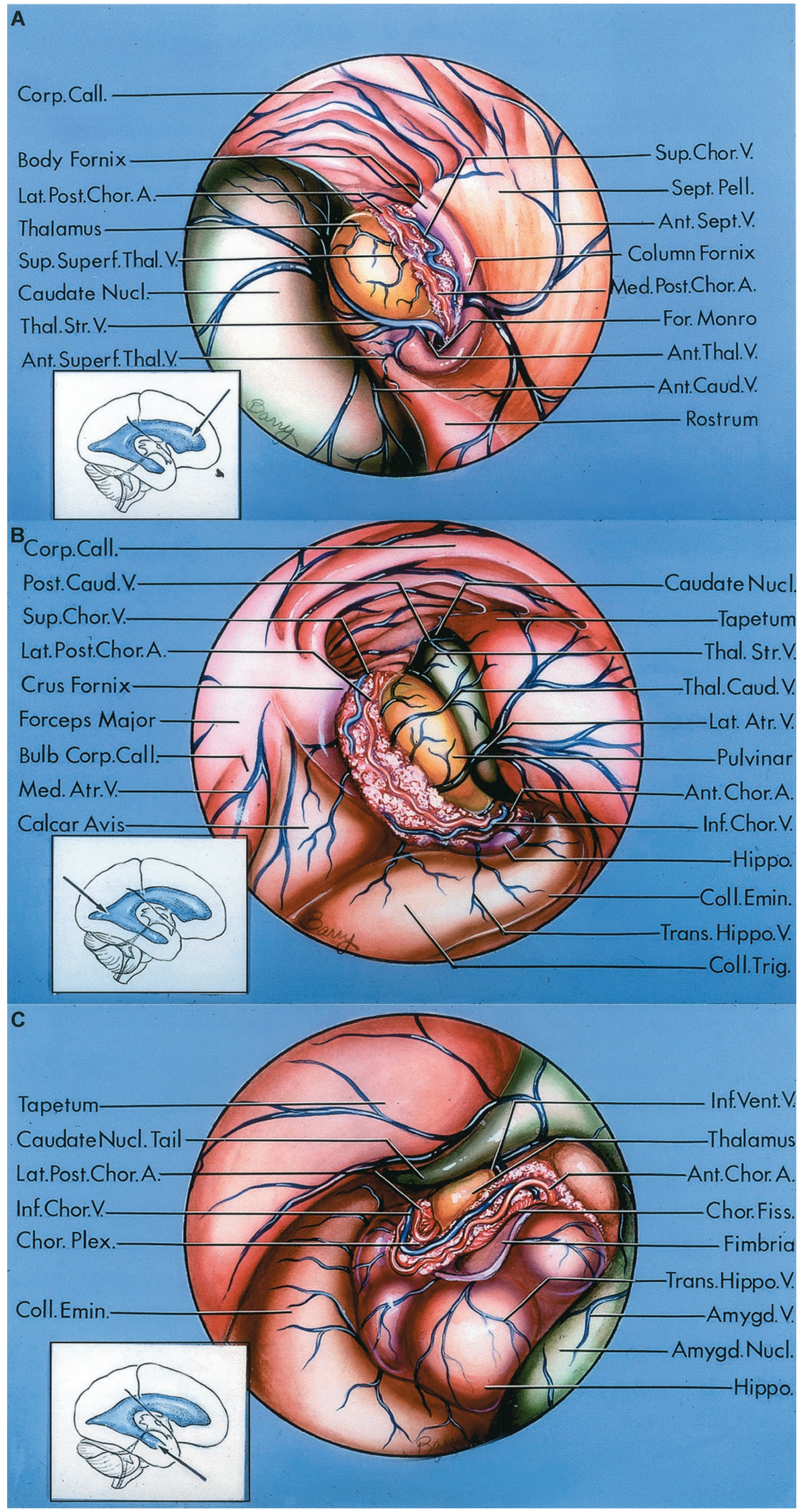


FIGURE 5.5. *Views into the lateral ventricles. The structures in the walls of the ventricle are shown in different colors: thalamus,* yellow; *caudate and amygdaloid nucleus,* green; *corpus callosum,* red; *fornix and hippocampal formation,* purple; *septum pellucidum,* orange; *and the prominences over the calcarine and collateral sulci,* brown. A, *anterior view, along the* arrow in the inset, *into the frontal horn and body of the lateral ventricle. The frontal horn is located anterior to the foramen of Monro and has the septum pellucidum in the medial wall, the genu and the body of the corpus callosum in the roof, the caudate nucleus in the lateral wall, the genu of the corpus callosum in the anterior wall, and the rostrum of the corpus callosum in the floor. The body of the lateral ventricle has the thalamus in its floor, the caudate nucleus in the lateral wall, the body of the fornix and septum pellucidum in the medial wall, and the corpus callosum in the roof. The choroid plexus is attached along the choroidal fissure, the cleft between the fornix and thalamus. The superior choroidal vein and branches of the lateral and medial posterior choroidal arteries course on the surface of the choroid plexus. The anterior and posterior septal veins cross the roof and the medial wall of the frontal horn and body. The anterior and posterior caudate veins cross the lateral wall of the frontal horn and body and join the thalamostriate vein, which passes through the foramen of Monro. A superior superficial thalamic vein courses on the thalamus.* B, *posterior view, along the* arrow in the inset, *into the atrium. The atrium has the tapetum of the corpus callosum in the roof, the bulb of the corpus callosum and the calcar avis in its medial wall, the collateral trigone in the floor, the caudate nucleus and tapetum in the lateral wall, and the crus of the fornix, pulvinar, and choroid plexus in the anterior wall. The temporal horn has the hippocampal formation and collateral eminence in the floor and the thalamus, tail of the caudate nucleus, and tapetum in the roof and the lateral wall. Branches of the anterior and lateral posterior choroidal arteries course on the surface of the choroid plexus. A thalamocaudate vein drains the part of the lateral wall of the body behind the area drained by the thalamostriate vein. The inferior choroidal vein courses on the choroid plexus in the temporal horn. The lateral and medial atrial veins cross the medial and lateral walls of the atrium. Transverse hippocampal veins cross the floor of the atrium and temporal horn.* C, *anterior view, along the* arrow in the inset, *into the temporal horn. The floor of the temporal horn is formed by the collateral eminence and the hippocampal formation. The roof and lateral wall are formed, from medial to lateral, by the thalamus, the tail of the caudate nucleus, and the tapetum of the corpus callosum. The medial wall is little more than the cleft between the thalamus and the fimbria, called the choroidal fissure, along which the choroid plexus is attached. The amygdaloid nucleus bulges into the anteromedial part of the temporal horn. The fimbria of the fornix arises on the surface of the hippocampal formation. Branches of the anterior and lateral posterior choroidal arteries course on the surface of the choroid plexus. The inferior ventricular vein drains the roof of the temporal horn and receives the amygdalar vein from the ventricular surface of the amygdaloid nucleus. The inferior choroidal vein joins the inferior ventricular vein. The transverse hippocampal veins drain the floor of the temporal horn.* A., *artery;* Amygd., *amygdaloid;* Ant., *anterior;* Atr., *atrial;* Call., *callosum;* Caud., *caudate;* Chor., *choroid, choroidal;* Coll., *collateral;* Corp., *corpus;* Emin., *eminence;* For., *foramen;* Hippo., *hippocampal, hippocampus;* Inf., *inferior;* Lat., *lateral;* Med., *medial;* Nucl., *nucleus;* Pell., *pellucidum;* Plex., *plexus;* Post., *posterior;* Sept., *septal, septum;* Sup., *superior;* Superf., *superficial;* Thal., *thalamic;* Thal.Str., *thalamostriate;* Trans., *transverse;* Trig., *trigone;* V., *vein.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

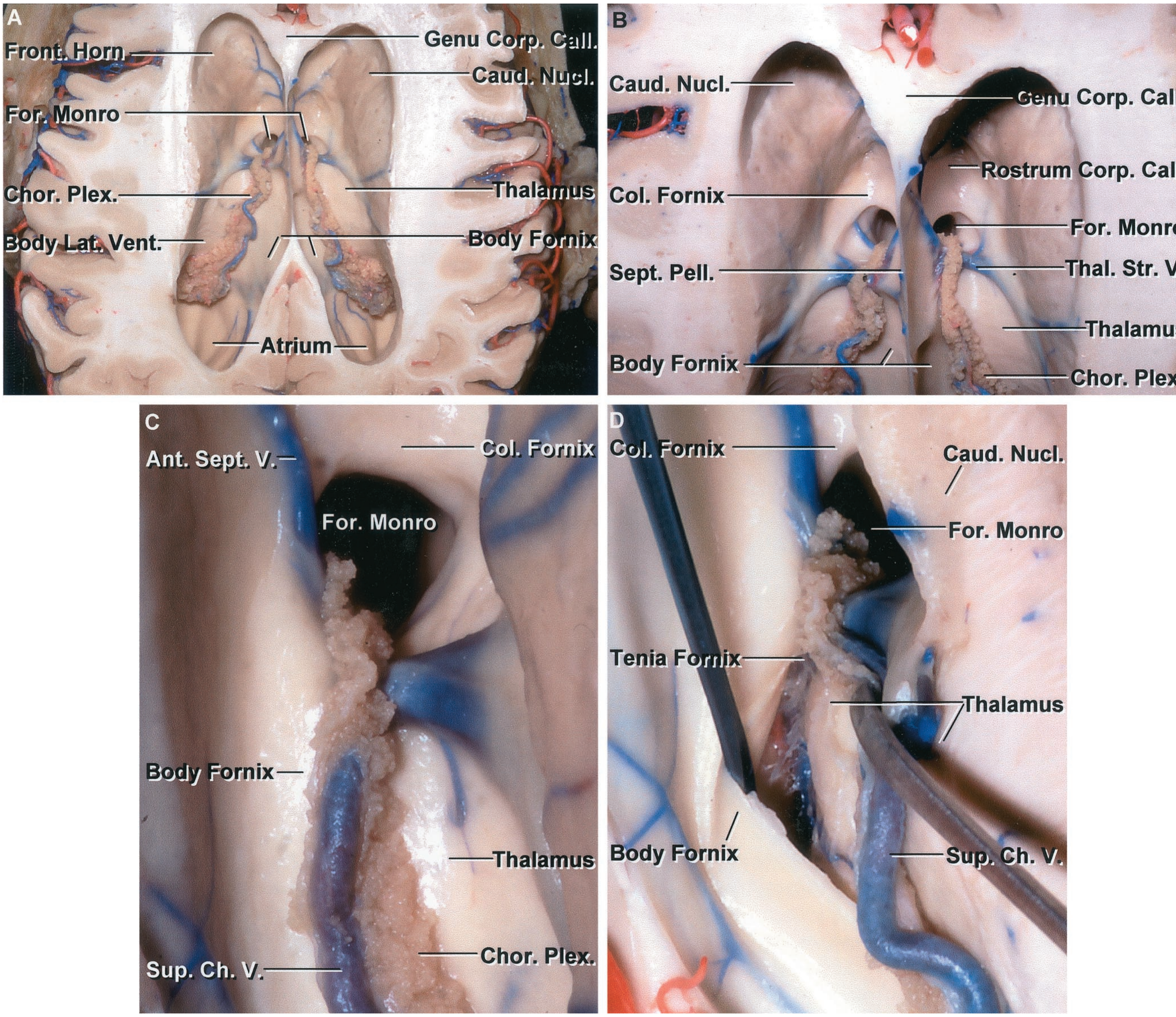
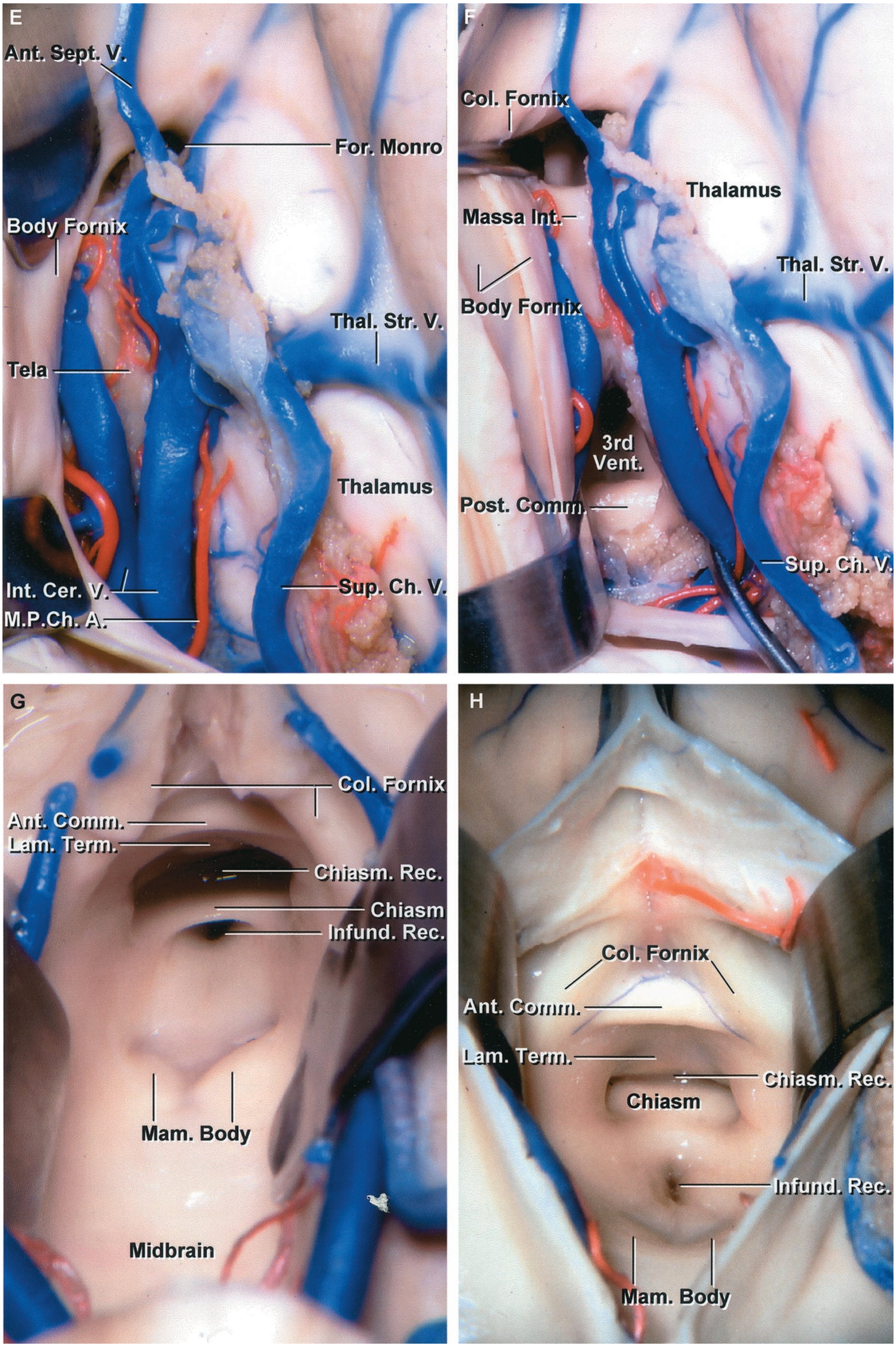


FIGURE 5.6. *Stepwise dissection of the choroidal fissure.* A, *superior view of the lateral ventricles. The choroidal fissure is the cleft between the fornix and the thalamus along which the choroid plexus is attached. The frontal horn is located anterior and the ventricular body behind the foramen of Monro. The thalamus forms the floor of the body of the lateral ventricle and the anterior wall of the atrium.* B, *enlarged view. The columns of the fornix form the anterior and superior margins of the foramen of Monro. The choroid plexus in the body extends through the posterior margin of the foramen of Monro and is continuous with the choroid plexus in the roof of the third ventricle. The right thalamostriate vein passes through the posterior edge of the foramen of Monro and the left thalamostriate vein passes through the choroidal fissure behind the foramen. The floor of the frontal horn is formed by the rostrum, and the anterior wall is formed by the genu of the corpus callosum. The lateral wall is formed by the caudate nucleus. The septum pellucidum is attached to the upper edge of the body of the fornix.* C, *enlarged view of the foramen of Monro. The columns of the fornix form the anterior and superior margins of the foramen. An anterior septal vein passes backward along the septum pellucidum and crosses the column of the fornix. The thalamostriate vein passes forward between the caudate nucleus and thalamus and turns medially to pass through the posterior margin of the foramen of Monro to empty into the internal cerebral vein. The choroid plexus is attached medially by the tenia fornix to the body of the fornix and laterally by the tenia thalami to the thalamus.* D, *the transchoroidal exposure is begun by dividing the tenia fornix that attaches the choroid plexus to the margin of the fornix. The tenia thalami that attaches the choroid plexus to the thalamus is not opened.* E, *the opening of the choroidal fissure has been extended backward from the foramen of Monro to expose both internal cerebral veins and the medial posterior choroidal arteries coursing in the velum interpositum. The anterior septal vein crosses the septum pellucidum. The lower layer of tela choroidea, attached to the striae medullaris thalami deep to the internal cerebral veins, is intact.* F, *the lower layer of tela choroidea that forms the floor of the velum interpositum has been opened, exposing the massa intermedia and posterior commissure within the third ventricle.* G, *the internal cerebral veins have been separated to expose the anteroinferior part of the third ventricle. The upper end of the midbrain forms the posterior part of the floor of the third ventricle. The mamillary bodies are situated in the midportion of the floor. The floor anterior to the mamillary bodies and behind the infundibular recess in very thin and is the site commonly opened in a third ventriculostomy. The chiasmatic recess extends forward above the posterior edge of the optic chiasm and below the anterior commissure.* *(Legend continues on next page.)*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

FIGURE 5.6. *Continued*
H, *enlarged view of the inner surface of the anterior wall of the third ventricle. The columns of the fornix extend downward behind the anterior commissure toward the mamillary bodies. The lamina terminalis, chiasmatic recess, posterior edge of the chiasm, and the infundibular recess are located along the anterior and lower wall of the third ventricle.* I, *the opening along the choroidal fissure has been extended posteriorly by opening the tenia fornix along the edge of the body and crus of the fornix. The upper part of the quadrigeminal cistern, where the internal cerebral veins converge on the vein of Galen, has been exposed. The medial posterior choroidal arteries course with the internal cerebral veins.* J, *the opening of the choroidal fissure has been extended downward along the choroidal fissure to the central part of the quadrigeminal cistern, exposing the basal and internal cerebral veins, pineal, and superior colliculus. Branches of the medial posterior choroidal arteries course beside the pineal.* K, *enlarged view. The tip of the pineal projects posteriorly above the superior colliculus and between the terminal part of the internal cerebral veins.* L, *the dissection has been extended forward along the choroidal fissure toward the temporal horn by dividing the tenia on the edge of the fimbria of the fornix to expose the basal vein, posterior cerebral arteries, and trochlear nerve in the posterior part of the ambient cistern below the thalamus.* M, *the choroidal fissure in the temporal horn has been opened by dividing the tenia fimbria. The choroid plexus attachment to the thalamus has not been disturbed. The posterior cerebral artery and basal vein course through the ambient cistern on the medial side of the temporal portion of the choroidal fissure.*



Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

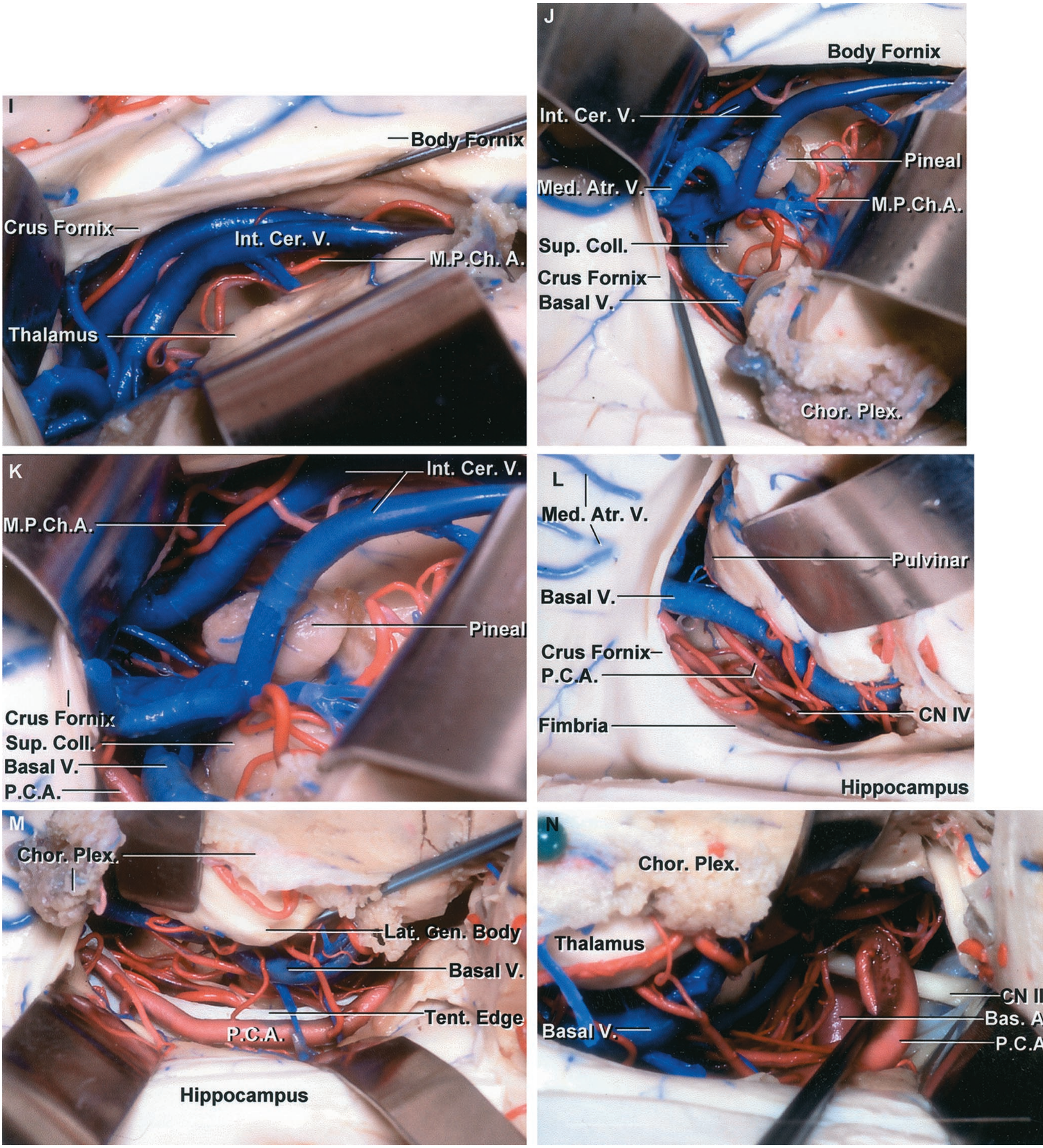


FIGURE 5.6. *Continued*
N, *the exposure has been extended through the amygdala anterior to the choroidal fissure to expose the oculomotor nerve and origin of the posterior cerebral artery. The posterior cerebral artery passes above the oculomotor nerve.* A., *artery;* Ant., *anterior;* Bas., *basilar;* Call., *callosum;* Caud., *caudate;* Cer., *cerebral;* Ch., *choroidal;* Chiasm., *chiasmatic;* Chor., *choroid;* Col., *column;* Coll., *colliculus;* Comm., *commissure;* Corp., *corpus;* CN, *cranial nerve;* For., *foramen;* Front., *frontal;* Gen., *geniculate;* Infund., *infundibular;* Int., *intermedia, internal;* Lam., *lamina;* Lat., *lateral;* Mam., *mamillary;* M.P.Ch.A., *medial posterior choroidal artery;* Nucl., *nucleus;* P.C.A., *posterior cerebral artery;* Pell., *pellucidum;* Plex., *plexus;* Rec., *recess;* Sept., *septal, septum;* Tent., *tentorial;* Term., *terminalis;* Thal. Str., *thalamostriate;* V., *vein;* Vent., *ventricle.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

Body

The body of the lateral ventricle extends from the posterior edge of the foramen of Monro to the point where the septum pellucidum disappears and the corpus callosum and fornix meet (*Figs. 5.3–5.5*). The roof is formed by the body of the corpus callosum, the medial wall by the septum pellucidum above and the body of the fornix below, the lateral wall by the body of the caudate nucleus, and the floor by the thalamus. The caudate nucleus and thalamus are separated by the striothalamic sulcus, the groove in which the stria terminalis and the thalamostriate vein course.

Atrium and Occipital Horn

The atrium and occipital horn together form a roughly triangular cavity, with the apex posteriorly in the occipital lobe and the base anteriorly on the pulvinar (*Figs. 5.3–5.5*). The atrium opens anteriorly above the thalamus into the body, anteriorly below the thalamus into the temporal horn, and posteriorly into the occipital horn. The roof of the atrium is formed by the body, splenium, and tapetum of the corpus callosum. The medial wall is formed by two roughly horizontal prominences that are located one above the other. The upper prominence, called the bulb of the corpus callosum, overlies and is formed by the large bundle of fibers called the forceps major, and the lower prominence, called the calcar avis, overlies the deepest part of the calcarine sulcus. The lateral wall has an anterior part, formed by the caudate nucleus as it wraps around the lateral margin of the pulvinar, and a posterior part, formed by the fibers of the tapetum as they sweep anteroinferiorly along the lateral margin of the ventricle. The anterior wall has a medial part composed of the crus of the fornix as it wraps around the posterior part of the pulvinar, and a lateral part, formed by the pulvinar of the thalamus. The floor is formed by the collateral trigone, a triangular area that bulges upward over the posterior end of the collateral sulcus. In the atrium, the choroid plexus has a prominent tuft called the glomus.

The occipital horn extends posteriorly into the occipital lobe from the atrium. It varies in size from being absent to extending far posteriorly in the occipital lobe, and it may vary in size from side to side. Its medial wall is formed by the bulb of the corpus callosum and the calcar avis, the roof and lateral wall are formed by the tapetum, and the floor is formed by the collateral trigone.

Temporal Horn

The temporal horn extends forward from the atrium below the pulvinar into the medial part of the temporal lobe and ends blindly in an anterior wall that is situated immediately behind the amygdaloid nucleus (*Figs. 5.3–5.5*). The floor of the temporal horn is formed medially by the hippocampus, the smooth prominence overlying the hippocampal formation, and laterally by the collateral eminence, the prominence overlying the collateral sulcus that separates the parahippocampal and occipitotemporal gyri on the inferior surface of the temporal lobe. The medial part of the roof is formed by the inferior surface of the thalamus and the tail of the caudate nucleus, which are separated by the striothalamic sulcus. The lateral part of the roof is formed by the tapetum of the corpus callosum, which also sweeps inferiorly to form the lateral wall of the temporal horn. The tapetum separates the temporal horn from the optic radiations. The only structure in the medial wall is the narrow cleft, the choroidal fissure, situated between the inferolateral part of the thalamus and the fimbria of the fornix.

Choroidal Fissure and Choroid Plexus

The choroidal fissure is the narrow C-shaped cleft between the fornix and the thalamus along which the choroid plexus is attached (*Figs. 5.3–5.6*). When the choroid plexus of the lateral ventricle is torn away, the fissure is seen as a narrow cleft situated in the medial part of the body, atrium, and temporal horn. The fornix forms the outer margin of the fissure, and the thalamus forms the inner margin. The choroidal fissure is limited in the body of the ventricle by the body of the fornix superiorly and by the thalamus inferiorly, in the atrium by the crus of the fornix posteriorly and the pulvinar anteriorly, and in the temporal horn by the fimbria of the fornix below and the stria terminalis and thalamus above. The choroidal fissure extends in a C-shaped arc from the foramen of Monro around the superior, inferior, and posterior surfaces of the thalamus to its inferior termination, called the inferior choroidal point, which is located just behind the head of the hippocampus and lateral to the lateral geniculate body. The thalamus is situated so that the part of its surface lateral to the choroidal fissure forms part of the wall of the lateral ventricle, and the part medial to the fissure forms part of the wall of the third ventricle or basal cisterns.

The choroid plexus from each lateral ventricle extends through the foramen of Monro and is continuous with the two parallel strands of choroid plexus in the roof of the third ventricle. In the atrium, the choroid plexus forms a prominent triangular tuft called the glomus. The edges of the thalamus and fornix bordering this choroidal fissure have small ridges, called the teniae, along which the tela choroidea, the membrane in which the choroid plexus arises, is attached. The tenia on the thalamic side is called the tenia thalami or tenia choroidea. The tenia on the forniceal side of the fissure is called the tenia fornicis, except in the temporal horn where it is referred to as the tenia fimbriae.

The choroidal fissure is formed at approximately 8 weeks of embryonic development when the vascular pia mater that forms the epithelial roof of the third ventricle invaginates into the medial wall of the cerebral hemisphere. No nervous tissue develops between the ependyma and pia mater along this invagination that forms the choroidal fissure, thus creating the thinnest site in the wall of the lateral ventricle. The choroidal arteries, which supply the choroid plexus, arise from the internal carotid and posterior cerebral arteries and enter the ventricles through the choroidal fissure. In addition, the veins coursing in the walls of the ventricles exit the ventricles by passing through the margin of the choroidal fissure in the subependymal location to reach the internal cerebral, basal, or

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

great veins. Opening through the fissure from the lateral ventricle during intracranial operations provides access to several structures that are difficult or impossible to expose through the extracerebral route.

The choroidal fissure is divided into body, atrial, and temporal parts. The body portion is situated in the body of the lateral ventricle between the body of the fornix and the superior surface of the thalamus (*Figs. 5.5* and *5.7*). The velum interpositum, through which the internal cerebral veins course, is located on the medial side of the body portion of the fissure in the roof of the third ventricle. Opening through the choroidal fissure from the body of the ventricle will expose the velum interpositum and the roof of the third ventricle. The choroidal fissure and choroid plexus do not extend into the frontal horn; however, some operative approaches to the superior part of the choroidal fissure are directed through the frontal horn and adjacent part of the body. The atrial part is located in the atrium of the lateral ventricle between the crus of the fornix and the pulvinar (*Figs. 5.5* and *5.8*). The fissure does not extend into the occipital horn. The quadrigeminal cistern, the pineal region, and the posterior portion of the ambient cistern can be exposed by opening through the fissure from the atrium. The temporal part is situated in the temporal horn between the fimbria of the fornix and the inferolateral surface of the thalamus (*Figs. 5.5* and *5.9*). Opening through the choroidal fissure in the temporal horn exposes the structures in the ambient and posterior part of the crural cisterns. The cisternal side of the temporal portion of the fissure is situated in the superolateral edge of the ambient cistern. The fissure is the thinnest site in the wall of the lateral ventricle bordering the basal cisterns and the roof of the third ventricle.

THIRD VENTRICLE

The third ventricle is located in the center of the head, below the corpus callosum and the body of the lateral ventricle, above the sella turcica, pituitary gland, and midbrain, and between the cerebral hemispheres, the two halves of the thalamus, and the two halves of the hypothalamus (*Figs. 5.10* and *5.11*). It is intimately related to the circle of Willis and its branches and the great vein of Galen and its tributaries. Tumors in the region of the third ventricle are among the most difficult to expose and remove.

Manipulation of the walls of the third ventricle may cause hypothalamic dysfunction, as manifested by disturbances of consciousness, temperature control, respiration, and hypophyseal

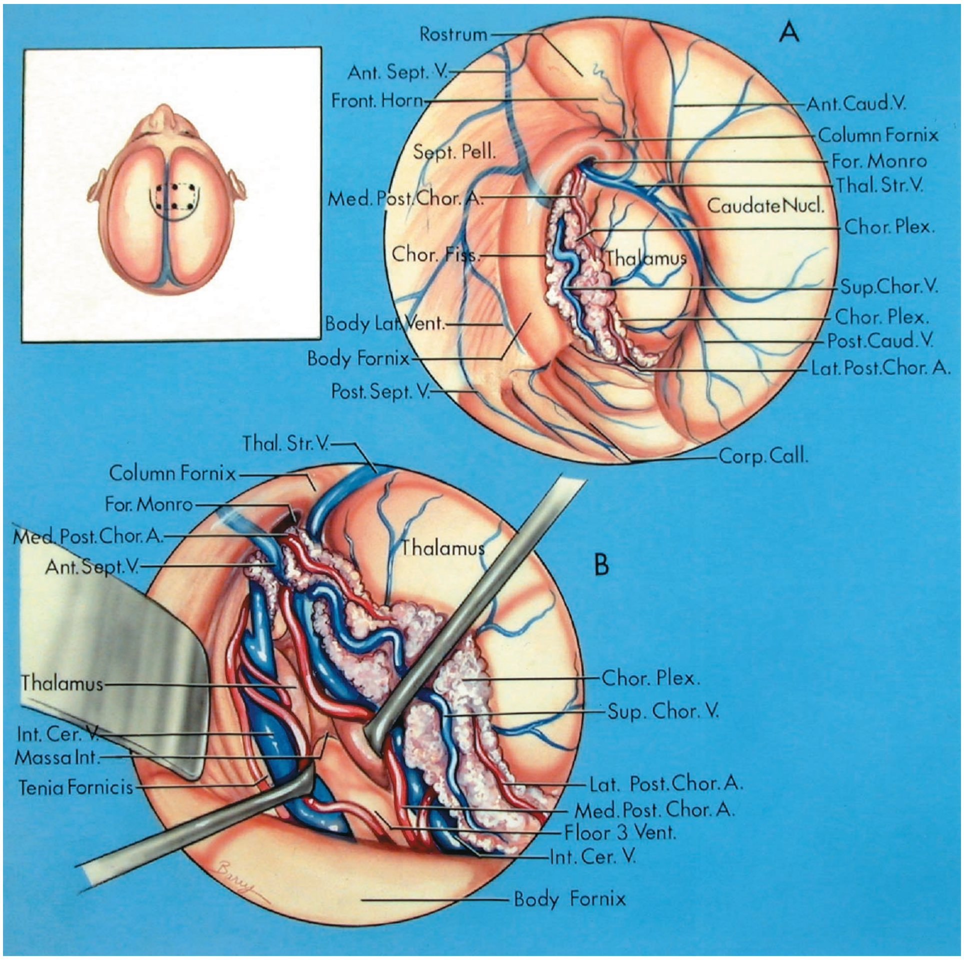


FIGURE 5.7. *Transchoroidal approach directed through the body portion of the choroidal fissure using an opening through the corpus callosum. The site of the scalp incision and bone flap are shown in the* inset. A, *operative exposure of the frontal horn and body of the right lateral ventricle. The choroidal fissure lies deep to the choroid plexus. Structures in the wall of the lateral ventricle include the thalamus, caudate nucleus fornix, foramen of Monro, septum pellucidum, and the rostrum of the corpus callosum. Vascular structures that converge on the choroidal fissure include the medial and lateral posterior choroidal arteries and the anterior and posterior septal, anterior and posterior caudate, superior choroidal, and thalamostriate veins.* B, *the choroidal fissure has been opened by incising along the tenia fornicis. The layers of tela choroidea in the roof of the third ventricle have been opened and the massa intermedia and interior and floor of the third ventricle have been exposed by separating the internal cerebral veins. The medial posterior choroidal arteries course around the internal cerebral veins.* A., *artery;* Ant., *anterior;* Call., *callosum;* Caud., *caudate;* Cer., *cerebral;* Chor., *choroid, choroidal;* Fiss., *fissure;* For., *foramen;* Front., *frontal;* Int., *intermedia, internal;* Lat., *lateral;* Med., *medial;* Nucl., *nucleus;* Pell., *pellucidum;* Plex., *plexus;* Post., *posterior;* Sept., *septal, septum;* Sup., *superior;* Thal. Str., *thalamostriate;* V., *vein;* Vent., *ventricle. (*From, *Nagata S, Rhoton AL Jr, Barry M: Microsurgical anatomy of the choroidal fissure.* ***Surg Neurol*** *30:3–59, 1988 [15].)*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

secretion, visual loss due to damage of the optic chiasm and tracts, and memory loss due to injury to the columns of the fornix in the walls of the third ventricle (24, 28, 37).

Neural Relationships

The third ventricle is a narrow, funnel-shaped, unilocular, midline cavity. It communicates at its anterosuperior margin with each lateral ventricle through the foramen of Monro and posteriorly with the fourth ventricle through the aqueduct of sylvius. It has a roof, a floor, and an anterior, posterior, and two lateral walls.

Roof

The roof of the third ventricle forms a gentle upward arch, extending from the foramen of Monro anteriorly to the suprapineal recess posteriorly (*Figs. 5.10–5.13*). The roof has four layers: one neural layer formed by the fornix, two thin membranous layers of tela choroidea, and a layer of blood vessels between the sheets of tela choroidea. The choroidal fissure is located in the lateral margin of the roof. The upper layer of the anterior part of the roof of the third ventricle is formed by the body of the fornix, and the posterior part of the roof is formed by the crura and the hippocampal commissure. The septum pellucidum is attached to the upper surface of the body of the fornix.

The tela choroidea forms two of the three layers in the roof below the layer formed by the fornix. The tela choroidea consists of two thin, semiopaque membranes derived from the pia mater, which are interconnected by loosely organized trabeculae. The final layer in the roof is a vascular layer located between the two layers of tela choroidea. The vascular layer consists of the medial posterior choroidal arteries and their branches and the internal cerebral veins and their tributaries. Parallel strands of choroid plexus project downward on each side of the midline from the inferior layer of tela choroidea into the superior part of the third ventricle.

The velum interpositum is the space between the two layers of tela choroidea in the roof of the third ventricle. It is located on the medial side of the body portion of the choroidal fissure in the roof of the third ventricle below the body of the fornix and between the superomedial surfaces of the thalami. The upper layer of the tela choroidea is attached to the lower surface of the fornix and the hippocampal commissure. The lower wall has an anterior part that is attached to the small ridges on the free edge of the fiber tracts, called the striae medullaris thalami, that extend along the superomedial bor-

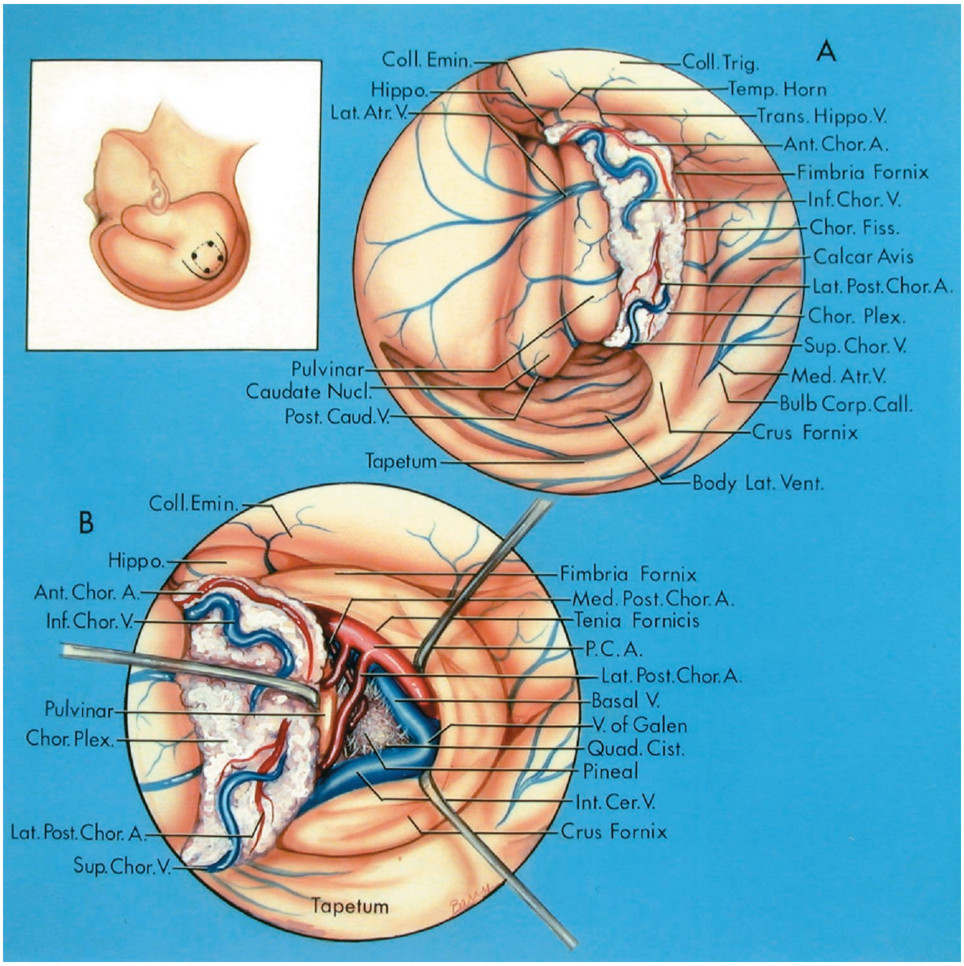


FIGURE 5.8. *Transchoroidal approach directed through the atrial portion of the choroidal fissure using a cortical incision in the superior parietal lobule. The site of the scalp incision, bone flap, and cortical incision are shown in the* inset. A, *the choroid plexus is attached along the choroidal fissure. The atrial portion of the choroidal fissure is situated between the crus of the fornix and the pulvinar. Structures in the wall of the atrium, body, and temporal horn of the lateral ventricle include the pulvinar, fornix, caudate nucleus, tapetum and bulb of the corpus callosum, calcar avis, hippocampal formation, and the collateral eminence and trigone. Vascular structures that converge on the choroidal fissure include the anterior and lateral posterior choroidal arteries and the lateral and medial atrial, posterior caudate, superior and inferior choroidal, and transverse hippocampal veins.* B, *the choroidal fissure has been opened by incising the tenia fornicis and retracting the crus of the fornix posteriorly to expose the quadrigeminal cistern, posterior cerebral and medial posterior choroidal arteries, pineal body, and internal cerebral, basal, and great veins.* A., *artery;* Ant., *anterior;* Atr., *atrial;* Call., *callosum;* Caud., *caudate;* Cer., *cerebral;* Chor., *choroid, choroidal;* Cist., *cistern;* Coll., *collateral;* Corp., *corpus;* Emin., *eminence;* Fiss., *fissure;* Hippo., *hippocampal, hippocampus;* Inf., *inferior;* Int., *internal;* Lat., *lateral;* Med., *medial;* Nucl., *nucleus;* P.C.A., *posterior cerebral artery;* Plex., *plexus;* Post., *posterior;* Quad., *quadrigeminal;* Sup., *superior;* Temp., *temporal;* Trans., *transverse;* Trig., *trigone;* V., *vein;* Vent., *ventricle. (From, Nagata S, Rhoton AL Jr, Barry M: Microsurgical anatomy of the choroidal fissure.* ***Surg Neurol*** *30:3–59, 1988 [15].)*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

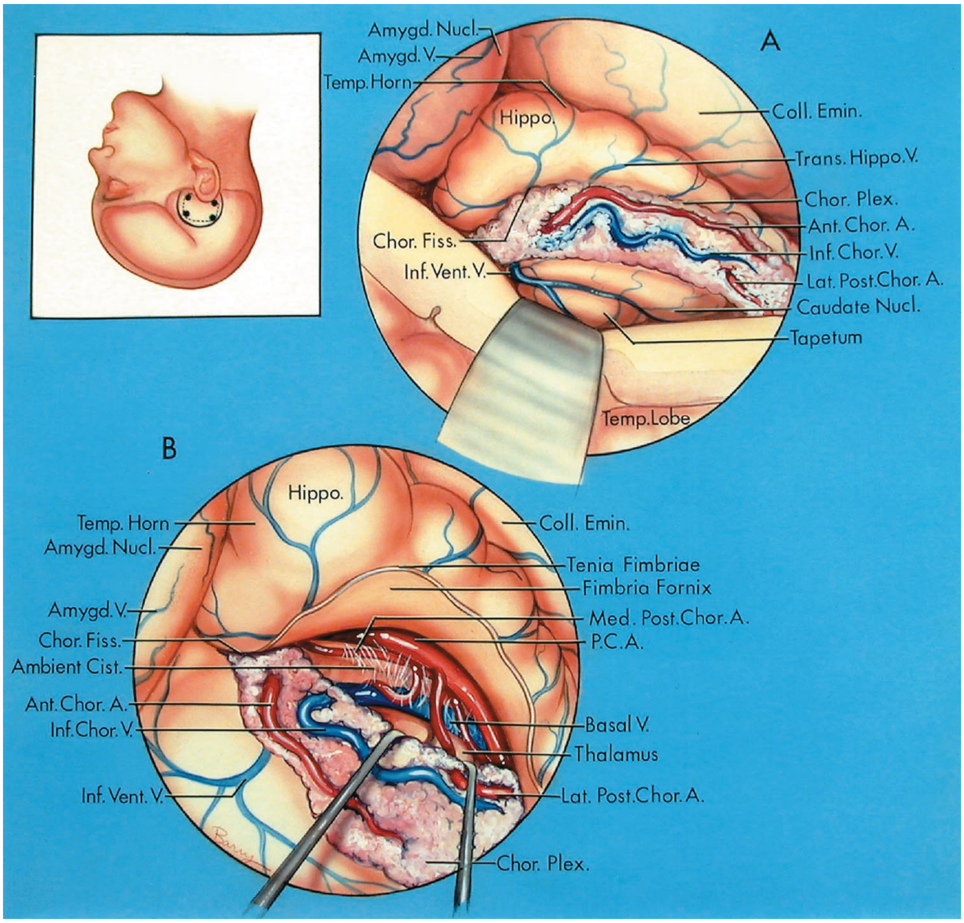


FIGURE 5.9. *Transchoroidal approach directed through the temporal portion of the choroidal fissure. The* inset *shows the site of the scalp incision and bone flap.* A, *the inferior surface of the temporal lobe has been opened to expose the temporal horn. The choroid plexus is attached along the choroidal fissure. Structures in the wall of the temporal horn include the hippocampal formation, collateral eminence, amygdaloid and caudate nuclei, and the tapetum of the corpus callosum. Vascular structures that pass through the choroidal fissure include the anterior and lateral posterior choroidal arteries and the transverse hippocampal, amygdalar, inferior choroidal, and inferior ventricular veins.* B, *the choroidal fissure has been opened by incising along the tenia fimbriae and retracting the choroid plexus upward. This exposes the ambient cistern, branches of the posterior cerebral artery, and tributaries of the basal vein. The medial posterior choroidal artery courses medial to the posterior cerebral artery.* A., *artery;* Amygd., *amygdalar, amygdaloid;* Ant., *anterior;* Caud., *caudate;* Chor., *choroid, choroidal;* Cist., *cistern;* Coll., *collateral;* Emin., *eminence;* Fiss., *fissure;* Hippo., *hippocampal, hippocampus;* Inf., *inferior;* Lat., *lateral;* Med., *medial;* Nucl., *nucleus;* P.C.A., *posterior cerebral artery;* Plex., *plexus;* Post., *posterior;* Temp., *temporal;* Trans., *transverse;* V., *vein;* Vent., *ventricle.* (From, *Nagata S, Rhoton AL Jr, Barry M: Microsurgical anatomy of the choroidal fissure.* ***Surg Neurol*** *30:3–59, 1988 [15].)*

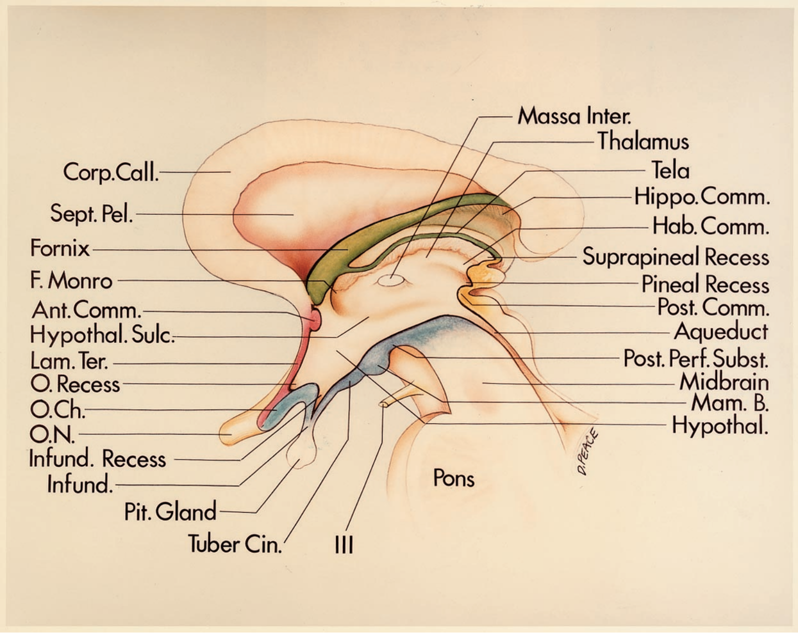


FIGURE 5.10. *Midsagittal section of the third ventricle. The floor* (blue) *extends from the optic chiasm to the aqueduct of sylvius and includes the lower surface of the optic chiasm, the infundibulum, the infundibular recess, the pituitary gland, the tuber cinereum, the mamillary bodies, the posterior perforated substance, and the part of the midbrain anterior to the aqueduct. The anterior wall* (red) *extends from the optic chiasm to the foramen of Monro and includes the upper surface of the optic chiasm, the optic recess, the lamina terminalis, the anterior commissure, and the foramen of Monro. The roof* (green) *extends from the foramen of Monro to the suprapineal recess and is formed by the fornix and the layers of tela choroidea, between which course the internal cerebral vein and the medial posterior choroidal artery. The hippocampal commissure, corpus callosum, and septum pellucidum are above the roof. The posterior wall extends from the suprapineal recess to the aqueduct and includes the habenular commissure, pineal gland, pineal recess, and posterior commissure. The oculomotor nerve exits from the midbrain. The hypothalamic sulcus forms a groove between the thalamic and hypothalamic surfaces of the third ventricle.* Ant., *anterior;* B., *body;* Call., *callosum;* Ch., *chiasm;* Cin., *cinereum;* Comm., *commissure;* Corp., *corpus;* For., *foramen;* Hab., *habenular;* Hippo., *hippocampal;* Hypothal., *hypothalamic, hypothalamus;* Infund., *infundibular, infundibulum;* Inter., *intermedia;* Lam., *lamina;* Mam., *mamillary;* N., *nerve;* O., *optic;* Pel., *pellucidum;* Perf., *perforated;* Pit., *pituitary;* Post., *posterior;* Sept., *septum;* Subst., *substance;* Sulc., *sulcus;* Ter., *terminalis.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

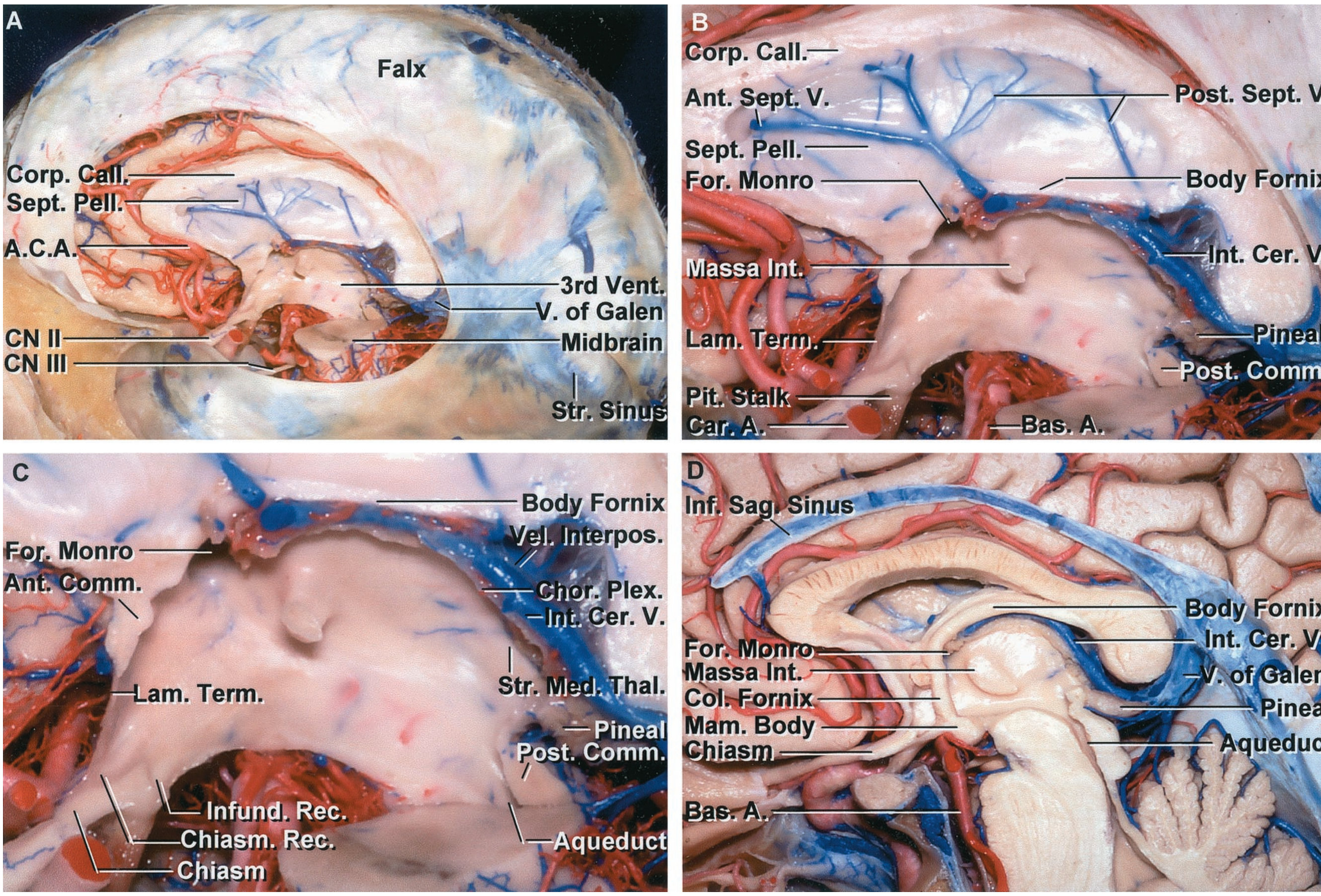


FIGURE 5.11. *Midsagittal views of the third ventricle.* A, *the third ventricle sits in the center of the cranium below the corpus callosum, body of the lateral ventricles, and septum pellucidum, above the midbrain and interpeduncular fossa, anterior to the quadrigeminal cistern and vein of Galen, and posterior to the anterior cerebral arteries. The interhemispheric fissure, along the side of the falx, offers one avenue to the third ventricle. The posterior part of the third ventricle can also be approached along the junction of the falx and tentorium, adjacent the straight sinus.* B, *enlarged view. The septum pellucidum separates the bodies and frontal horns of the lateral ventricles and is crossed by anterior and posterior septal veins. The anterior cerebral artery ascends along the front wall of the third ventricle, the basilar bifurcation is positioned below the floor, and the vein of Galen blocks access to the posterior wall.* C, *enlarged view of the third ventricle. The anterior wall of the third ventricle is formed by the lamina terminalis and anterior commissure and blends above into the rostrum of the corpus callosum. The roof is formed by the body of the fornix and the velum interpositum through which the internal cerebral veins and medial posterior choroidal arteries course. The posterior wall, formed by the pineal and habenular and posterior commissures, is located anterior to the quadrigeminal cistern and the venous complex created by numerous veins converging on the vein of Galen. The floor is formed, from anterior to posterior, by the optic chiasm, tuber cinereum above the pituitary stalk, mamillary bodies, and upper midbrain. The section extends to the lateral side of the mamillary bodies. The velum interpositum is the space within the roof of the third ventricle along which the internal cerebral veins and medial posterior choroidal arteries pass. The body of the fornix is located above the velum interpositum. The upper wall of the velum interpositum is formed by the layer of tela choroidea attached to the lower margin of the fornix. The floor is formed by the layer of tela attached along the striae medullaris thalami. The internal cerebral veins and medial posterior choroidal arteries course between the two layers of tela. The choroid plexus in the roof of the third ventricle arises in the lower layer of tela.* D, *another third ventricle. This section extends just to the left of the midline through the column and body of the fornix. The body of the fornix forms the roof of the third ventricle. The columns pass anterior to the foramen of Monro and descend behind the anterior commissure to reach the mamillary bodies.*

der of the thalamus from the foramen of Monro to the habenular commissure. The posterior part of the lower wall is attached to the superior surface of the pineal body. The suprapineal recess of the third ventricle is located between the lower layer of tela choroidea and the upper surface of the pineal body. The paired parallel strands of choroid plexus in the roof of the third ventricle are attached to the lower layer of tela choroidea. Many of the veins draining the frontal horn and body converge on the velum interpositum to form the internal cerebral veins. The internal cerebral veins arise in the anterior part of the velum interpositum, just behind the foramen of Monro, and they exit the velum interpositum above the pineal body to enter the quadrigeminal cistern and join the great vein. The velum interpositum is usually a closed space that tapers to a narrow apex just behind the foramen of Monro, but it may infrequently have an opening situated

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

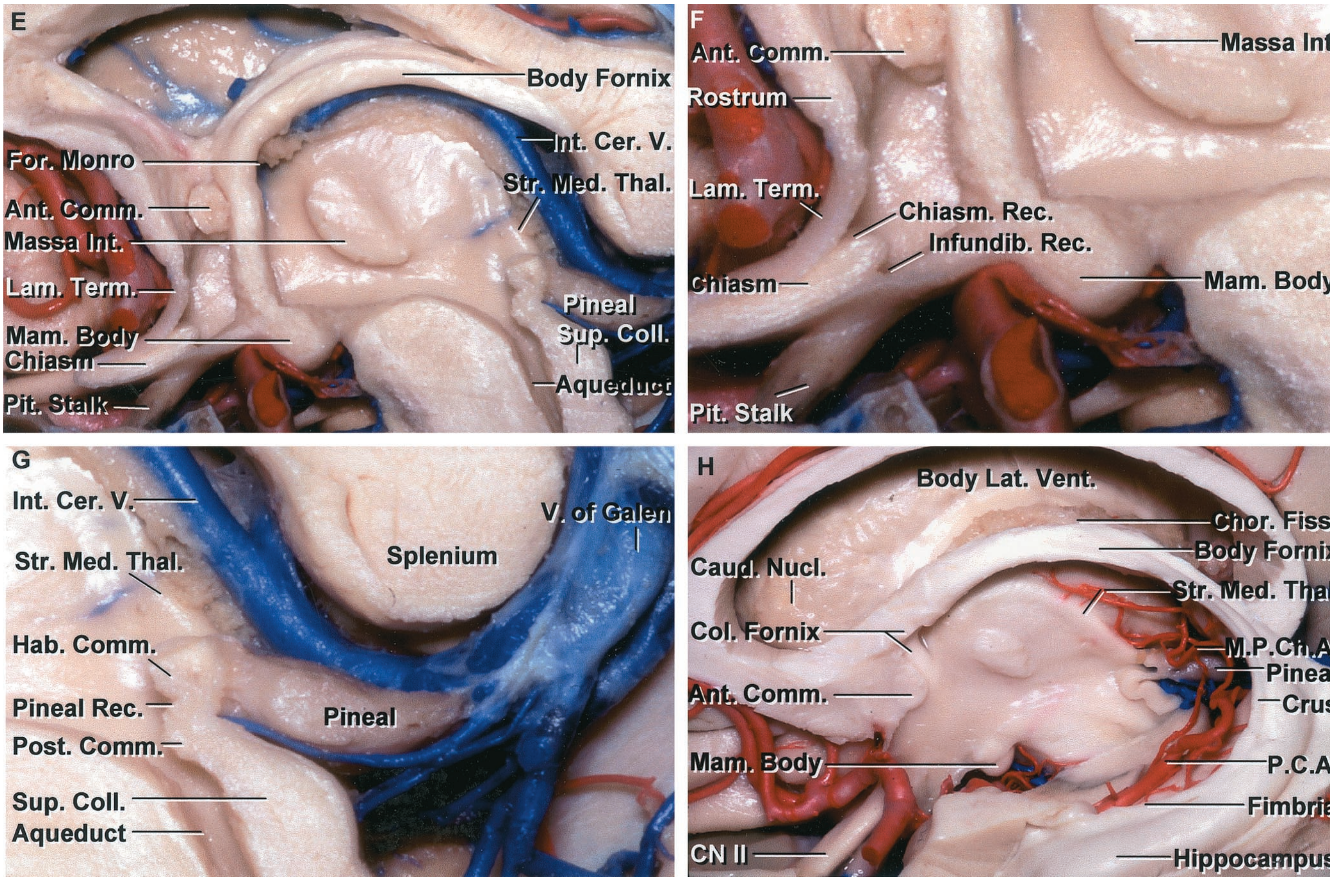


FIGURE 5.11. *Continued*
E, enlarged view. The anterior wall is made up of the lamina terminalis and the anterior commissure. The optic chiasm, mamillary bodies, and midbrain are in the floor. F, enlarged view. The chiasmatic recess is located above the optic chiasm and behind the lamina terminalis. The infundibular recess is located below and behind the optic chiasm. The lamina terminalis blends into the rostrum of the corpus callosum. The anterior commissure is positioned between the rostrum of the corpus callosum and the columns of the fornix. The thalamus and hypothalamus form the lateral wall of the third ventricle. G, enlarged view of the posterior part of the third ventricle. The posterior wall of the third ventricle is formed by the aqueduct, pineal, and habenular and posterior commissures. The pineal recess extends into the base of the pineal in the interval between the habenular and posterior commissures. H, lateral view of the third ventricle with the hippocampus and fornix preserved. The body of the fornix forms the roof of the third ventricle. The velum interpositum, through which the internal cerebral veins course, is located between the body of the fornix and the striae medullaris thalami. The quadrigeminal cistern and pineal region are located anteromedial to the crus of the fornix, and the ambient cistern and posterior cerebral artery are located medial to the temporal horn and the fimbria. Opening the choroidal fissure adjacent to the body of the fornix exposes the third ventricle. The medial posterior choroidal arteries turn forward beside the pineal to reach the velum interpositum. A., *artery;* A.C.A., *anterior cerebral artery;* Ant., *anterior;* Bas., *basilar;* Call., *callosum;* Car., *carotid;* Caud., *caudate;* Cer., *cerebral;* Chiasm., *chiasmatic;* Chor., *choroid;* CN, *cranial nerve;* Col., *column;* Coll., *colliculus;* Comm., *commissure;* Corp., *corpus;* For., *foramen;* Hab., *habenular;* Infund., *infundibular;* Int., *intermedia, internal;* Interpos., *interpositum;* Lam., *lamina;* Lat., *lateral;* Mam., *mamillary;* Med., *medial;* M.P.Ch.A., *medial posterior choroidal artery;* Nucl., *nucleus;* P.C.A., *posterior cerebral artery;* Pell., *pellucidum;* Pit., *pituitary;* Plex., *plexus;* Post., *posterior;* Rec., *recess;* Sag., *sagittal;* Sept., *septal, septum;* Str., *straight;* Sup., *superior;* Term., *terminalis;* Thal., *thalami;* V., *vein;* Vel., *velum;* Vent., *ventricle.*

between the splenium and pineal body that communicates with the quadrigeminal cistern to form the cisterna velum interpositum. There also may be a space above the velum interpositum between the hippocampal commissure and splenium called the cavum vergae.

Floor

The floor extends from the optic chiasm anteriorly to the orifice of the aqueduct of sylvius posteriorly (*Figs. 5.10, 5.13,* and *5.14*). The anterior half of the floor is formed by diencephalic structures, and the posterior half is formed by mesencephalic structures. When viewed from inferiorly, the structures forming the floor include, from anterior to posterior, the optic chiasm, the infundibulum of the hypothalamus, the tuber cinereum, the mamillary bodies, the posterior perforated substance, and (most posteriorly) the part of the tegmentum of the midbrain located above the medial aspect of the cerebral peduncles. The optic chiasm is located at the junction of the floor and the anterior wall of the third ventricle. The chiasm slopes posteriorly and superiorly from its junction with the optic nerves. The inferior surface

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

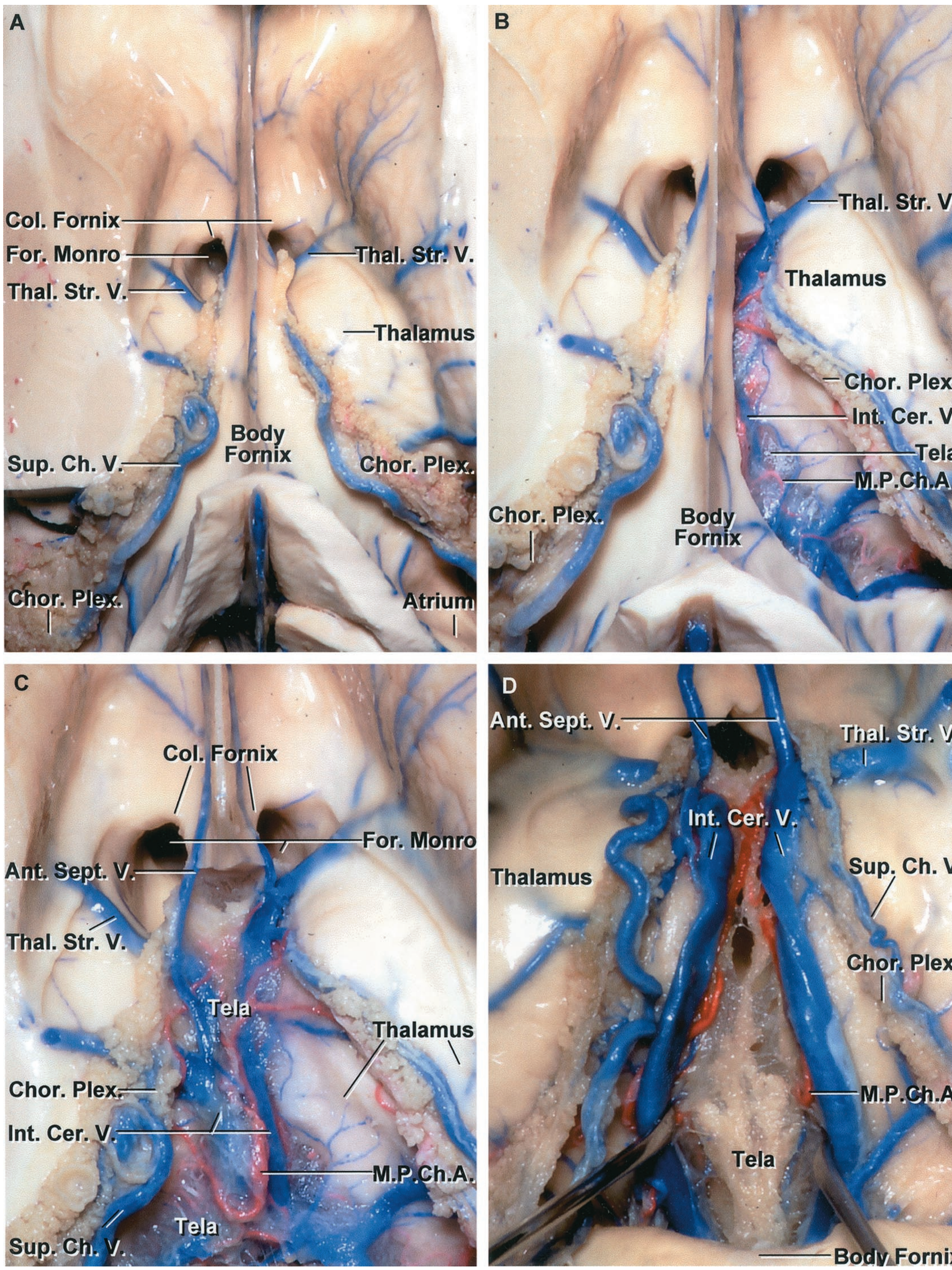


FIGURE 5.12. *Roof of the third ventricle. Superior views.* A, *the upper part of the hemispheres has been removed to expose the frontal horn and body of the lateral ventricle. The choroid plexus is attached along the choroidal fissure located between the body of the fornix and the thalamus. The superior choroidal veins course along the choroid plexus. The thalamostriate veins pass through the posterior margins of the foramen of Monro. The columns of the fornix pass anterior and superior to the foramen of Monro. The body of the fornix forms the upper part of the roof of the third ventricle.* B, *the right lateral edge of the fornix has been removed to expose the upper layer of tela choroidea that spans the interval below the body of the fornix and forms the upper wall of the velum interpositum in the roof of the third ventricle. The velum is positioned between an upper layer of tela attached to the lower surface of the body of the fornix and a lower layer of tela attached below the internal cerebral veins to the striae medullaris thalami. The internal cerebral veins and medial posterior choroidal arteries course in the velum interpositum.* C, *the body of the fornix has been folded backward. The upper layer of tela that rests against the lower surface of the body of the fornix has been preserved. The tela is a thin, arachnoid-like membrane, through which the internal cerebral veins and the medial posterior choroidal arteries can be seen. The anterior septal veins pass above the foramen of Monro.* D, *the upper layer of tela has been removed to expose the internal cerebral veins and medial posterior choroidal arteries. The internal cerebral veins have been retracted laterally. The anterior septal veins course along the septum and join the internal cerebral veins near the foramen of Monro.* E, *the tela has been opened to expose the massa intermedia, mamillary bodies, and posterior commissure.* F, *the exposure has been directed to the posterior part of the third ventricle. The aqueduct is positioned below the posterior and habenular commissures. The pineal recess extends posteriorly between the habenular and posterior commissures into the base of the pineal.* Ant., *anterior;* Cer., *cerebral;* Ch., *choroidal;* Chor., *choroid;* Col., *column;* Comm., *commissure;* For., *foramen;* Hab., *habenular;* Int., *intermedia, internal;* Mam., *mamillary;* M.P.Ch.A., *medial posterior choroidal artery;* Plex., *plexus;* Post., *posterior;* Rec., *recess;* Sept., *septal;* Sup., *superior;* Thal.Str., *thalamostriate;* V., *vein.*

of the chiasm forms the anterior part of the floor, and the superior surface forms the lower part of the anterior wall. The optic tracts arise from the posterolateral margin of the chiasm and course obliquely away from the floor toward the lateral margin of the midbrain. The infundibulum, tuber cinereum, mamillary bodies, and posterior perforated substance are located in the

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

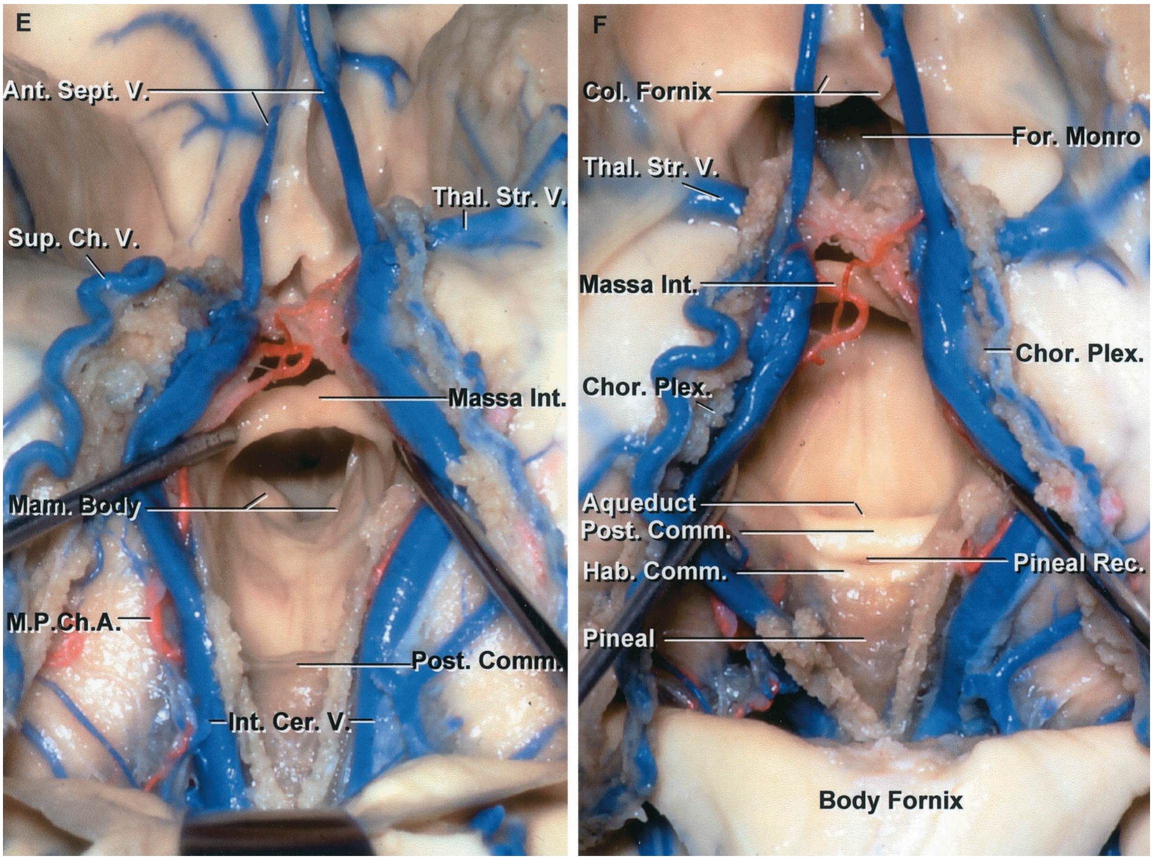


FIGURE 5.12. *Continued*

space limited anteriorly and laterally by the optic chiasm and tracts and posteriorly by the cerebral peduncles.

The infundibulum of the hypothalamus is a hollow, funnel-shaped structure located between the optic chiasm and the tuber cinereum. The pituitary gland (hypophysis) is attached to the infundibulum, and the axons in the infundibulum extend to the posterior lobe of the hypophysis. The tuber cinereum is a prominent mass of hypothalamic gray matter located anterior to the mamillary bodies. The tuber cinereum merges anteriorly into the infundibulum. The tuber cinereum around the base of the infundibulum is raised to form a prominence called the median eminence. The mamillary bodies form paired, round prominences posterior to the tuber cinereum. The posterior perforated substance is a depressed, punctuated area of gray matter located in the interval between the mamillary bodies anteriorly and the medial surface of the cerebral peduncles posteriorly. The posterior part of the floor extends posterior and superior to the medial part of the cerebral peduncles and superior to the tegmentum of the midbrain.

When viewed from above and inside the third ventricle, the optic chiasm forms a prominence at the anterior margin of the floor. The infundibular recess extends into the infundibulum behind the optic chiasm. The mamillary bodies form paired prominences on the inner surface of the floor posterior to the infundibular recess. The part of the floor between the mamillary bodies and the aqueduct of sylvius has a smooth surface that is concave from side to side. This smooth surface lies above the posterior perforated substance anteriorly and the medial part of the cerebral peduncles and the tegmentum of the midbrain posteriorly.

Anterior Wall

The anterior margin of the third ventricle extends from the foramina of Monro above to the optic chiasm below (*Figs. 5.10, 5.11,* and *5.15*). Only the lower two-thirds of the anterior surface is seen on the external surface of the brain; the upper third is hidden posterior to the rostrum of the corpus callosum. The part of the anterior wall visible on the surface is formed by the optic chiasm and the lamina terminalis. The lamina terminalis is a thin sheet of gray matter and pia mater that attaches to the upper surface of the chiasm and stretches upward to fill the interval between the optic chiasm and the rostrum of the corpus callosum.

When viewed from within, the boundaries of the anterior wall are formed, from superior to inferior, by the columns of the fornix, foramina of Monro, anterior commissure, lamina terminalis, optic recess, and optic chiasm. The foramen of Monro on each side is located at the junction of the roof and the anterior wall. The foramen is a ductlike canal that opens

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

between the fornix and the thalamus into the lateral ventricle and extends inferiorly below the fornix into the third ventricle as a single channel. The foramen of Monro is bounded anteriorly by the junction of the body and the columns of the fornix and posteriorly by the anterior pole of the thalamus. The size and shape of the foramina of Monro depend on the size of the ventricles: if the ventricles are small, each foramen is a crescent-shaped opening bounded anteriorly by the concave curve of the fornix and posteriorly by the convex anterior tubercle of the thalamus. As the ventricles enlarge, the foramen on each side becomes rounder. The structures that pass through the foramen are the choroid plexus, the distal branches of the medial posterior choroidal arteries, and the thalamostriate, superior choroidal, and septal veins.

The anterior commissure is a compact bundle of fibers that crosses the midline in front of the columns of the fornix. The anterior-posterior diameter of the anterior commissure varies from 1.5 to 6.0 mm (37). In our specimens, the distance from the posterior end of the anterior commissure to the anterior border of the foramen of Monro ranged from 1.0 to 3.5 mm (average, 2.2 mm), and the distance from the upper edge of the optic chiasm to the anterior border of the anterior commissure ranged from 8 to 12 mm (average, 10 mm). The lamina terminalis fills the interval between the anterior commissure and the optic chiasm. The lamina attaches to the midportion of the superior surface of the chiasm, leaving a small cleft between the upper half of the chiasm and the lamina, called the optic recess.

Posterior Wall

The posterior wall of the third ventricle extends from the suprapineal recess above to the aqueduct of sylvius below (*Figs. 5.10* and *5.11*). When viewed from anteriorly and within the third ventricle, it consists, from above to below, of the suprapineal recess, the habenular commissure, the pineal body and its recess, the posterior commissure, and the aqueduct of sylvius. The suprapineal recess projects posteriorly between the upper surface of the pineal gland and the lower layer of tela choroidea in the roof. The pineal gland extends posteriorly into the quadrigeminal cistern from its stalk. The stalk of the pineal gland has an upper and a lower lamina. The habenular commissure, which interconnects the habenulae, crosses the midline in the upper lamina, and the posterior commissure crosses in the lower lamina. The pineal recess projects posteriorly into the pineal body between the two laminae. The shape of the orifice of the aqueduct of sylvius is triangular; the base of the triangle is on the posterior commissure and the other two limbs are formed by the central gray matter of the midbrain.

When viewed from posteriorly, the only structure in the posterior wall is the pineal body. The pineal gland projects posteriorly into the quadrigeminal cisterns and is concealed by the splenium of the corpus callosum above, the thalamus laterally, and the quadrigeminal plate and the vermis of the cerebellum inferiorly.

Lateral Wall

The lateral walls are not visible on the external surface of the brain, but are hidden between the cerebral hemispheres (*Figs. 5.10* and *5.11*). They are formed by the hypothalamus inferiorly and the thalamus superiorly. The lateral walls have an outline like the lateral silhouette of a bird's head with an open beak. The head is formed by the oval medial

FIGURE 5.13. *Floor and roof of the third ventricle.* A, *the floor of the third ventricle is located medial to the uncus and anterior perforated substance and above the midbrain. From anterior to posterior, the floor includes the lower margin of the optic chiasm, the pituitary stalk surrounded by the tuber cinereum, mamillary bodies, and the midbrain. The interpeduncular fossa is located below the posterior part of the floor. The anterior part of the optic tract extends along the lateral margin of the floor, but further posteriorly, the tracts deviate laterally away from the floor to pass around the upper margin of the cerebral peduncle.* B, *enlarged view. The tuber cinereum is situated around the pituitary stalk. The infundibular recess extends into the base of the stalk. A third ventriculostomy is commonly performed by opening through the thin area (*yellow arrow*) in the floor just in front of the mamillary bodies. The oculomotor nerves arise behind the mamillary bodies below the posterior part of the floor of the third ventricle.* C, *another specimen showing the thin area in front of the mamillary bodies (*yellow arrow*) through which a third ventriculostomy is completed. The anterior perforated substance and optic tracts are positioned lateral to the anterior part of the floor of the third ventricle. The mamillary bodies and upper midbrain are positioned below the posterior part of the floor.* D, *view of another third ventricle from below with the vascular structure preserved. The internal carotid, posterior communicating, anterior choroidal, and posterior cerebral arteries all give rise to branches that reach the walls of the lateral and third ventricles. The thalamoperforating branches of the posterior cerebral artery supply some of the posterior part of the floor of the third ventricle.* E, *inferior view with the floor of the third ventricle removed to expose the roof. The pituitary stalk has been reflected forward to expose the ventricular side of the infundibular recess and lamina terminalis. The lamina terminalis slopes upward from the upper edge of the chiasm to the area in front of the anterior commissure where it blends into the rostrum of the corpus callosum. The columns of the fornix cross above and anterior to the foramen of Monro and descend toward the mamillary bodies. The massa intermedia crosses the midportion of the third ventricle. The velum interpositum, in which the internal cerebral veins and medial posterior choroidal arteries course, is positioned between the thalami in the roof of the third ventricle. The posterior commissure is exposed below the pineal gland. The vein of Galen, into which the basal veins empty, is located just behind the third ventricle.* F, *enlarged view. The infundibular recess is located below the optic chiasm in the base of the pituitary stalk, and the chiasmatic recess is located above the optic chiasm. The lamina terminalis forms the anterior wall of the chiasmatic recess. The anterior commissure crosses the anterior wall in front of the columns of the fornix. The foramina of Monro open upward into both lateral ventricles. The lower wall of the velum interpositum is formed by the layer of tela choroidea, in which the choroid plexus in the roof of the third ventricle arises, and which is attached laterally to the striae medullaris thalami. The internal cerebral veins can be seen through the layer of tela forming the lower wall of the velum interpositum.* G, *another specimen with the floor of the third ventricle removed. The posterior cerebral arteries, from which the lateral and medial posterior choroidal arteries arise, passes around the midbrain. The lamina terminalis is exposed above the optic chiasm and slopes upward toward the anterior commissure. The columns of the fornix pass along the anterior and superior margins of the foramen of Monro and behind the anterior commissure. The lower layer of tela choroidea in the velum interpositum has been removed to expose the vascular layer in the roof of the third ventricle formed by the internal cerebral veins and medial posterior choroidal arteries. Another layer of tela, which spans the interval above the internal cerebral veins and below the body of the fornix, separates the vascular layer from the body of the fornix.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

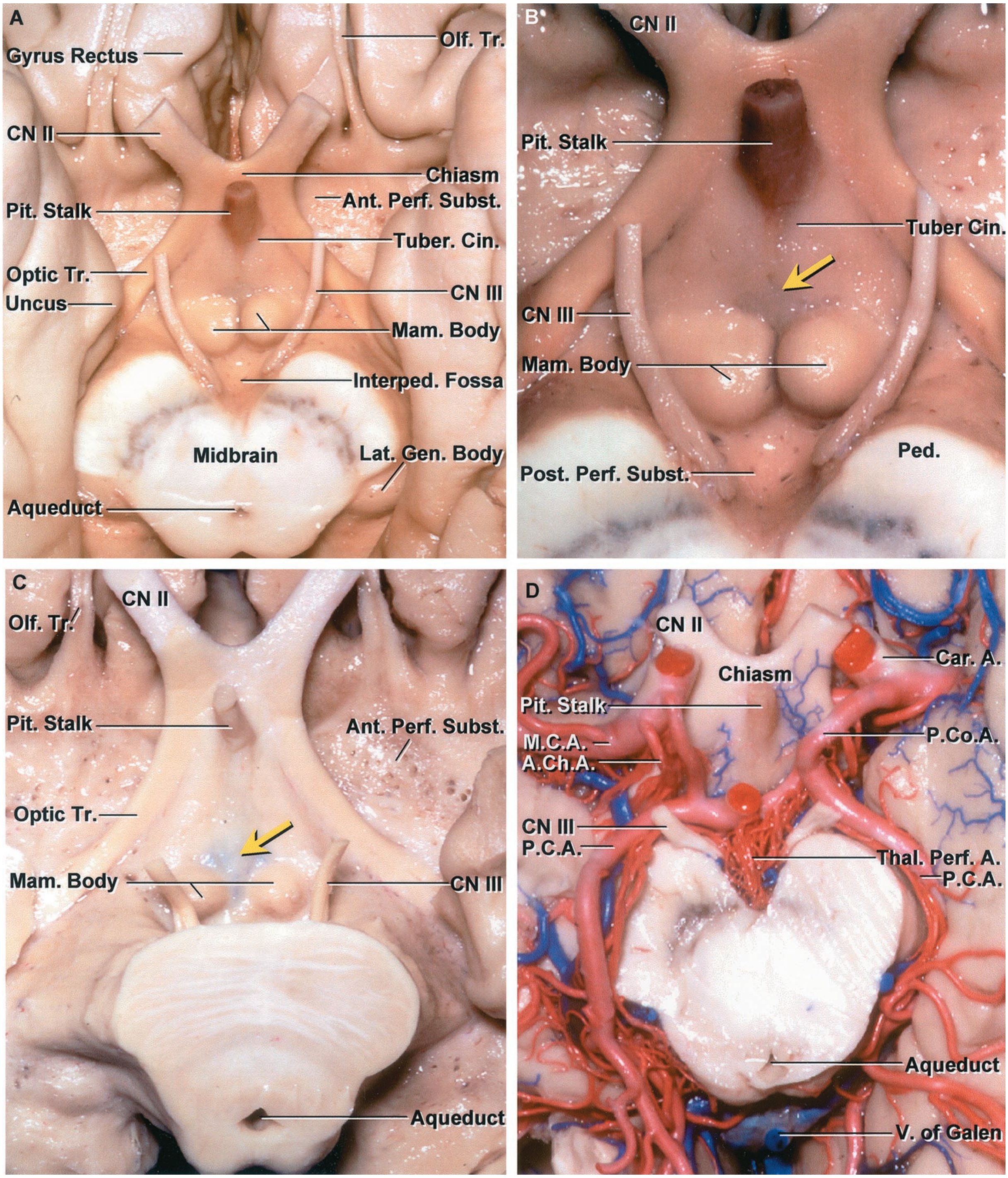


FIGURE 5.13. *Continued*

H, *enlarged view. The upper layer of tela choroidea that spans the interval below the body of the fornix has been removed. The body of the fornix, exposed by removing the upper layer of tela, blends anteriorly into the columns of the fornix that pass along the anterior and superior margin of the foramen of Monro. The lamina terminalis has been opened in the interval between the optic chiasm and anterior commissure to expose the perforating branches of the anterior cerebral artery.* A., *artery;* A.C.A., *anterior cerebral artery;* A.Ch.A., *anterior choroidal artery;* Ant., *anterior;* Calc., *calcarine;* Car., *carotid;* Cin., *cinereum;* CN, *cranial nerve;* Col., *column;* Comm., *commissure;* For., *foramen;* Gen., *geniculate;* Infund., *infundibular;* Int., *intermedia, internal;* Interped., *interpeduncular;* Interpos., *interpositum;* Lam., *lamina;* Lat., *lateral;* Mam., *mamillary;* M.C.A., *middle cerebral artery;* M.P.Ch.A., *medial posterior choroidal artery;* Olf., *olfactory;* P.C.A., *posterior cerebral artery;* P.Co.A., *posterior communicating artery;* Ped., *peduncle;* Perf., *perforated;* Pit., *pituitary;* Post., *posterior;* Rec., *recess;* Subst., *substance;* Term., *terminalis;* Thal.Perf., *thalamoperforating;* Tr., *tract;* V., *vein;* Vel., *velum.* *(Figure continues on next page.)*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

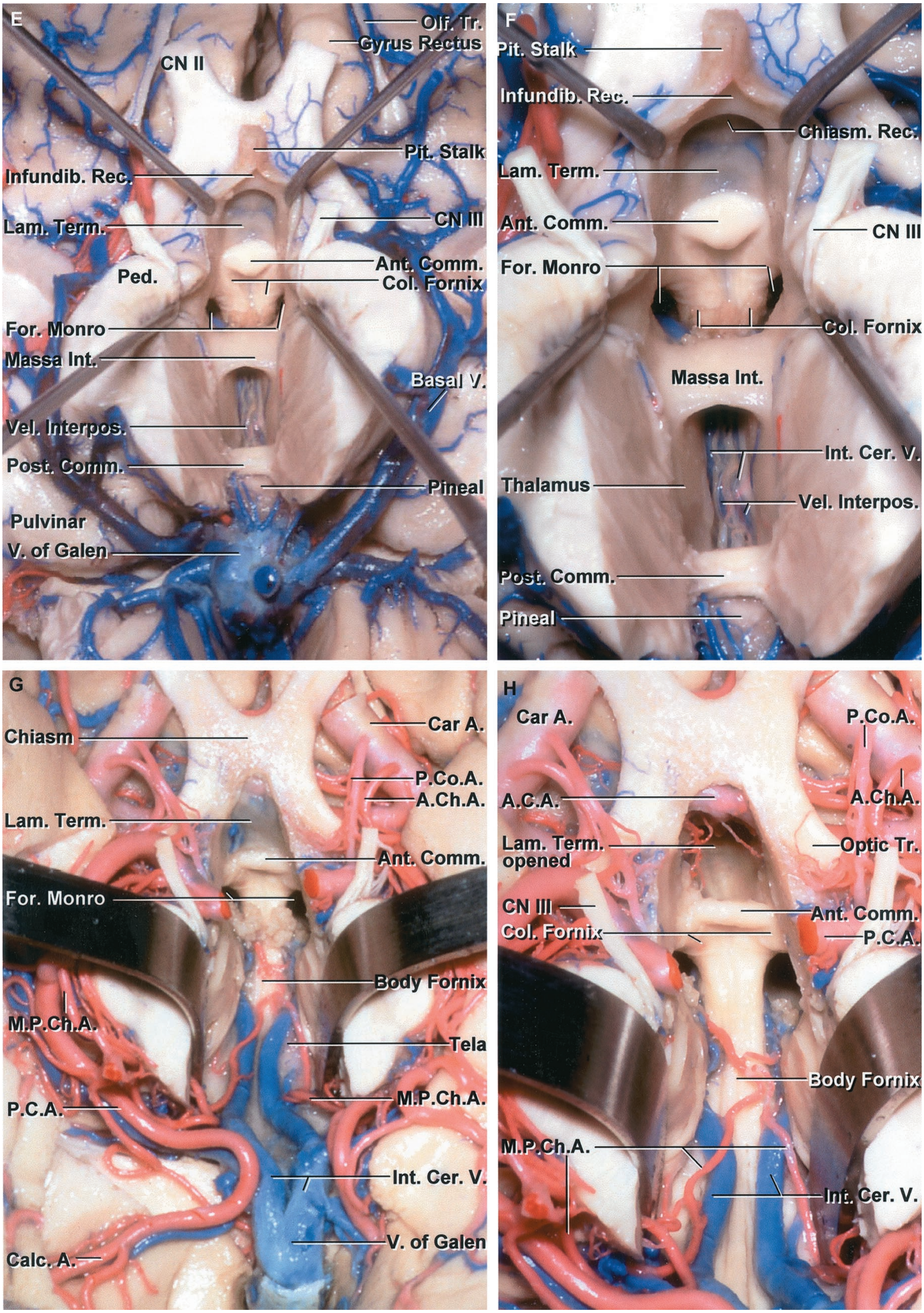


FIGURE 5.13. *Continued*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

surface of the thalamus; the open beak, which projects anteriorly and inferiorly, is represented by the recesses in the hypothalamus: the pointed upper beak is formed by the optic recess and the lower beak is formed by the infundibular recess. The hypothalamic and thalamic surfaces are separated by the hypothalamic sulcus, a groove that is often ill-defined and extends from the foramen of Monro to the aqueduct of sylvius. The superior limit of the thalamic surfaces of the third ventricle is marked by narrow, raised ridges, known as the striae medullaris thalami. These striae extend forward from the habenulae along the superomedial surface of the thalamus near the attachment of the lower layer of the tela choroidea. The habenulae are small eminences on the dorsomedial surfaces of the thalamus just in front of the pineal gland. The habenulae are connected across the midline in the rostral stalk of the pineal gland by the habenular commissure.

The massa intermedia projects into the upper half of the third ventricle and often connects the opposing surfaces of the thalamus. It is present in approximately 75% of brains, being located 2.5 to 6.0 mm (average, 3.9 mm) posterior to the foramen of Monro. The columns of the fornix form distinct prominences in the lateral walls of the third ventricle just below the foramina of Monro, but inferiorly they sink below the surface.

Tentorial Incisura

The lateral and third ventricles are situated above the tentorial incisura, the triangular space situated between the free edges of the tentorium and the dorsum sellae (*Fig. 5.16*) (18, 23, 27). The apex of the incisura is dorsal to the midbrain in the area posterior to the pineal body, and the base is on the dorsum sellae. The midbrain is situated in the center of the incisura. The area between the midbrain and the free edges is divided into (a) an anterior incisural space located in front of the brainstem; (b) paired middle incisural spaces situated lateral to the midbrain; and (c) a posterior incisural space located behind the midbrain. The frontal horns are located above the anterior incisural space; the bodies of the lateral ventricles are located directly above the central part of the incisura, where they sit on and are separated from the central part of the incisura by the thalamus; the atria are located above the posterior incisural space; and the temporal horns are situated superolateral to the middle incisural space. The three incisural spaces contain some of the basal cisterns and are so intimately related to the lateral ventricles that some operative approaches to the basal cisterns situated within the incisura are directed through the lateral ventricles and choroidal fissure.

The anterior incisural space, which is situated anterior to the midbrain, extends obliquely upward around the optic chiasm along the anterior wall of the third ventricle to the area below the rostrum of the corpus callosum and the floor of the frontal horn. This space contains the interpeduncular cistern, which is situated between the cerebral peduncles, and the chiasmatic cistern, which is located below the optic chiasm. The chiasmatic cistern communicates around the optic chiasm with the cisternal laminae terminalis, which lies anterior to the lamina terminalis in the area below the floor of the frontal horn.

The middle incisural space, which is located between the temporal lobe and the midbrain, is so intimately related to the temporal horn and temporal part of the choroidal fissure that some operative approaches to this space are directed through the temporal horn. The temporal horn extends into the medial part of the temporal lobe lateral to the middle incisural space and ends approximately 3 cm from the anterior pole of the temporal lobe. This space is the site of the crural and ambient cisterns. The crural cistern, located between the cerebral peduncle and uncus and roofed by the optic tract, opens posteriorly into the ambient cistern.

The ambient cistern is a narrow communicating channel demarcated medially by the midbrain, above by the pulvinar, and laterally by the parahippocampal and dentate gyri and the fimbria of the fornix. The cisternal side of the temporal portion of the choroidal fissure is located in the superolateral part of the ambient cistern between the fimbria and the lower thalamic surface. The crural cistern cannot be reached through the choroidal fissure because the fissure ends just behind the uncus and the cistern at the inferior choroidal point. The crural cistern can be exposed from the temporal horn by an incision extending forward from the inferior choroidal point through the amygdala.

The posterior incisural space, the site of the quadrigeminal cistern, is located medial to the atrium. This cistern encloses a space that corresponds to the pineal region and has a roof, floor, and anterior and lateral walls. The choroid fissure lies at the junction of the anterior and lateral walls of the quadrigeminal cistern. The lateral walls of the quadrigeminal cistern separate the cistern from the atria. Each lateral wall has anterior and posterior parts: the anterior part is formed by the crus of the fornix and the posterior part is formed by the part of the medial surface of the occipital lobe situated below the splenium.

The anterior wall of the cistern has medial and lateral parts. The medial part of the anterior wall is formed by the quadrigeminal plate and pineal body. The suprapineal recess of the third ventricle bulges into the cistern above the pineal body. The lateral part of the anterior wall of the cistern is formed by the part of the pulvinar that lies medial to the crus of the fornix. Below the colliculi, the cistern extends into the cleft between the midbrain and cerebellum called the cerebellomesencephalic fissure. This fissure cannot be reached through the choroidal fissure. The trochlear nerves arise below the inferior colliculi and course laterally around the midbrain and below the pulvinars to enter the ambient cisterns.

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 broad envelope of arachnoid tissue is applied to the lower surface of the splenium and is continuous anteriorly with the velum interpositum. It is within this envelope, in the superomedial part of the cistern, that the venous structures are found in the greatest density. The superomedial location of the major veins in the cistern contrasts with the location of the large arteries that are found in the inferolateral part of the cistern.

The quadrigeminal cistern opens anteriorly below the pulvinars into the ambient cisterns. The quadrigeminal cistern may communicate with the velum interpositum. Another potential

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

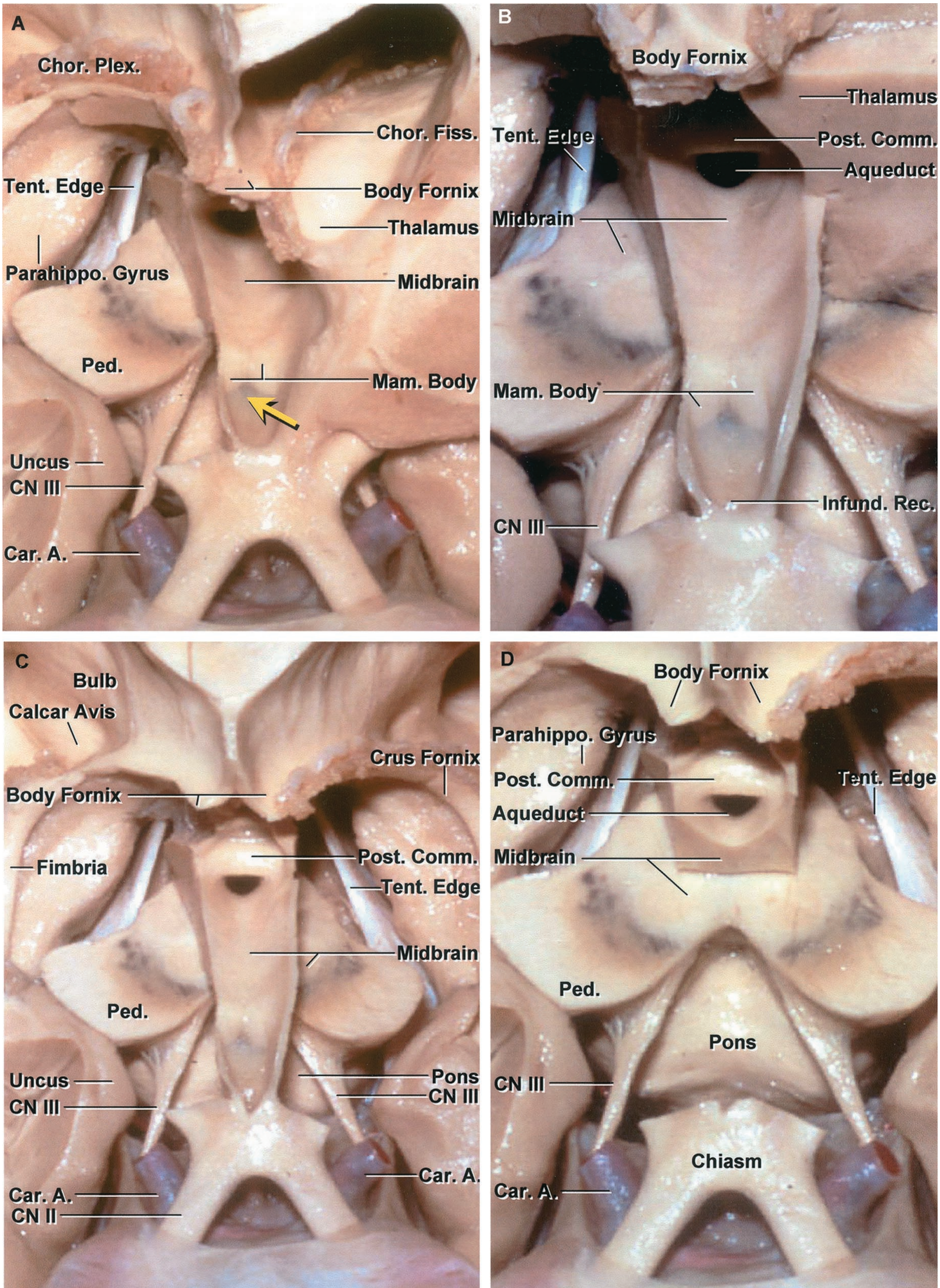


FIGURE 5.14.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

cavity that may communicate with the quadrigeminal cistern is the cavum vergae, which is located immediately above the velum interpositum between the hippocampal commissure and the splenium. The cavum vergae is infrequently present because the hippocampal commissure commonly fuses to the lower surface of the splenium.

ARTERIAL RELATIONSHIPS

Each part of the lateral and third ventricles has surgically important arterial relationships. All of the arterial components of the circle of Willis are located in the anterior incisural space below the frontal horns and bodies of the lateral ventricles. The internal carotid arteries bifurcate into the anterior and middle cerebral arteries in the area below the frontal horns and give rise to the anterior choroidal arteries, which send branches through the choroidal fissures to the choroid plexus. The posterior part of the circle of Willis and the apex of the basilar artery are situated below the thalami, bodies of the lateral ventricles, floor of the third ventricle, and between the temporal horns. The anterior cerebral arteries pass around the anterior wall of the third ventricle and the floor and anterior wall of the frontal horns to reach the roof of the frontal horns and bodies. The posterior cerebral arteries pass medial to the temporal horns and atria and give rise to the posterior choroidal arteries, which pass through the choroidal fissure to supply the choroid plexus in the temporal horns, atria, and bodies. The posterior cerebral, pericallosal, superior cerebellar, and choroidal arteries pass adjacent to the posterior wall. Both the anterior and posterior cerebral arteries send branches into the roof, and the middle cerebral arteries pass below the frontal horns to reach the sylvian fissures and then course over the insulae, where they are lateral to the bodies of the lateral ventricle. The internal carotid, anterior choroidal, anterior and posterior cerebral and the anterior and posterior communicating arteries give rise to perforating branches that reach structures in or near the walls of the lateral and third ventricles (*Figs. 5.17* and *5.18*) (8, 9, 20, 21, 29, 30). The relationships between these arteries and the ventricles are reviewed in greater detail below.

Choroidal Arteries

The arteries most intimately related to the lateral ventricles and choroidal fissures are the choroidal arteries that supply the choroid plexus in the lateral and third ventricles. They arise from the internal carotid and posterior cerebral arteries in the basal cisterns and reach the choroid plexus by passing through the choroidal fissures (*Figs. 2.9, 2.10, 2.33,* and *5.19*; *Tables 5.1–5.3*).

The choroid plexus of the lateral ventricles is supplied by the anterior and posterior choroidal arteries (7, 26). The posterior choroidal arteries are divided into lateral and medial groups called the lateral and medial posterior choroidal arteries. Illustrations and text related to the course of each of these arteries is reviewed in Chapter 2. Each of the choroidal arteries gives off branches to the neural structures along its course. The most common pattern is for the anterior choroidal arteries to supply a portion of the choroid plexus in the temporal horn and atrium; the lateral posterior choroidal arteries to supply a portion of the choroid plexus in the atrium, body, and posterior part of the temporal horn; and the medial posterior choroidal arteries to supply the choroid plexus in the roof of the third ventricle and part of that in the body of the lateral ventricle. The size of the plexal areas supplied by the anterior and posterior choroidal arteries is inversely related: as the area supplied by one artery enlarges, the area supplied by the other decreases. The same inverse relationship occurs between the areas supplied by the lateral and medial posterior choroidal arteries. The lateral and medial posterior choroidal arteries arising on one side may infrequently send branches to the choroid plexus in the opposite lateral ventricle.

The anterior choroidal artery arises from the internal carotid artery in the anterior incisural space and courses posteriorly to reach the middle incisural space, where it passes through the choroidal fissure near the inferior choroidal point and courses along the medial border of the choroid plexus in close relation to the lateral posterior choroidal arteries. It passes posteriorly and dorsally along the plexus, reaching the foramen of Monro in a few hemispheres. There are frequent anastomoses between the branches of the anterior and lateral posterior choroidal arteries on the surface of the choroid plexus.

The lateral posterior choroidal arteries are a group that arise in the ambient and quadrigeminal cisterns from the posterior cerebral artery or its cortical branches. These branches enter the ventricle behind the branches of the anterior choroidal artery. They pass laterally around the pulvinar and through the choroidal fissure at the level of the fimbria, crus, and body of the fornix to reach the choroid plexus in the temporal horn, atrium, and

FIGURE 5.14. *Anterior view of the floor and lower part of the third ventricle.* A, *the right thalamus has been removed. The posterior part of the floor of the third ventricle is formed by the upper surface of the midbrain located behind the mamillary bodies. The tentorial edges join at the tentorial apex located in the quadrigeminal cistern behind the aqueduct. The choroidal fissure in the body of the ventricle is located between the body of the fornix and the upper surface of the thalamus. The floor between the optic chiasm and mamillary bodies is located above the chiasmatic cistern. The most common site for a third ventriculostomy is located just in front of the mamillary bodies.* B, *the anterior part of the left thalamus has been removed to expose the cerebral peduncles and upper midbrain on both sides of the third ventricle. The oculomotor nerves arise below the posterior part of the floor of the third ventricle. The infundibular recess is located behind the optic chiasm. The pons is exposed below the mamillary bodies and infundibular recess.* C, *both thalami have been removed. The third ventricular floor extends from the optic chiasm to the aqueduct. The choroidal fissure in the body of the ventricle is located between the body of the fornix and the thalamus, in the atrium it is between the crus of the fornix and the pulvinar, and in the temporal horn it is between the fimbria and lower surface of the thalamus.* D, *enlarged view. The upper midbrain and pons are located below the floor of the third ventricle. The oculomotor nerves exit the midbrain below the floor. The aqueduct and posterior commissure are positioned in the posterior wall of the third ventricle in front of the tentorial apex and quadrigeminal cistern.* A., *artery;* Car., *carotid;* Chor., *choroid;* CN, *cranial nerve;* Comm., *commissure;* Infund., *infundibular;* Mam., *mamillary;* Parahippo., *parahippocampal;* Ped., *peduncle;* Plex., *plexus;* Post., *posterior;* Rec., *recess;* Tent., *tentorial.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

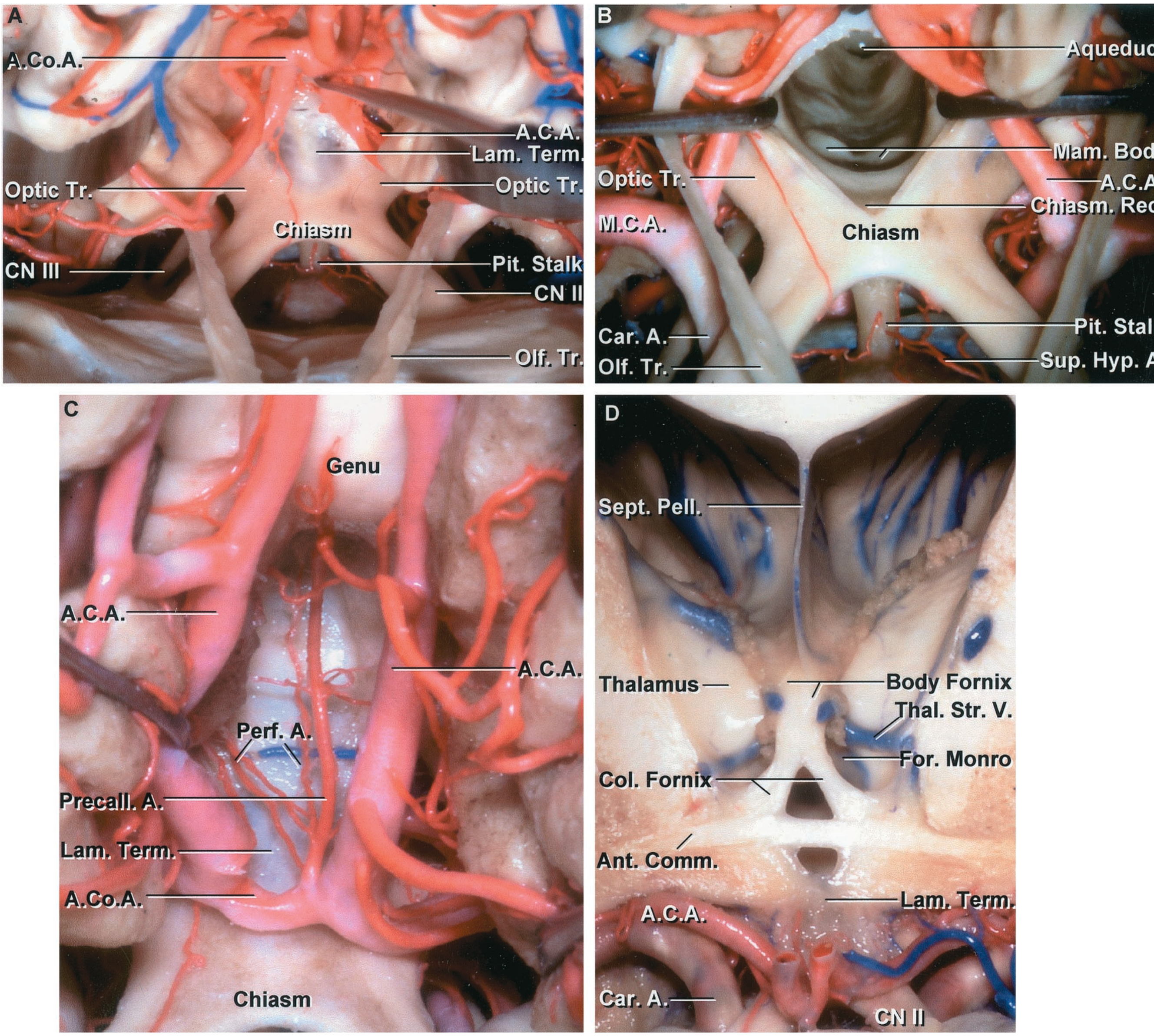


FIGURE 5.15. *Anterior wall of the third ventricle.* A, *the frontal lobe and the anterior carotid arteries have been elevated to expose the optic chiasm and lamina terminalis. The pituitary stalk extends downward from the floor of the third ventricle. The optic tracts pass along the lateral margin of the floor of the third ventricle. The lamina terminalis blends above into the rostrum of the corpus callosum. The olfactory tracts pass backward above the optic nerves.* B, *the lamina terminalis has been opened to expose the chiasmatic recess, mamillary bodies, and aqueduct. The pituitary stalk is exposed below the infundibular recess located behind the optic chiasm and in front of the mamillary bodies. Superior hypophyseal arteries pass medially from the carotid artery.* C, *another third ventricle. The anterior communicating artery commonly passes in front of the lamina terminalis. Perforating arteries arise from a precallosal branch of the anterior communicating artery and penetrate the anterior wall of the third ventricle to reach the columns of the fornix.* D, *anterior view of a cross section through the anterior part of the third ventricle and body of the lateral ventricle. The lamina terminalis, which has been opened, extends upward in front of the anterior commissure and blends into the rostrum of the corpus callosum. The anterior cerebral arteries have been folded forward. The choroid plexus extends through the foramen of Monro into the roof of the third ventricle below and the body of the lateral ventricle above.* E, *the cross section of another third ventricle extends through the anterior commissure. The body of the fornix sits in the floor of the body of the ventricle. The columns of the fornix pass around the superior and anterior margins of the foramen of Monro and behind the anterior commissure. The lamina terminalis extends upward from the chiasm.*

body. If the anterior choroidal artery supplies the choroid plexus in the temporal horn and atrium, the lateral posterior choroidal arteries will course outside the ventricle along the medial edge of the temporal and atrial parts of the choroidal fissure and reach the choroid plexus by passing through the body portion of the choroidal fissure. The lateral posterior choroidal arteries may

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

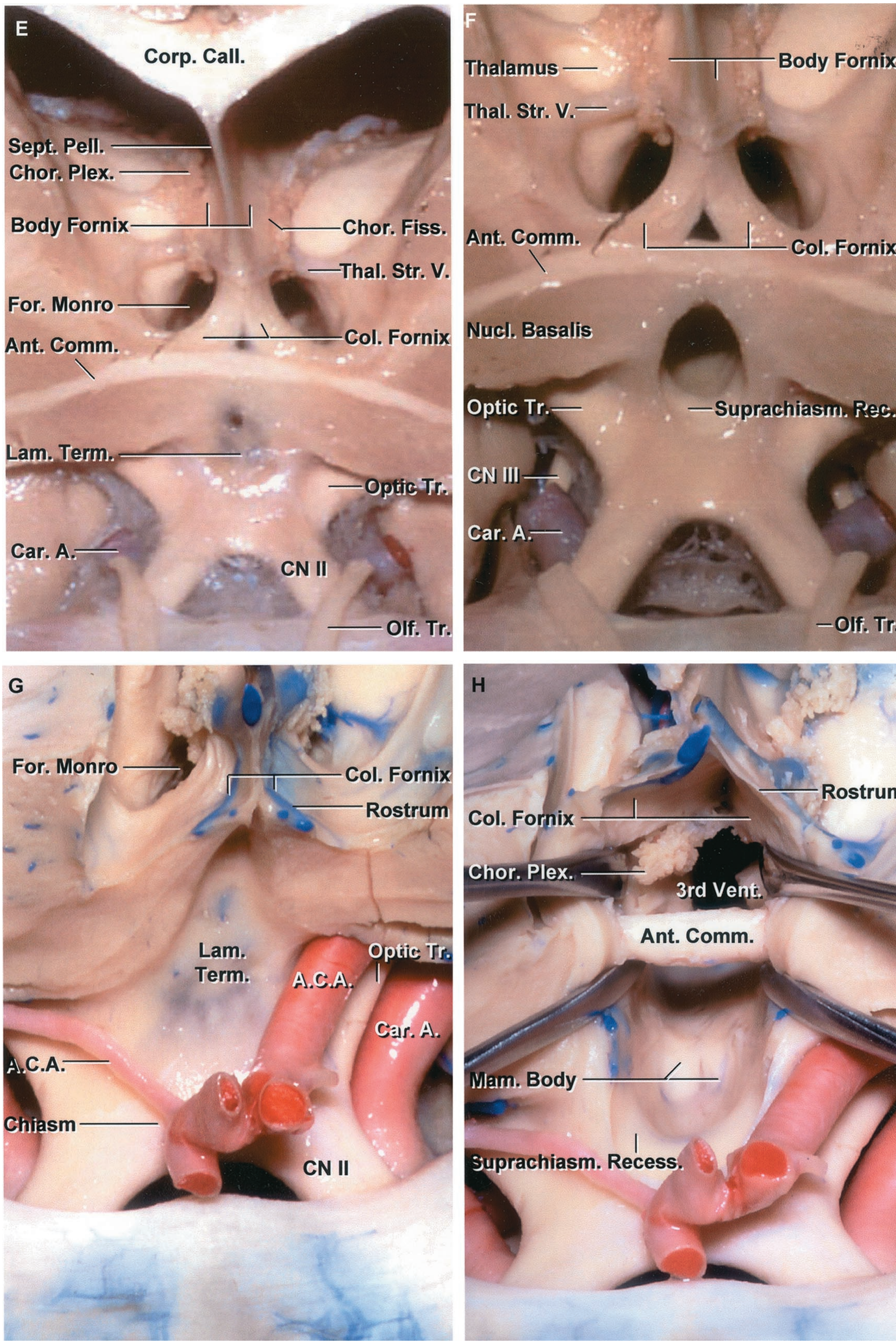


FIGURE 5.15. *Continued* F, *enlarged view. The lamina terminalis has been opened. The chiasmatic recess is located between the lower part of the lamina terminalis and the posterior part of the optic chiasm. The nucleus basalis is located below the lateral part of the anterior commissure.* G, *another third ventricle. The lamina terminalis extends upward from the optic chiasm and blends into the rostrum of the corpus callosum.* H, *the lamina terminalis has been opened. The posterior margin of the chiasm is exposed behind the anterior communicating artery. The anterior commissure is exposed behind the upper edge of the lamina terminalis. The incision has been extended upward through the rostrum of the corpus callosum between the columns of the fornix. This exposes the roof of the third ventricle above the anterior commissure. The choroid plexus hangs down from the tela into the roof of the third ventricle. The mamillary bodies are exposed in the floor.* A., *artery;* A.C.A., *anterior cerebral artery;* A.Co.A., *anterior communicating artery;* Ant., *anterior;* Car., *carotid;* Chiasm., *chiasmatic;* Chor., *choroid;* CN, *cranial nerve;* Col., *column;* Fiss., *fissure;* For., *foramen;* Hyp., *hypophyseal;* Lam., *lamina;* Mam., *mamillary;* M.C.A., *middle cerebral artery;* Nucl., *nucleus;* Olf., *olfactory;* Pell., *pellucidum;* Perf., *perforating;* Pit., *pituitary;* Plex., *plexus;* Precall., *precallosal;* Rec., *recess;* Sept., *septum;* Sup., *superior;* Suprachiasm., *suprachiasmatic;* Term., *terminalis;* Thal. Str., *thalamostriate;* Tr., *tract;* V., *vein;* Vent., *ventricle.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

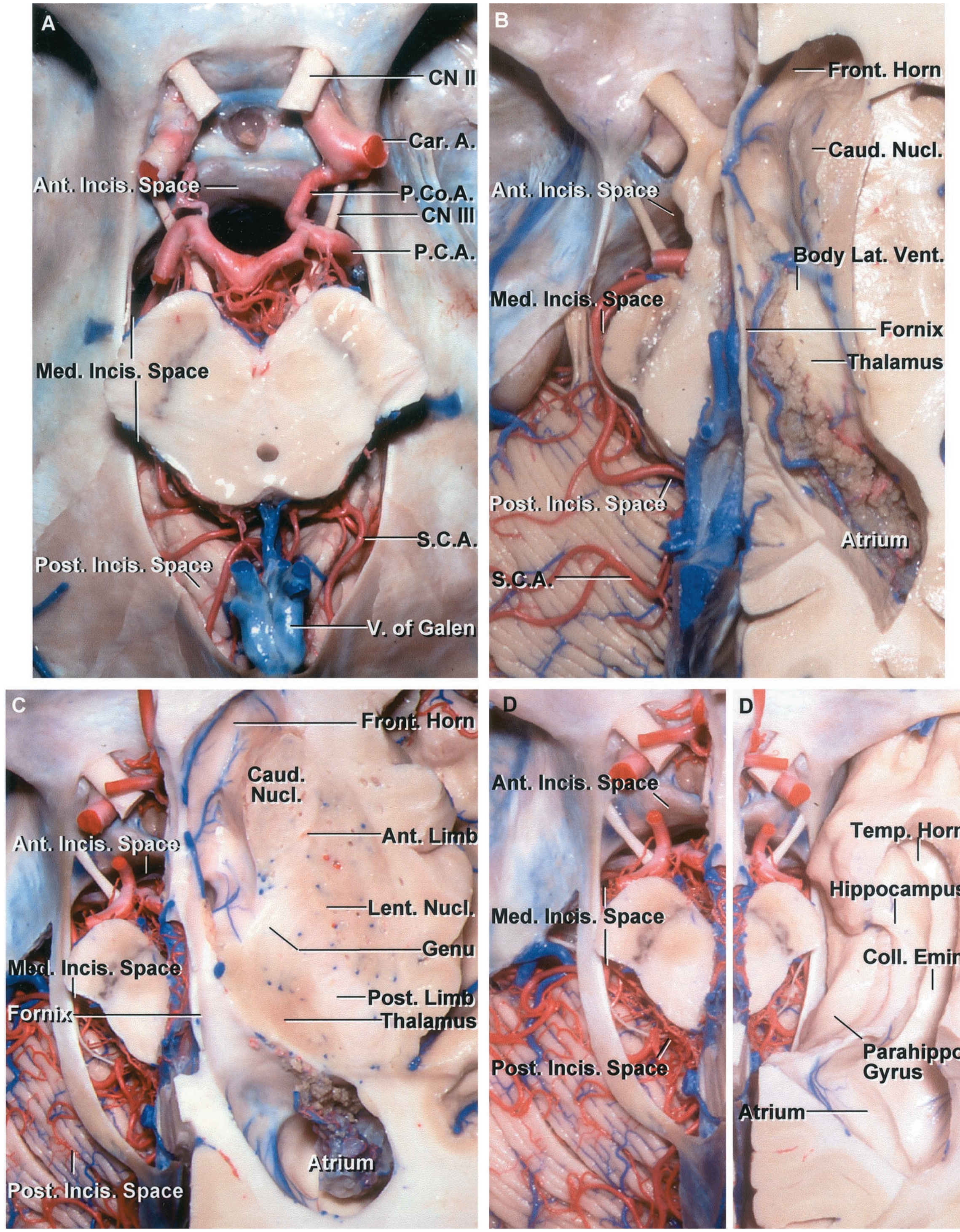


FIGURE 5.16. *Superior views showing the relationships of the lateral ventricles to the tentorial incisura.* A, *the tentorial incisura is divided into an anterior incisural space located anterior to the brainstem, a middle incisural space located between the midbrain and tentorial edge, and a posterior incisural space located between the tentorial apex and posterior surface of the midbrain. The anterior incisural space contains the chiasmatic and interpeduncular cisterns. The middle incisural space communicates with the ambient and crural cistern. The posterior incisural space contains the quadrigeminal cistern.* B, *superior view with the left cerebrum and left half of the tentorium removed. The frontal horn sits above the anterior incisural space. The thalamus sits directly above the midbrain in the center of the tentorial incisura. The middle incisural space is located between the midbrain and tentorial edge. The atrium faces the posterior incisural space and quadrigeminal cistern.* C, *another specimen. The axial section of the right hemisphere extends through the internal capsule. The frontal horn is located above the anterior incisural space. The thalamus is located above the midbrain in the center of the incisura and above the middle incisural spaces. The medial wall of the atrium forms the lateral wall of the quadrigeminal cistern and posterior incisural space. The internal capsule is situated above the lateral edge of the three incisural spaces.* D, *comparison of the relationships in the tentorial incisura* (D-left) *and temporal horn* (D-right). *The neural structures on the right have been removed except the temporal horn. The temporal lobe on the left was removed to expose the tentorial incisura. The choroidal fissure opens between the fimbria and the thalamus into the middle incisural space located lateral to the midbrain. The temporal horn is positioned lateral to the middle incisural space. The lower part of the medial wall of the atrium faces the posterior incisural space.* A., *artery;* Ant., *anterior;* Car., *carotid;* Caud., *caudate;* CN, *cranial nerve;* Coll., *collateral;* Front., *frontal;* Incis., *incisural;* Lat., *lateral;* Lent., *lenticular;* Med., *medial;* Nucl., *nucleus;* Parahippo., *parahippocampal;* P.C.A., *posterior cerebral artery;* P.Co.A., *posterior communicating artery;* Post., *posterior;* S.C.A., *superior cerebellar artery;* Temp., *temporal;* V., *vein;* Vent., *ventricle.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

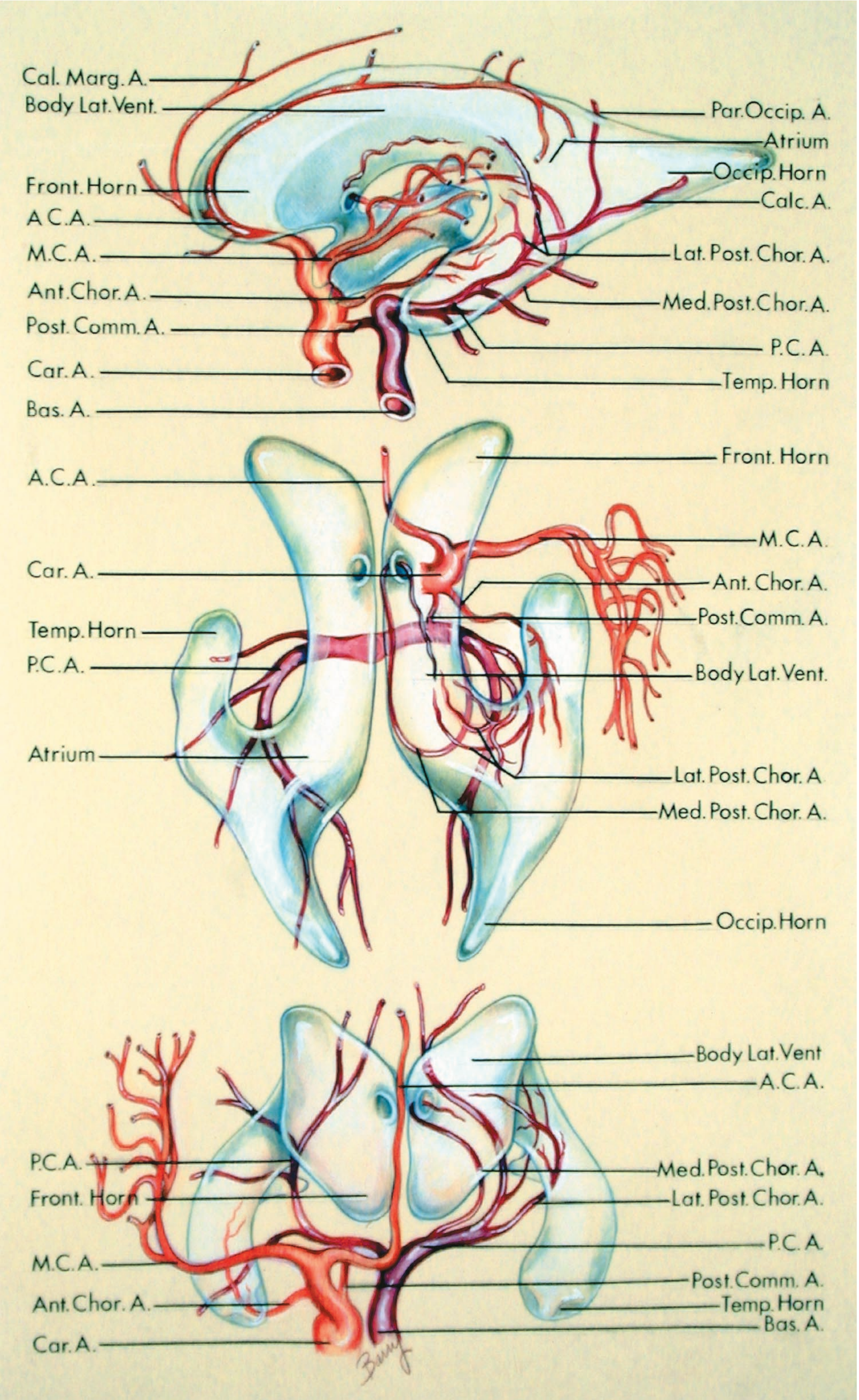


FIGURE 5.17. *Arterial relationships of the lateral ventricles. Lateral (*top*), superior (*middle*), and anterior (*bottom*) views. The internal carotid artery and its branches are shown in* orange*, and the basilar artery and its branches are shown in* red*. The internal carotid, basilar, anterior, middle, posterior cerebral, and anterior, lateral, and medial posterior choroidal arteries all have important relationships to the frontal, temporal, and occipital horns and the atria and bodies of the lateral ventricles. The carotid arteries bifurcate into their anterior and middle cerebral branches in the area below the posterior part of the frontal horns. The origins of the middle cerebral arteries are situated below the frontal horns. The anterior cerebral arteries pass anteromedially below the frontal horns and give rise to the pericallosal and callosomarginal branches, which curve around the anterior wall and roof of the frontal horn. The anterior choroidal arteries enter the anterior part of the temporal horns. The posterior communicating arteries are situated below the thalami and bodies of the lateral ventricles. The basilar artery bifurcates below the bodies of the lateral ventricles into the posterior cerebral arteries, which course below the thalami near the medial aspect of the temporal horns and atria. The medial posterior choroidal arteries arise from the proximal part of the posterior cerebral arteries, encircle the brainstem below the thalami, and pass forward in the roof of the third ventricle, where they give branches to the choroid plexus in the roof of the third ventricle and the bodies of the lateral ventricles. The lateral posterior choroidal branches of the posterior cerebral arteries pass laterally through the choroidal fissures to enter the temporal horns and atria of the lateral ventricles. The middle cerebral arteries course on the insulae in the area above the temporal horns and lateral to the bodies of the lateral ventricles. The posterior cerebral arteries bifurcate into the calcarine and parieto-occipital arteries in the area medial to the atria.* A., *artery;* A.C.A., *anterior cerebral artery;* Ant., *anterior;* Bas., *basilar;* Cal. Marg., *callosomarginal;* Calc., *calcarine;* Car., *carotid;* Chor., *choroidal;* Comm., *communicating;* Front., *frontal;* Lat., *lateral;* M.C.A., *middle cerebral artery;* Occip., *occipital;* Par. Occip., *parieto-occipital;* P.C.A., *posterior cerebral artery;* Post., *posterior;* Temp., *temporal;* Vent., *ventricle.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

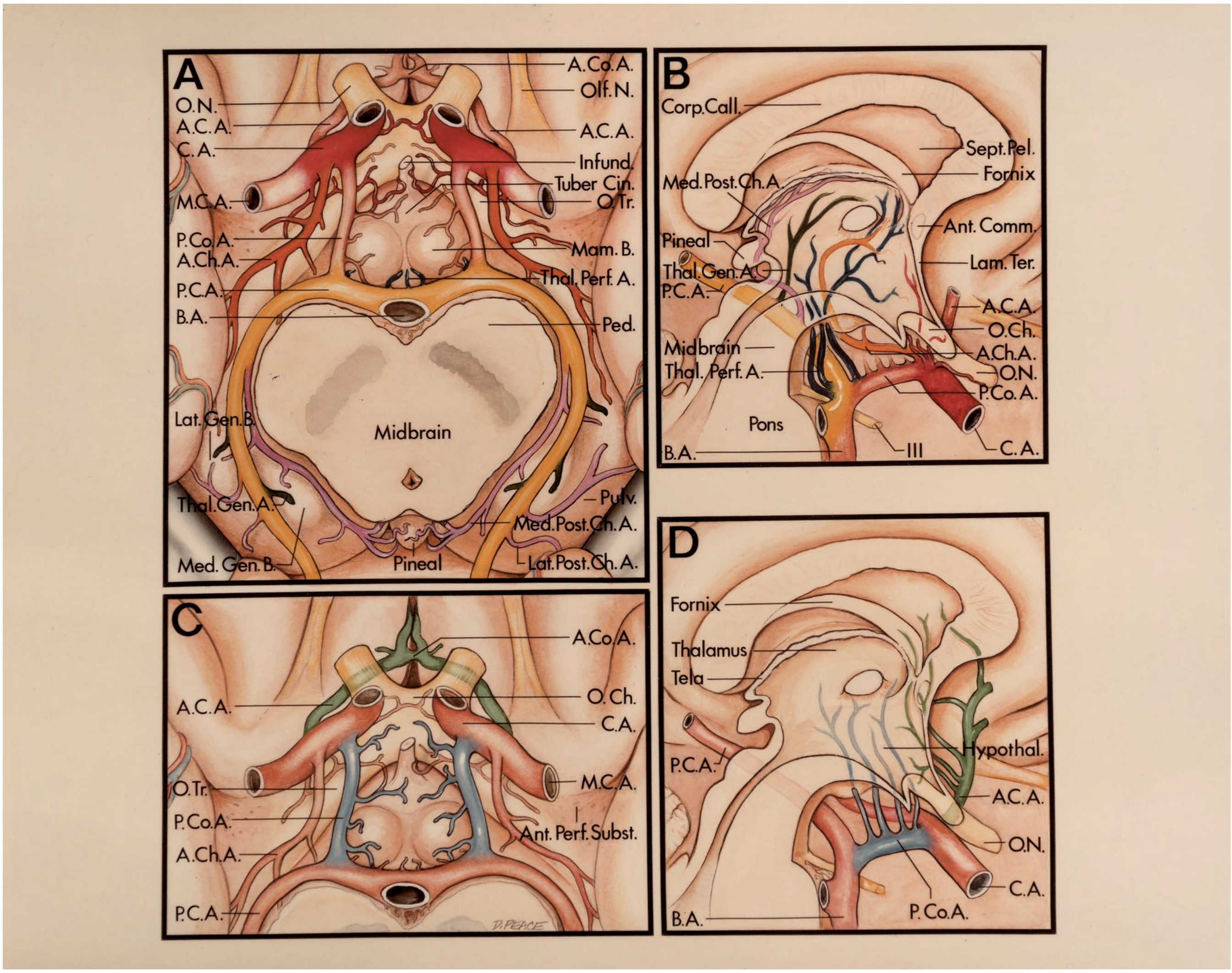


FIGURE 5.18. *Arterial relationships of the third ventricle.* A *and* C *are inferior views of the floor of the third ventricle and* B *and* D *are midsagittal sections through the third ventricle.* A *and* B *show the relationship of the main trunks and perforating branches of the following arteries to the third ventricle: internal carotid (*dark red*), anterior choroidal (*orange*), basilar apex (*yellow*), posterior cerebral (*yellow*), medial posterior choroidal (*pink*), lateral posterior choroidal (*pink*), thalamoperforating (*blue*), and thalamogeniculate (*dark green*) arteries.* C *and* D *show the relationships of the main trunks and perforating branches of the following arteries to the third ventricle: anterior cerebral (*light green*), anterior communicating (*light green*), and posterior communicating (*blue*) arteries. The olfactory and optic nerves are anterior to the floor of the third ventricle. The structures in the floor are the optic chiasm, optic tracts, infundibulum, tuber cinereum, and mamillary bodies. The midbrain and cerebral peduncles are inferior to the posterior half of the floor. The anterior perforated substance is lateral to the optic tracts. The lateral geniculate and medial geniculate bodies are attached to the lower margin of the thalamus near the pulvinar, lateral to the midbrain. The structures in the anterior wall of the third ventricle are the anterior commissure, lamina terminalis, and optic chiasm. The corpus callosum and septum pellucidum are above the roof of the third ventricle. The roof is formed of the two layers of tela choroidea, the fornix, and a vascular layer composed of the internal cerebral veins and the medial posterior choroidal arteries. The oculomotor nerve exits from the midbrain.* A., *artery;* A.C.A., *anterior cerebral artery;* A.Ch.A., *anterior choroidal artery;* A.Co.A., *anterior communicating artery;* Ant., *anterior;* B., *body;* B.A., *basilar artery;* C.A., *carotid artery;* Call., *callosum;* Ch., *chiasm, choroidal;* Cin., *cinereum;* Comm., *commissure;* Corp., *corpus;* Gen., *geniculate;* Hypothal., *hypothalamus;* Lam., *lamina;* Lat., *lateral;* Mam., *mamillary;* M.C.A., *middle cerebral artery;* Med., *medial;* N., *nerve;* O., *optic;* Olf., *olfactory;* P.C.A., *posterior cerebral artery;* P.Co.A., *posterior communicating artery;* Ped., *peduncle;* Pell., *pellucidum;* Perf., *perforated;* Post., *posterior;* Pulv., *pulvinar;* Sept., *septum;* Subst., *substance;* Term., *terminalis;* Thal.Gen., *thalamogeniculate;* Thal.Perf., *thalamoperforating;* Tr., *tract.*

send branches from the body of one lateral ventricle through the foramen of Monro, or between the fornix and thalamus to the choroid plexus in the third ventricle, or through the foramen of Monro to the choroid plexus in the body of the contralateral lateral ventricle. These branches intermingle with the branches of the medial posterior choroidal artery in the body of the ventricle and at the foramen of Monro.

The medial posterior choroidal arteries most frequently arise as one to three branches from the posteromedial aspect of the proximal part of the posterior cerebral artery in the interpedun-

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

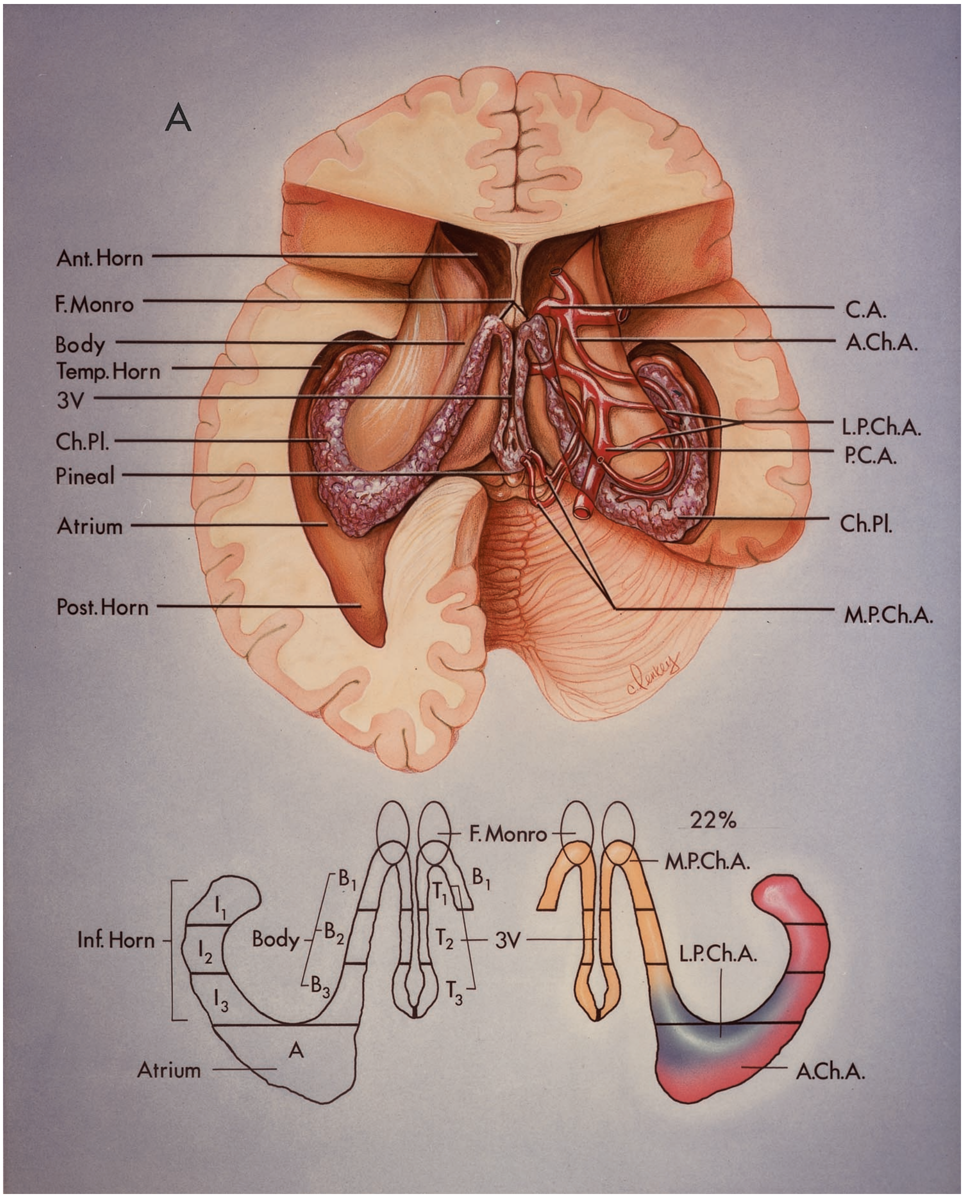


FIGURE 5.19. A. Upper: *Superior view with part of the cerebral hemispheres, corpus callosum, and the fornix removed to show the relationship between the lateral and third ventricle and the choroid plexus. The left hemisphere shows the relationship of the ventricles to the choroid plexus. The choroid plexus of the lateral ventricle extends from the temporal horn into the atrium and body of the lateral ventricle. It does not extend backward into the posterior horn or forward into the anterior (frontal) horn, but passes through the foramen of Monro and continues posteriorly in the roof of the third ventricle to the suprapineal recess above the pineal body. The right hemisphere shows the relationships between the choroidal arteries and the choroid plexus. The anterior choroidal artery arises from the carotid artery and supplies the plexus of the temporal horn and atrium. The lateral posterior choroidal arteries arise from the posterior cerebral artery or its branches and supply the plexus in the posterior part of the temporal horn, atrium, and body of the lateral ventricle. The medial posterior choroidal arteries arise from the posterior cerebral artery and supply the plexus in the third and, in many cases, the body of the lateral ventricle.* Lower left: *Classification of the choroid plexus. The portion of the choroid plexus within the temporal horn and body of the lateral ventricle and the third ventricle is subdivided into an anterior, middle, and posterior third. The subdivisions within the lateral and third ventricles are designated as follows: inferior (temporal) horn of the lateral ventricle—anterior third I_1, middle third I_2, and posterior third I_3; atrium of the lateral ventricle—A; body—anterior third B_1, middle third B_2, and posterior third B_3; and third ventricle—anterior third T_1, middle third T_2, and posterior third T_3. The criteria used to divide the area of supply of each artery into small, medium, and large groups are listed in* Table 5.1. Lower right: *Schematic illustration of the choroid plexus showing the most common pattern of supply (22% of hemispheres). The anterior choroidal artery is shown in* red, *the lateral posterior choroidal artery in* blue, *the medial posterior choroidal artery in* yellow, *and the contralateral lateral posterior choroidal artery in* green. *The area of the field of supply of the choroidal arteries is as follows: anterior choroidal artery, medium; lateral posterior choroidal artery, small; and medial posterior choroidal artery, large. The medial posterior choroidal arteries are shown together in both hemispheres. (Legend continues on next page.)*

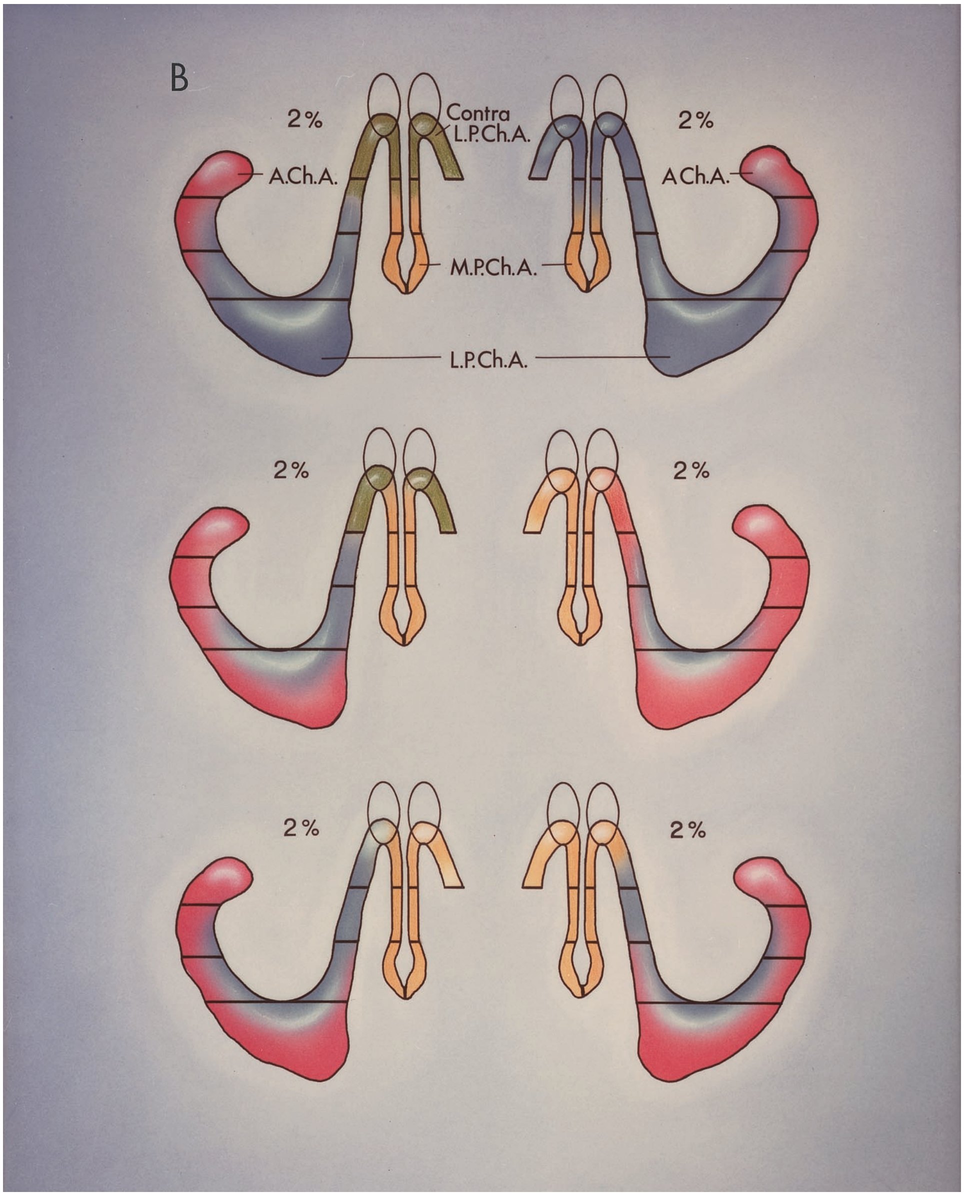
cular and crural cisterns. These branches encircle the midbrain medial to the main trunk of the posterior cerebral artery, turn forward at the side of the pineal gland to enter the roof of the third ventricle, and course in the velum interpositum, between the thalami, adjacent to the internal cerebral veins and the opposite medial posterior choroidal arteries. A few medial posterior choroidal arteries may arise from the distal parts of the posterior cerebral artery or its cortical branches and run in an anterior or retrograde course from their origin to reach the roof of the third ventricle. The medial posterior choroidal arteries supply the choroid plexus in the roof of the third ventricle and sometimes pass through the ipsilateral foramen of Monro or choroidal fissure to supply the choroid plexus in the lateral ventricle. They occasionally send branches through the contralateral foramen of Monro and choroidal fissure to supply the choroid plexus in the contralateral lateral ventricle. They may send tiny branches along their course to the cerebral peduncle, geniculate bodies, tegmentum, colliculi, pulvinar, pineal body, posterior commissure, habenula, striae medullaris thalami, occipital cortex, and thalamus.

Internal Carotid Artery

The internal carotid artery exits the cavernous sinus along the medial surface of the anterior clinoid process and bifurcates below the frontal horn (*Figs. 5.15–5.18*) (9, 29). The branches arising from the ophthalmic and communicating segments pass to the optic nerves, chiasm, and tract, and the

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

FIGURE 5.19. *Continued*
B, *schematic illustration of the choroid plexus showing size of the area supplied by the choroidal arteries. The criteria used to divide the area of supply of each artery into small, medium, and large groups are listed in* Table 5.1. *The second to seventh most common patterns are listed in* Table 5.2.



floor of the third ventricle, but the branches arising from the choroidal segment are directed upward through the anterior perforated substance to supply structures in or near the walls of the lateral and third ventricles, which include the genu and posterior limb of the internal capsule, the adjacent part of the globus pallidus, and the thalamus. The internal carotid artery also gives off the superior hypophyseal artery, which runs medially below the floor of the third ventricle, to reach the tuber cinereum and join its mate of the opposite side to form a vascular ring around the infundibulum.

Posterior Communicating Artery

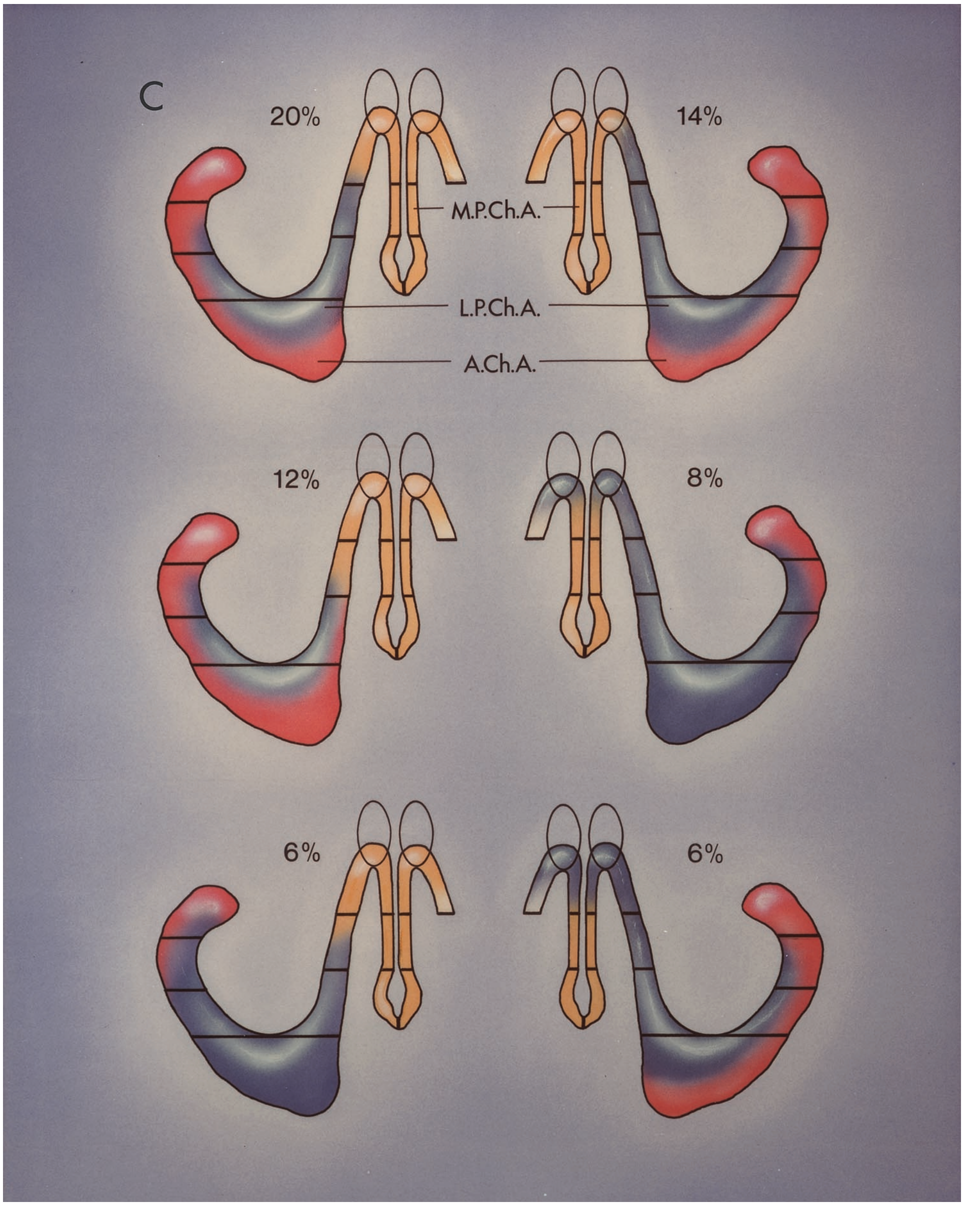
The posterior communicating artery arises from the posterior wall of the internal carotid artery below the frontal horn in the anterior incisural space and courses posteromedially below the optic tracts and the floor of the third ventricle to join the posterior cerebral artery (*Figs. 2.8, 5.17,* and *5.18*). Its branches penetrate the floor of the third ventricle between the optic chiasm and carotid peduncle to reach the hypothalamus, thalamus, subthalamus, and internal capsule in the area below the body of the lateral ventricle.

Anterior Cerebral and Anterior Communicating Arteries

The anterior cerebral artery ascends in front of the lamina terminalis and anterior wall of the third ventricle to reach the area below the floor of the frontal horn (*Figs. 5.11, 5.15, 5.17,* and *5.18*) (20, 21). It then passes below the rostrum and around the genu of the corpus callosum in close proximity to the floor, anterior wall, and roof of the frontal horn and the roof of the body of the lateral ventricle. The tightness of the curve around the frontal horn is a good indicator of

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

FIGURE 5.19. *Continued*
C, *schematic illustration of the choroid plexus showing the size of area supplied by the choroidal arteries. The criteria used to divide the area of supply into small, medium, and large groups are listed in* Table 5.1. *The least common patterns are listed in* Table 5.3. A.Ch.A., *anterior choroidal artery;* Ant., *anterior;* C.A., *carotid artery;* Ch., *choroid;* F., *foramen;* Inf., *inferior;* L.P.Ch.A., *lateral posterior choroidal artery;* M.P.Ch.A., *medial posterior choroidal artery;* P.C.A., *posterior cerebral artery;* Pl., *plexus;* Post., *posterior;* Temp., *temporal;* V, *ventricle.*



the size of the lateral ventricles. The distal part of the anterior cerebral artery may be exposed not only above, but also below the corpus callosum, because the terminal branch of the pericallosal artery may pass around the splenium and course forward in the roof of the third ventricle, reaching as far anterior as the foramen of Monro. The pericallosal branches that penetrate the corpus callosum reach the septum pellucidum and the fornix in the medial wall of the frontal horn and body.

The anterior cerebral and anterior communicating arteries give rise to perforating branches that terminate in the whole anterior wall of the third ventricle and reach the adjacent parts of the hypothalamus, fornix, septum pellucidum, and striatum. A precallosal artery may originate from the anterior cerebral or the anterior communicating artery, run upward across the lamina terminalis, and send branches into the anterior wall.

The recurrent branch of the anterior cerebral artery is frequently encountered in approaches below the anterior part of the third ventricle and frontal horn. It and the segment of the anterior cerebral artery proximal to the anterior communicating artery send branches into the area near the lateral wall of the frontal horn and body. These branches supply part of the genu and anterior limb of the internal capsule, globus pallidus, and less commonly, the thalamus.

Middle Cerebral Artery

The middle cerebral artery arises below the frontal horn (*Figs. 5.17* and *5.18*) (8). The penetrating branches of the mid-

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

TABLE 5.1. Criteria for classification of area supplied by the choroidal arteries by size[a]

Artery and size of field supply	Plexal area supplied	Percentage of hemispheres
Anterior choroidal		
Small	Only I_1, I_2, I_3	18
Medium	I_1, I_2, I_3, A	64
Large	I_{1-3}, A, and extends into body	18
Lateral posterior choroidal		
Small	Only I_3, A, B_3	38
Medium	I_2, I_3, A, B_3, B_2, and infrequently B_1	46
Large	I_1, I_2–B_1, and the plexus in third ventricle and/ or contralateral ventricle	16
Medial posterior choroidal		
Small	Only T_3, T_2	10
Medium	T_3, T_2, T_1	28
Large	T_3, T_2, T_1, and the plexus in lateral ventricle	62

[a] A, atrium of the lateral ventricle; B, body of the lateral ventricle: B_1 anterior third, B_2 middle third, B_3 posterior third; I, inferior (temporal) horn of the lateral ventricle: I_1 anterior third, I_2 middle third, and I_3 posterior third; and T, third ventricle: T_1 anterior third, T_2 middle third, and T_3 posterior third.

TABLE 5.2. Most common patterns of supply by the choroidal arteries[a]

Hemispheres present	% present	AChA (red)	LPChA (blue)	MPChA (yellow)
Upper				
Left	20%	Medium	Medium	Large
Right	14%	Medium	Medium	Medium
Middle				
Left	12%	Large	Small	Large
Right	8%	Small	Large	Medium
Lower				
Left	6%	Small	Medium	Large
Right	6%	Medium	Large	Small

[a] AChA, anterior choroidal artery; LPChA, lateral posterior choroidal artery; MPChA, medial posterior choroidal artery.

dle cerebral artery that supply structures in the area lateral to the frontal horn and body of the lateral ventricle are called the lenticulostriate arteries. They enter the deep structures lateral to the frontal horn and body of the lateral ventricle, including the lentiform nucleus, the entire anterior-posterior length of the internal capsule, and the body and head of the caudate nucleus.

Posterior Cerebral Artery

The bifurcation of the basilar artery into the posterior cerebral arteries is located below the posterior half of the floor of the third ventricle and below the bodies of the lateral ventricles (*Figs. 5.13*, *5.17*, and *5.18*) (30, 38). A high basilar bifurcation may indent the floor. Its branches reach the walls of the temporal horn, atrium, and body of the lateral ventricle, and the floor, roof, and posterior and lateral walls of the third ventricle.

The thalamogeniculate and the thalamoperforating arteries are two of the larger perforating branches of the posterior cerebral artery. The thalamoperforating arteries enter the brain through the posterior perforated substance to supply structures in the floor and lateral walls of the third ventricle, including the anterior two-thirds of the thalamus in the area below the floor of the body of the lateral ventricle. They also send branches into the cerebral peduncle, hypothalamus, midbrain, and internal capsule. The thalamogeniculate arteries arise in the ambient and enter the brain in the region of the geniculate bodies and send branches into the posterolateral part of the thalamus, including the geniculate bodies and the adjacent part of the internal capsule.

Superior Cerebellar Artery

This artery arises from the basilar artery, encircles the midbrain below the posterior cerebral artery, and passes through

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

TABLE 5.3. Least common patterns of supply by the choroidal arteries[a]

Hemispheres present	% present	AChA (red)	LPChA (blue)	MPChA (yellow)
Upper				
Left	2%[b]	Small	Medium	Small
Right	2%	Small	Large	Small
Middle				
Left	2%[b]	Medium	Small	Medium
Right	2%	Large	Small	Medium
Lower				
Left	2%	Large	Medium	Medium
Right	2%	Large	Medium	Large

[a] AChA, anterior choroidal artery; LPChA, lateral posterior choroidal artery; MPChA, medial posterior choroidal artery.
[b] Partially supplied by the large contralateral lateral posterior choroidal artery (green).

the quadrigeminal cistern to reach the superior surface of the cerebellum (10). The segment of the artery in the quadrigeminal cistern is exposed in the supra- and infratentorial operative approaches to the posterior part of the third ventricle, and its cortical branches are exposed in the infratentorial approaches. The perforating branches of the posterior cerebral and superior cerebellar arteries supply the walls of the cistern. The posterior cerebral arteries supply the structures above the level of the sulcus, between the superior and inferior colliculi, and the superior cerebellar arteries supply the structures below this level.

VENOUS RELATIONSHIPS

The deep cerebral venous system is intimately related to the walls of the lateral and third ventricles and the basal cisterns. Illustrations and more extensive text related to these veins is provided under Deep Veins in Chapter 4 (*Figs. 4.16, 4.17,* and *5.20*). These veins represent a formidable obstacle to the operative approaches directed from the lateral ventricle to the third ventricle, and in the region of the posterior wall, atrium, pineal region, and quadrigeminal cistern, where the internal cerebral vein and the basal vein of Rosenthal on each side converge on the great vein of Galen.

The deep venous system of the brain collects into channels that course in a subependymal location through the walls of the lateral and third ventricles as they converge on the internal cerebral, basal, and great veins (*Figs. 5.3, 5.6, 5.11, 5.12,* and *5.20*) (14, 17, 19). The veins from the frontal horn, the body of the lateral ventricle, and the surrounding gray and white matter drain into the internal cerebral vein; the veins from the temporal horn and the adjacent periventricular structures drain into the basal veins; and those draining the atrium and adjacent parts of the brain drain into the basal, internal cerebral, or great vein. The veins collecting blood from the periventricular white and gray matter join to form subependymal channels in the walls of the lateral ventricles.

During operations on the lateral ventricles, the veins provide orienting landmarks more commonly than the arteries because the arteries in the ventricular walls are small and poorly seen, but the veins are larger and are easily visible through the ependyma. These venous landmarks are especially helpful in the presence of hydrocephalus, when the normal angles between the neural structures disappear. On cerebral angiograms, these veins may provide a more accurate estimate of the site and size of a lesion than the arteries, because they are more closely adherent to the ependymal and pial surfaces of the brain than the arteries.

The ventricular veins arise from tributaries that drain the basal ganglia, thalamus, internal capsule, corpus callosum, septum pellucidum, fornix, and deep white matter and course along the walls of the ventricle in a subependymal location toward the choroidal fissure. The ventricular veins are divided into medial and lateral groups based on whether they course through the thalamic or forniceal side of the choroidal fissure: the lateral group passes through the thalamic or inner side of the fissure, and the medial group passes through the outer or forniceal circumference of the fissure.

The lateral group drains the lateral wall of the frontal, temporal, and occipital horns, the body, and the atrium, the floor of the body, the anterior wall of the atrium, and the roof of the temporal horn. The medial group drains the medial wall and roof of the frontal and occipital horns, body, and atrium and the floor of the temporal horn. The veins comprising the medial and lateral groups frequently join near the choroidal fissure to form a common stem before terminating in the large veins in the velum interpositum and basal cisterns.

The medial group of veins in the frontal horn consists of the anterior septal veins, and the lateral group consists of the anterior caudate veins. The medial group of veins in the body is formed by the posterior septal veins, and the lateral group consists of the thalamostriate, thalamocaudate, and posterior caudate veins. The medial group of veins in the atrium and occipital horn consists of the medial atrial veins, and the

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

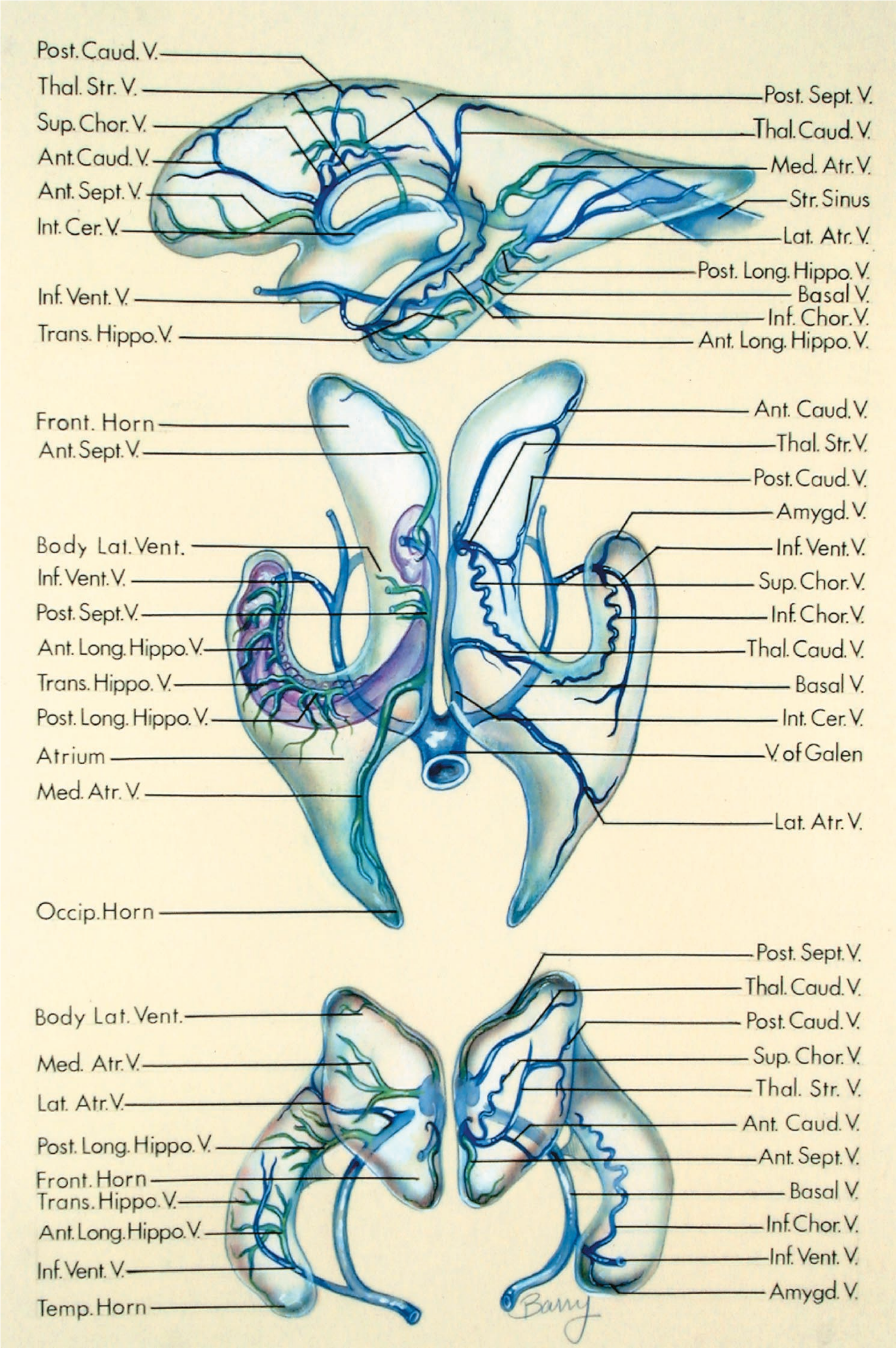


FIGURE 5.20. *Venous relationships of the lateral ventricles. Lateral (*top*), anterior (*middle*), and superior (*lower*) views. The ventricular veins are divided into medial and lateral groups. The ventricular veins drain into the internal cerebral, basal, and great veins. The lateral group consists of the anterior caudate vein in the frontal horn; the thalamostriate, posterior caudate, and thalamocaudate veins in the body; the lateral atrial veins in the atrium and occipital horn; and the inferior ventricular and amygdalar veins in the temporal horn. The medial group is formed by the anterior septal vein in the frontal horn; the posterior septal veins in the body; the medial atrial veins in the atrium; and the transverse hippocampal veins in the temporal horn. The transverse hippocampal veins drain into the anterior and posterior longitudinal hippocampal veins. The superior choroidal veins drain into the thalamostriate and internal cerebral veins, and the inferior choroidal vein drains into the inferior ventricular vein. The great vein drains into the straight sinus.* Amygd., *amygdalar;* Ant., *anterior;* Atr., *atrial;* Caud., *caudate;* Cer., *cerebral;* Chor., *choroidal;* Front., *frontal;* Hippo., *hippocampal;* Inf., *inferior;* Int., *internal;* Lat., *lateral;* Long., *longitudinal;* Med., *medial;* Occip., *occipital;* Post., *posterior;* Sept., *septal;* Str., *straight;* Sup., *superior;* Temp., *temporal;* Thal.Caud., *thalamocaudate;* Thal.Str., *thalamostriate;* Trans., *transverse;* V., *vein;* Vent., *ventricular, ventricle.*

lateral group is composed of the lateral atrial veins. The medial group of veins courses on the floor of the temporal horn, and the lateral group courses on the roof. The roof and lateral wall are drained predominantly by the inferior ventricular vein and the floor is drained by the transverse hippocampal veins.

Choroidal Veins

The superior and inferior choroidal veins are the largest veins on the choroid plexus (*Figs. 5.3, 5.6,* and *5.12*) (19). The superior choroidal vein, the largest of the choroidal veins, runs forward on the choroid plexus in the body of lateral ventricle and terminates near the foramen of Monro in the thalamostri-

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

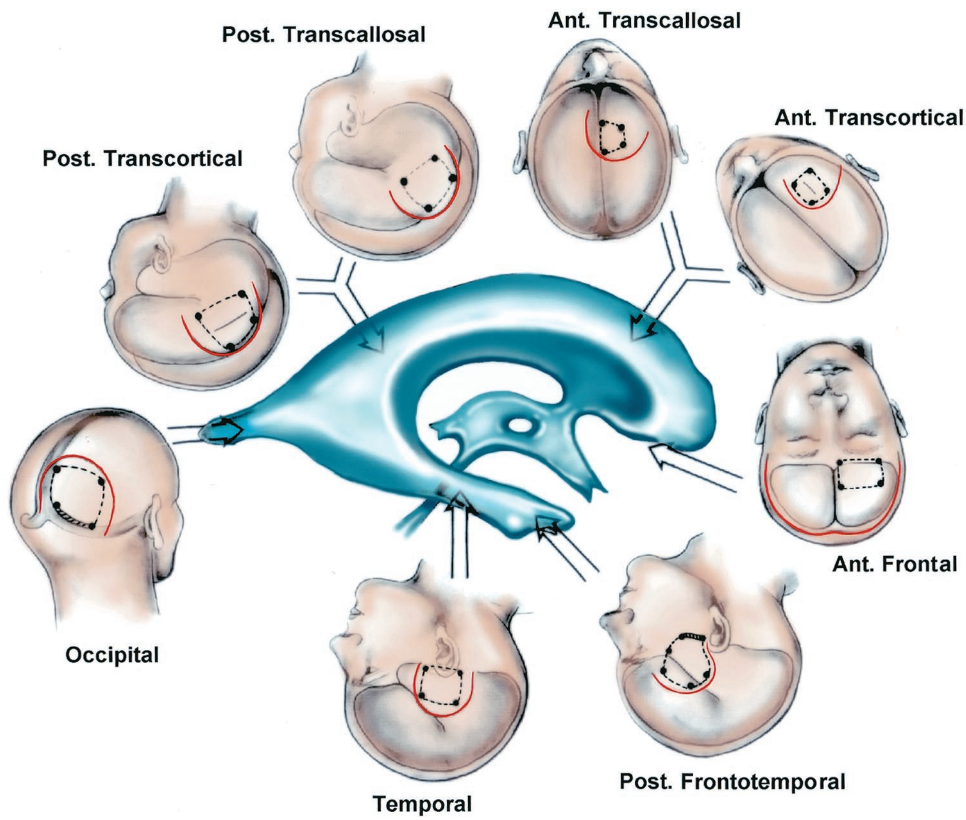


FIGURE 5.21. *Surgical approaches to the lateral ventricles. The site of the skin incision* (solid line*) and the bone flap (*broken line*) are shown for each approach. The anterior part of the lateral ventricle may be reached by the anterior transcallosal, anterior transcortical, and the frontal approaches. The posterior routes to the lateral ventricle are the posterior transcallosal, posterior transcortical, and occipital approaches. The inferior part of the lateral ventricle are reached using the frontotemporal and temporal approaches.* Ant., *anterior;* Post., *posterior.*

ate or internal cerebral veins or their tributaries. The inferior choroidal vein drains the choroid plexus in the temporal horn and atrium.

Internal Cerebral, Basal, and Great Veins

The venous relationships in the quadrigeminal cistern medial to the atrium are the most complex in the cranium because the internal cerebral, basal, and great veins and many of their tributaries converge on this area (*Figs. 5.3, 5.6, 5.11, 5.12,* and *5.20*). The internal cerebral veins exit the velum interpositum and the basal veins exit the ambient cisterns to reach the quadrigeminal cistern, where they join to form the vein of Galen.

The internal cerebral vein originates from multiple tributaries at the foramen of Monro and courses posteriorly in the roof of the third ventricle above the striae medullaris thalami between the two layers of the tela choroidea. Its anterior portion courses adjacent to the midline beside its mate from the opposite side. It diverges from the midline along the superolateral surface of the pineal. Further posteriorly, beneath the splenium of the corpus callosum, it converges on the midline and unites with its mate from the opposite side to form the vein of Galen.

The basal vein originates on the surface of the anterior perforated substance by the union of multiple veins and passes through the crural and ambient cisterns. It courses posteromedially above the uncus to reach the anterior portion of the cerebral peduncle. At the most medial point of the basal vein anterior to the peduncle, it turns posterolaterally to reach the lateral most point of the cerebral peduncle and then turns posteromedially around the inferior and posterior aspects of the pulvinar to join the vein of Galen or the internal cerebral vein in the quadrigeminal cistern.

SURGICAL CONSIDERATIONS

The lateral and third ventricles are among the most surgically inaccessible areas in the brain. Numerous operative approaches to the ventricles have been described since the pioneer work of Dandy (*Figs. 5.21* and *5.22*) (3–5). The routes through which the lateral and third ventricles can be reached are (a) from above, through the corpus callosum or the cerebral cortex; (b) from anterior, through the anterior interhemispheric fissure, corpus callosum, and lamina terminalis; (c) from below, through the basal cisterns, suprasellar region, or through or below the temporal lobe; and (d) from posterior, through the interhemispheric fissure, quadrigeminal cisterns, corpus callosum, and cerebral cortex. The selection of the best operative approach is determined by the relationship of the lesion to the lateral and third ventricles, the size of the ventricles and the structures involved, including the foramen of Monro, aqueduct of sylvius, optic nerves and chiasm, pineal gland, sella turcica, pituitary gland, fornix, midbrain, thalamus, corpus callosum, interhemispheric fissure, and basal cisterns. Before considering the specific operative approaches, some general principles are reviewed. These principles apply to all of the operative approaches discussed in this issue of *Neurosurgery*.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

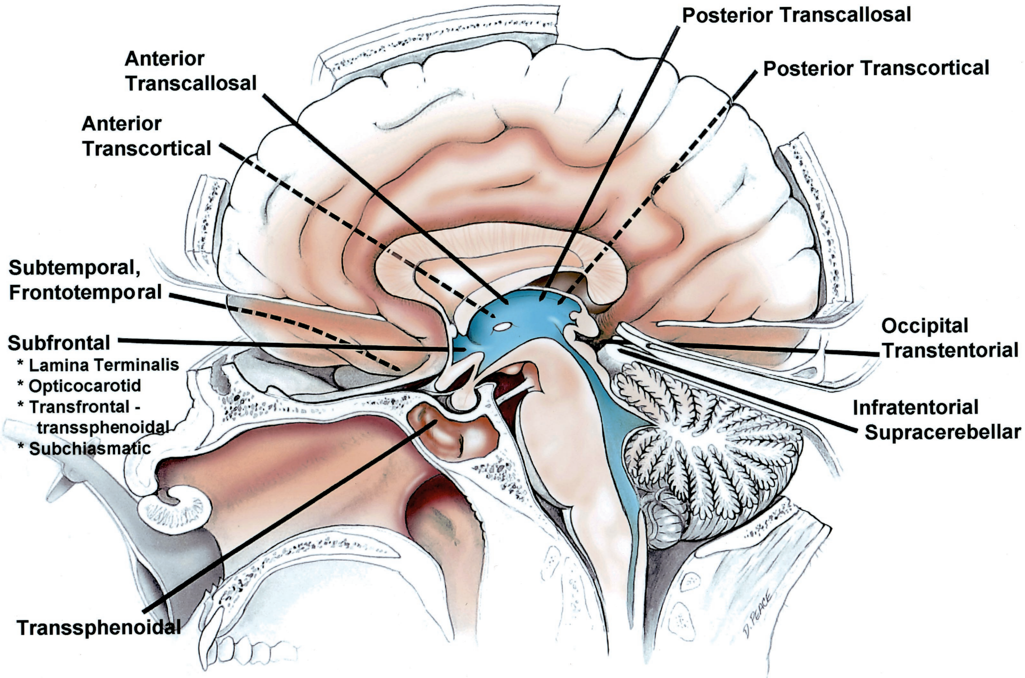


FIGURE 5.22. *Midsagittal view of the head showing the operative approaches to the third ventricle. The approaches that are directed along or near the midline are shown as* solid lines, *and those that approach the third ventricle away from the midline are shown as* dotted lines. *The midline or near-midline approaches to the anteroinferior part of the third ventricle are the transsphenoidal and the subfrontal. The subfrontal operative route is divided into four different approaches: (a) the lamina terminalis approach through the lamina terminalis; (b) the opticocarotid approach through the opticocarotid triangle; (c) the subchiasmatic approach below the optic chiasm between the optic nerves; and (d) the transfrontal-transsphenoidal approach through the planum sphenoidale and sphenoid sinus. The approaches to the floor and anteroinferior part of the third ventricle that are directed off the midline are the subtemporal and the frontotemporal. The approaches to the anterosuperior part of the third ventricle in the region of the foramen of Monro are the anterior transcallosal and the anterior transcortical. The supratentorial approaches to the posterior part of the third ventricle are the posterior transcallosal, posterior transcortical, and occipital transtentorial. The infratentorial supracerebellar approach is directed below the tentorium cerebelli to the posterior part of the third ventricle.*

Craniotomy Placement

The craniotomy flap should be placed so as to minimize the need for brain retraction. The sites of retraction used to reach the walls of the lateral and third ventricles include the orbital surface of the frontal lobe to reach the chiasmatic area; the frontal and parietal parasagittal cortex for the transcallosal approaches; the inferior and medial surfaces of the frontal lobe for the anterior frontal approach; the inferior surface of the frontal lobe and the anterior and inferior parts of the temporal lobe for the frontotemporal approaches; the inferior surface of the temporal lobe for the subtemporal approach; the inferior and medial surface of the occipital lobe for the occipital approach; and the superior surface of the cerebellum for the infratentorial approaches. To minimize the need for brain retraction, the surgeon should place the craniotomy as follows. For the parasagittal approaches, the flaps should extend to or across the midline. For the occipital approach, the flap should reach the margins of the sagittal and transverse sinuses and the torcular herophili. For the anterior frontal approach, the flap should have its medial margin on the midline and, if needed, its anterior margin on the floor of the anterior fossa. For the subfrontal, subtemporal, and frontotemporal approaches, the flap should have its lower border on the floor of the anterior and / or middle fossa. For the posterior frontotemporal approach, the flap should be based on the floor of the frontal and temporal fossae and the lateral half of the sphenoid ridge should be removed. For the infratentorial approaches the opening should reach the margin of the transverse sinus and torcular herophili.

Self-retaining, rather than hand-held, retractors are used. The extracerebral space is increased and the need for retraction is further reduced by draining cerebrospinal fluid through a ventriculostomy if hydrocephalus is present, through a basal cistern if hydrocephalous is not significant and a cistern in accessible in the exposure, or through a lumbar spinal drain if there is no ventricular obstruction.

Neural Incisions

It is impossible to reach the lateral and third ventricles without opening some neural structures. The surgical approaches to the lateral and third ventricles may require cortical incisions in the frontal, parietal, or temporal lobes and the anterior or posterior part of the corpus callosum, displacement or division of the fornix, and opening of the lamina terminales, choroidal fissure, septum pellucidum, floor of the third ventricle, and dissection and separation of the tumor from the quadrigeminal plate, the optic nerves, chiasm, and tracts, the pituitary gland and its stalk, and the cerebral peduncle. The brain may be retracted to expose an external wall of the third or lateral ventricle, such as the corpus callosum or lamina terminalis, but then the wall must be incised to reach the ventricle. After reaching the lateral ventricles, opening of the choroidal fissure or another neural incision through a site such as the fornix is needed to expose those lesions that extend into the third ventricle or the basal cisterns. Opening through the choroidal fissure in the body of the ventricle will expose the velum interpositum and the roof of the third ventricle, opening through the fissure in the atrium will expose the quadrigeminal cistern and the pineal region, and opening through it

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

in the temporal horn will expose the ambient cistern. When opening the choroidal fissure, it is better to open through the tenia fornicis than through the tenia choroidea, because fewer arteries and veins pass through the tenia fornicis (*Figs. 5.3, 5.6–5.9,* and *5.23*).

The incision and retraction of neural structures to reach the lateral and third ventricles, such as the olfactory and oculomotor nerves, the optic pathways, and the quadrigeminal plate, causes deficits that are well defined and that correspond to the area injured. The sacrifice of other neural structures has produced variable results: in some cases there was no deficit, and in others the deficit was transient or permanent or resulted in the loss of life. Structures sacrificed with variable results include the anterior and posterior parts of the corpus callosum and various parts of the fornix. Callosal incisions have resulted in disorders of the interhemispheric transfer of information, visuospatial transfer, the learning of bimanual motor tasks, and memory and have also resulted in such deficits as alexia, apraxia, and astereognosis (15, 24, 28, 33). Division of the fornix on both sides may cause a memory loss. The cerebral retraction needed for the anterior and posterior transcallosal approaches and the cortical incisions for the transventricular surgical approaches have caused convulsions, hemiplegia, mutism, impairment of consciousness, and visual field loss. Manipulation of lesions extending into the walls of the third ventricle may cause hypothalamic dysfunction as manifested by disturbances of temperature control, respiration, consciousness, and hypophyseal secretion; visual loss due to damage of the optic chiasm and tracts; and memory loss due to injury to the body and columns of the fornix. Dissection medial to the atrium in the area of the quadrigeminal plate may cause disorders of eye movement, edematous closure of the aqueduct of sylvius, blindness from edema in the colliculi or geniculate bodies, and extraocular palsies due to edema of the nuclei of the nerves or the central pathways in the brainstem (5).

Opening the choroidal fissure carries the risk of damaging the fornix. However, unilateral damage to the fornix produces no deficit, and damage to the forniceal fibers from both hemispheres does not usually produce a permanent memory loss (15, 24, 28, 33). Opening the temporal part of the choroidal fissure risks damaging the fimbria and hippocampal formation. There is abundant experimental and clinical evidence that massive bilateral damage of the hippocampal formation, causes impairment of recent memory. However, unilateral damage of the hippocampal formation produces no deficit. The stria terminalis that borders the temporal portion of the choroidal fissure is the most prominent efferent pathway from the amygdaloid nuclear complex to the nuclei of the stria terminalis. However, there is no evidence that unilateral lesions of the stria terminalis or amygdaloid nucleus cause emotional disturbances. Bilateral lesions of the amygdaloid complex may produce a reduction in emotional excitability.

Arterial Considerations

Intraventricular tumors and arteriovenous malformations are commonly supplied by the choroidal arteries (*Fig. 5.19*; *Tables 5.1–5.3*). The fact that the choroidal arteries converge on and pass through the choroidal fissure assists in identifying this fissure situated on the periphery of the thalamus through which operative procedures may be directed to the third ventricle, pineal region, and ambient and quadrigeminal cisterns. Opening through the fissure will expose these arteries proximal to a ventricular lesion; opening through the fissure in the body of ventricle will expose the medial posterior choroidal arteries in the velum interpositum and the roof of the third ventricle; opening through the fissure in the atrium will expose the medial and lateral posterior choroidal arteries in the quadrigeminal cistern and the pineal region; and opening through it in the temporal horn will expose the anterior, medial, and lateral posterior choroidal arteries in the ambient cistern.

Other arteries that may also be exposed in removing tumors of the lateral and third ventricles are the anterior cerebral and anterior communicating arteries in the region of the anterior wall of the third ventricle and the frontal horns and bodies of the lateral ventricle; the posterior part of the circle of Willis, the apex of the basilar artery, and the proximal part of the posterior cerebral arteries in the area below the third ventricular floor and medial to the temporal horns; the distal part of the posterior cerebral arteries in the area of the posterior third ventricle and medial to the atria; the posterior cerebral, pericallosal, superior cerebellar, and choroidal arteries adjacent to the posterior wall of the third ventricle and medial to the atria; and both the anterior and posterior cerebral arteries that send branches into the roof of the lateral ventricle. In addition, the internal carotid artery, anterior, middle, and posterior cerebral arteries, and anterior and posterior communicating arteries give rise to perforating branches that reach the walls of the lateral and third ventricles. Only infrequently should any of these be sacrificed. Occlusion of the perforating branches of these arteries at the anterior part of the circle of Willis is likely to result in disturbances in memory and personality, and occlusion of those at the posterior part of the circle of Willis is more likely to result in disorders of the level of consciousness and are frequently combined with disorders of extraocular motion. Sacrifice of the perforating branches of the posterior communicating artery in the subtemporal approaches has resulted in infarction in the basal ganglia (32). Obliteration of the thalamoperforating arteries in the cisterns medial to the temporal horn may cause coma and death. Injuries to the superior cerebellar artery in approaches to the posterior part of the third ventricle may cause a cerebellar deficit.

Venous Considerations

The ventricular veins provide valuable landmarks in directing the surgeon to the foramen of Monro and choroidal fissure during operations on the ventricles (*Figs. 5.3, 5.6, 5.11, 5.12, 5.20,* and *5.23*). This is especially true if hydrocephalus is present, as commonly occurs with ventricular tumors, because the borders between the neural structures in the ventricular walls become less distinct as the ventricles dilate. The thalamostriate vein is helpful in delimiting the junction of the caudate nucleus and thalamus, because it usually courses along the sulcus separating these structures.

The number of veins sacrificed in approaching a ventricular lesion should be kept to a minimum because of the undesir-

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

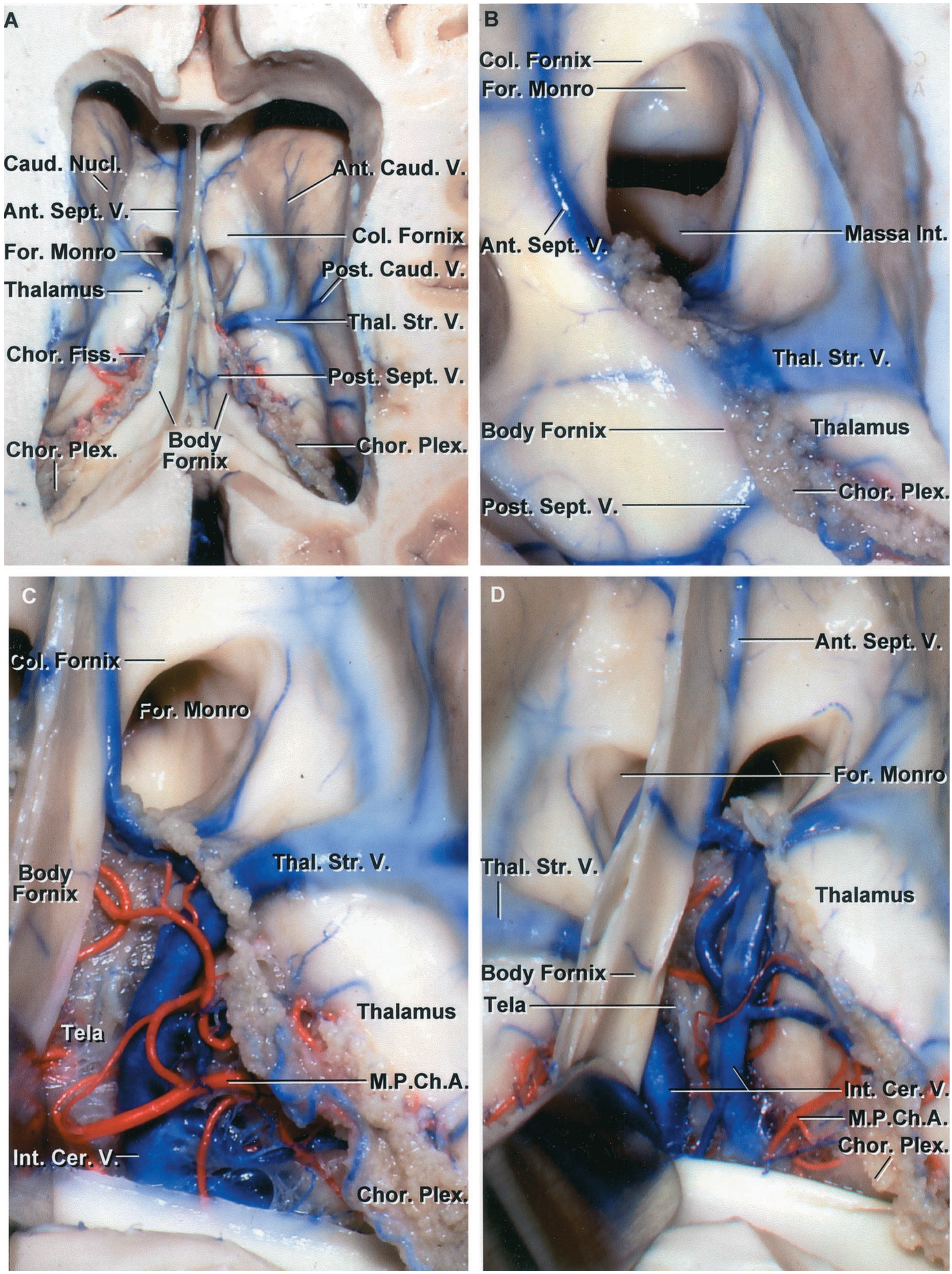


FIGURE 5.23. *Transchoroidal approach to the third ventricle directed along the forniceal side of the choroidal fissure.* A, *superior view of the frontal horn and body of the lateral ventricle. The body of the fornix forms the upper part of the roof of the third ventricle. The left thalamostriate vein passes through the posterior margin of the foramen of Monro and the right thalamostriate vein passes through the choroidal fissure a few millimeters behind the foramen. Anterior septal and anterior caudate veins cross the wall of the frontal horn. Posterior septal and posterior caudate veins cross the wall of the body of the lateral ventricle. The thalamus sits in the floor of the body. The choroidal fissure, located between the thalamus and fornix, is opened by dividing the tenia fornix that attaches the choroid plexus to the lateral edge of the fornix, leaving the attachment of the choroid plexus to the thalamus undisturbed.* B, *enlarged view. The columns of the fornix form the anterior and superior wall of the foramen of Monro. The massa intermedia is seen through the foramen. Anterior and posterior septal veins cross the septum pellucidum and fornix.* C, *the tenia fornix, which attaches the choroid plexus to the fornix, has been divided and the body of the fornix retracted medially to expose the internal cerebral vein and medial posterior choroidal arteries. The lower layer of tela, which attaches to the striae medullaris thalami and forms the floor of the velum interpositum, is intact.* D, *the separation of the fornix and choroid plexus has been extended posteriorly to the junction of the atrium and body of the ventricle. The lower layer of tela remains intact.* E, *the lower layer of tela has been opened to expose the massa intermedia, posterior commissure, and the floor of the third ventricle. The ependyma covering the anterior septal vein has been opened so that a short segment of the vein can be mobilized. The possibility of damaging the thalamostriate vein is reduced by allowing the choroid plexus to remain attached to the thalamus and the upper surface of the vein.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

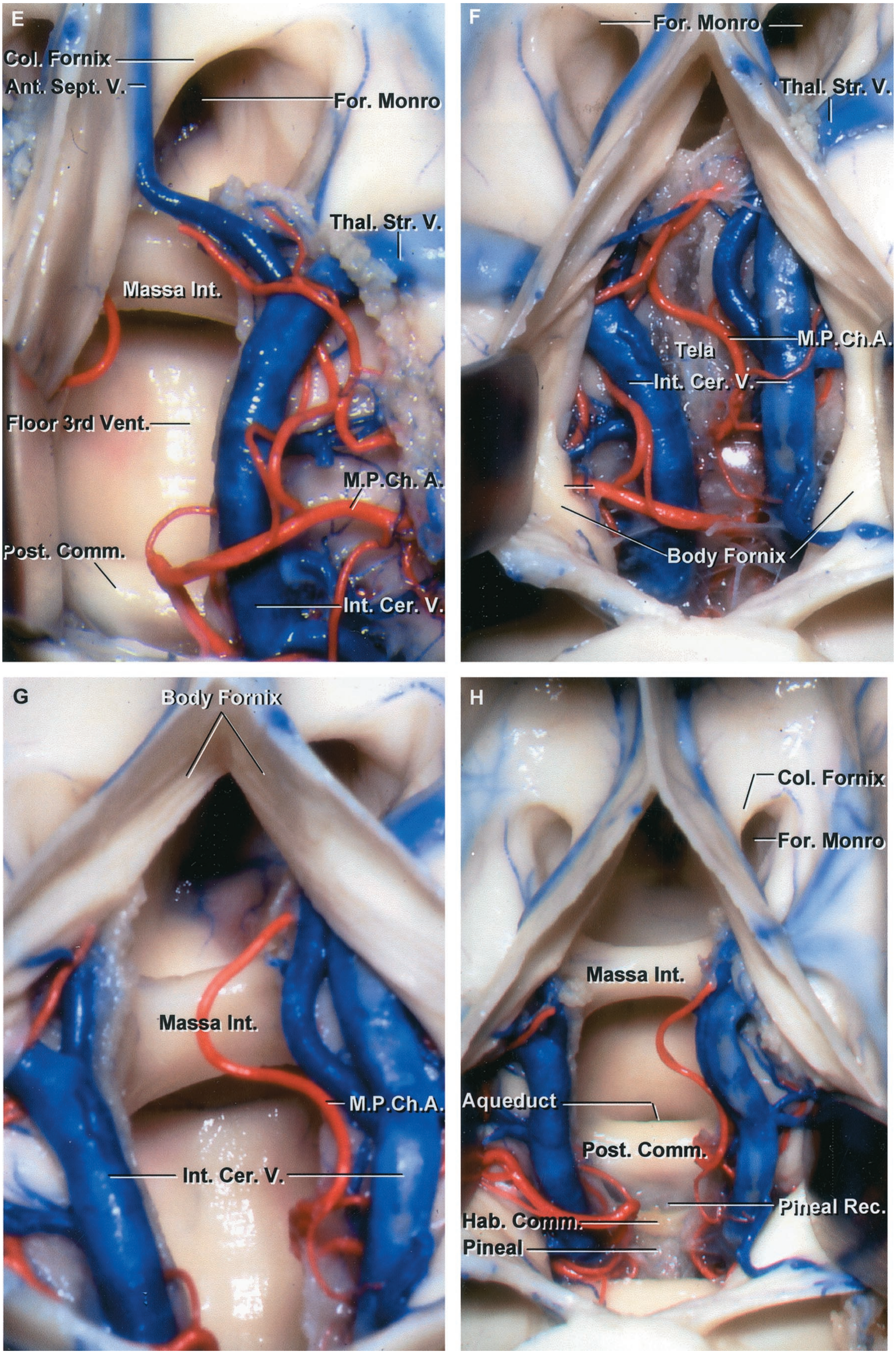


FIGURE 5.23. *Continued*
F–H, *interforniceal approach.* F, *the interforniceal approach is completed by incising the fornix longitudinally in the midline. Each half of the body of the fornix has been retracted laterally to expose the internal cerebral veins, medial posterior choroidal arteries, and the layer of tela choroidea that attaches to the striae medullaris thalami.* G, *the tela has been opened to expose the floor of the third ventricle and the massa intermedia.* H, *the view has been directed posteriorly toward the aqueduct and the posterior and habenular commissures. The pineal recess extends into the base of the pineal between the habenular and posterior commissures. The pineal gland extends backward from the pineal recess.* Ant., *anterior;* Caud., *caudate;* Cer., *cerebral;* Chor., *choroid;* Col., *column;* Comm., *commissure;* Fiss., *fissure;* For., *foramen;* Hab., *habenular;* Int., *intermedia, internal;* M.P.Ch.A., *medial posterior choroidal artery;* Nucl., *nucleus;* Plex., *plexus;* Post., *posterior;* Rec., *recess;* Sept., *septal;* Thal.Str., *thalamostriate;* V., *vein;* Vent., *ventricle.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

able consequences of their loss. Obliteration of the deep veins, including the great, basal, and internal cerebral veins and their tributaries, and the bridging veins from the cerebrum to the dural sinuses is inescapable in reaching and removing some tumors in or near the ventricles. Before sacrificing these veins, the surgeon should try placing them under moderate or even severe stretch (accepting the fact that they may be torn) if it will allow satisfactory exposure and yield some possibility of the veins being saved. Before sacrificing the basal, internal cerebral, and great veins, the surgeon should try working around them or displacing them out of the operative route or try dividing only a few of their small branches, which may allow displacement of the main trunk out of the operative field.

Sacrificing branches of the superficial and deep venous systems has produced inconstant deficits. Dandy (5) noted that, not infrequently, one internal cerebral vein had been sacrificed without effect, and on a few occasions both veins and even the great vein of Galen had been ligated with recovery without any apparent disturbance of function. On the other hand, injury to this venous network may cause diencephalic edema, mental symptoms, coma, hyperpyrexia, tachycardia, tachypnea, miosis, rigidity of limbs, and exaggeration of deep tendon reflexes (15, 24, 28, 33). Occlusion of the thalamostriate and other veins at the foramen of Monro may cause drowsiness, hemiplegia, mutism, and hemorrhagic infarction of the basal ganglia. Obliteration of veins coursing between the cerebrum and the superior sagittal sinus anterior or posterior to the rolandic vein, as may be required in the transcallosal approaches, although usually not causing a deficit, may be accompanied by hemiplegia. Sacrificing the internal occipital vein or the bridging veins from the occipital pole to the superior sagittal or transverse sinuses may cause hemianopsia. Cerebellar swelling after the transection of the bridging vein between the cerebellum and tentorium has been reported (15, 24, 28, 33).

Tumor Removal

Tissue should be removed from within the capsule of an encapsulated ventricular tumor before trying to separate the capsule from adjacent structures. If the tumor could be cystic, the initial step is aspiration with a needle. If the tumor is encapsulated, the capsule is opened, the tumor is biopsied, and an intracapsular removal is completed. The capsule is separated from the neural and vascular structures after the contents of the capsule have been removed. The most common cause of tumor appearing to be tightly adherent is not adhesions between the capsule and surrounding structures; rather, it is residual tumor within the capsule wedging the tumor into position. As the intracapsular contents are removed, the tumor collapses, thus making it possible to remove more tumor through the small exposure. Tumors are not commonly so densely adherent that they defy easy removal after their intracapsular contents are removed. If the tumor does not separate easily from the neural tissue after the intracapsular contents have been removed, a brief wait often allows the pulsation of the brain to dislodge the tumor into the exposure, and then more tumor can frequently be removed from within the capsule. Under magnification, individual adhesions between vital structures and the tumor can be divided with microinstruments. This technique has been especially helpful in removing craniopharyngiomas. It is frequently possible to remove the capsule of craniopharyngiomas and epidermoid tumors involving the third ventricle, but not that of chromophobe adenomas. The capsule of the chromophobe adenoma is the dura mater of the cranial base, which has been stretched upward over the tumor. The stretched dura over the dome of the chromophobe adenoma may be excised, but an attempt to pull this pseudocapsule of dura mater from its attachment to the cranial base may cause severe vascular and neural injury. A remnant of the tumor capsule may be left if it is attached firmly to vital structures such as the optic nerves or chiasm, colliculi, thalamus, or hypothalamus. The response of craniopharyngiomas, chromophobe adenomas, pinealomas, and some gliomas to radiation therapy is sufficiently good that it may be relied on to deal with residual neoplasm. The removal is limited frequently to biopsy only or an internal decompression if the tumor is malignant or infiltrative.

A colloid cyst is first aspirated with a needle through the foramen of Monro. It is often possible to perform the entire operation through the foramen of Monro, especially if it is enlarged. Grumous material within the cyst is then removed using a microsuction, perhaps with the addition of forceps extraction. In the case of a very large colloid cyst, an approach through the choroidal fissure is preferable to dividing the fornix.

The arteries that pass over the tumor capsule to neural tissues should be preserved. Any vessel that stands above the surface of the capsule should be dealt with initially as if it were a vessel supplying the brain. An attempt should be made to displace the vessel off the tumor capsule using a small dissector after the tumor has been removed from within the capsule.

A shunt may be needed if obstruction to the flow of cerebrospinal fluid at the foramen of Monro, aqueduct of sylvius, third ventricle, or tentorial incisura persists at the end of the operation. If the initial operation creates an opening from the third ventricle through the lamina terminalis, floor of the third ventricle, or pineal region into the subarachnoid space, this may suffice. The floor of the third ventricle in front of the mamillary body may be opened using endoscopic techniques. If a suboccipital exposure has been used to approach a tumor of the pineal region, a tube may be led from the lateral ventricle or from an opening in the posterior part of the third ventricle to the cisterna magna, thus creating a Torkildsen shunt.

OPERATIVE APPROACHES

The operative approaches to the lateral ventricles are divided into anterior, posterior, and inferior approaches (*Fig. 5.21*). The anterior approaches are directed to the frontal horn and body of the lateral ventricle and the anterior part of the third ventricle. The posterior approaches are directed to the atrium and posterior third ventricle, and the inferior approaches are directed to the temporal horn and basal cisterns.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

The anterior approaches are the anterior transcallosal, anterior transcortical, and anterior frontal. The posterior approaches are the posterior transcallosal, posterior transventricular, occipital transtentorial, and infratentorial supracerebellar. The lateral approaches are the pterional, posterior frontotemporal, and subtemporal. The transsphenoidal and subfrontal approaches may also be used for selected lesions involving the anterior wall and floor of the third ventricle; however, these approaches are most commonly used for lesions involving the sella and are reviewed in Chapter 8.

Anterior Approaches

Anterior Transcallosal Approach

This approach, directed through the corpus callosum, is suitable for reaching lesions located within the frontal horn and body of the lateral ventricle and the anterosuperior part of the third ventricle (*Fig. 5.24*). The alternative to the anterior transcallosal approach is the anterior transcortical approach directed through the middle frontal gyrus. It is easier to expose the opening of the foramen of Monro into both lateral ventricles through this approach than through the anterior transcortical approach. The transcallosal approach is easier to perform than the transventricular approach if the ventricles are of a normal size or are minimally enlarged.

The patient is positioned supine with the sagittal suture in the vertical plane and the head elevated 20 to 30 degrees. An alternative position is the lateral position with the right side down, so that gravity will assist the retraction of the medial surface of the right cerebral hemisphere away from the right side of the falx. A right frontal horseshoe, bicoronal, or S-shaped skin incision is used. The right frontal bone flap extending to the lateral edge of or across the sagittal sinus is located two-thirds in front and one-third behind the coronal suture. The dura mater is opened with the base on the sagittal sinus. The area in front of the coronal suture is often relatively devoid of bridging veins entering the superior sagittal sinus; some, usually no more than one, may have to be divided to allow retraction of the medial surface of the right frontal lobe away from the falx (*Fig. 5.3*). The arachnoid membrane, encountered deep to the free edge of the falx, is opened to expose the corpus callosum and the anterior cerebral arteries. Smaller veins from the corpus callosum and adjacent part of the frontal lobe that empty into the anterior end of the inferior sagittal sinus may have to be sacrificed. Opening the arachnoid below the falx exposes the branches of the anterior cerebral arteries, which may cross the midline above the corpus callosum. The right and left cingulate gyri, which face each other, are separated to expose the corpus callosum and the pericallosal arteries. The approach is best directed between the pericallosal arteries, although some of their branches may cross the midline above the corpus callosum. If both pericallosal arteries are retracted to one side, it may be necessary to divide some of the branches that run laterally from the pericallosal arteries to the corpus callosum and the cingulate gyrus to reach the corpus callosum.

The part of the corpus callosum above the foramen of Monro is split in the midline. An incision 2 cm in length provides satisfactory access to both lateral ventricles. Image guidance will aid in selecting the site to open the corpus callosum. After the ventricle is opened by either the transcallosal or transventricular approach, the foramen of Monro is found by following the choroid plexus and the thalamostriate vein anteriorly to where they converge on the foramen. The choroid plexus is attached along the choroidal fissure between the fornix and thalamus, and the thalamostriate vein courses in a more lateral position in the groove between the thalamus and caudate nucleus. The veins in the frontal horn are seen to drain posteriorly toward the foramen of Monro because the choroidal fissure through which they pass to reach the internal cerebral vein does not extend into the frontal horn.

The close relationship of the genu of the internal capsule to the foramen of Monro should be kept in mind when retracting the walls of the lateral ventricle (*Figs. 5.2* and *5.3*). The genu of the internal capsule touches the wall of the ventricle in the area lateral to the foramen of Monro near the anterior pole of the thalamus. Care should be exercised in retracting this area because a thin brain spatula could easily cut into the ventricular wall in this critical region resulting in hemiplegia.

The callosal opening may expose the frontal horn and body on the same or opposite side of the cranial exposure, but the anatomy makes this obvious. A simple rule for determining whether the left or right lateral ventricle has been exposed is to determine whether the thalamostriate vein is to the left or right side of the choroid plexus; the left lateral ventricle has been opened if the thalamostriate vein is further to the patient's left side than the choroid plexus; the right lateral ventricle has been entered if the thalamostriate vein is further to the patient's right side than the choroid plexus. Entry into a cavum between the leaves of the septum pellucidum may be confusing until the surgeon realizes that no intraventricular structures are present. Opening the septum pellucidum will provide access to the opposite lateral ventricle and the opening of the foramen of Monro into both lateral ventricles.

There are several methods of enlarging the opening at the foramen of Monro if needed to explore a deeper portion of the third ventricle (*Fig. 5.24B*). One is to incise the ipsilateral column of the fornix at the anterosuperior edge of the foramen of Monro. A preferable alternative to incising the fornix is the transchoroidal approach in which the choroidal fissure, located between the fornix and thalamus, is opened, thus allowing the fornix to be pushed to the opposite side to expose the structures in the roof of the third ventricle (*Figs. 5.23* and *5.24*). The fissure is the thinnest site in the wall of the lateral ventricle bordering the roof of the third ventricle. Another alternative is the interforniceal approach, in which the body of the fornix is split in the midline, in the direction of its fibers, to expose the velum interpositum (2, 13, 35). The transchoroidal and interforniceal approaches have the advantage of giving access to the central portion of the third ventricle behind the foramen of Monro by displacing, rather than transecting, the fibers in the fornix (15, 36). Both approaches provide a satisfactory view into the third ventricle with the transcallosal approach. Sectioning the thalamostriate vein at the posterior

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

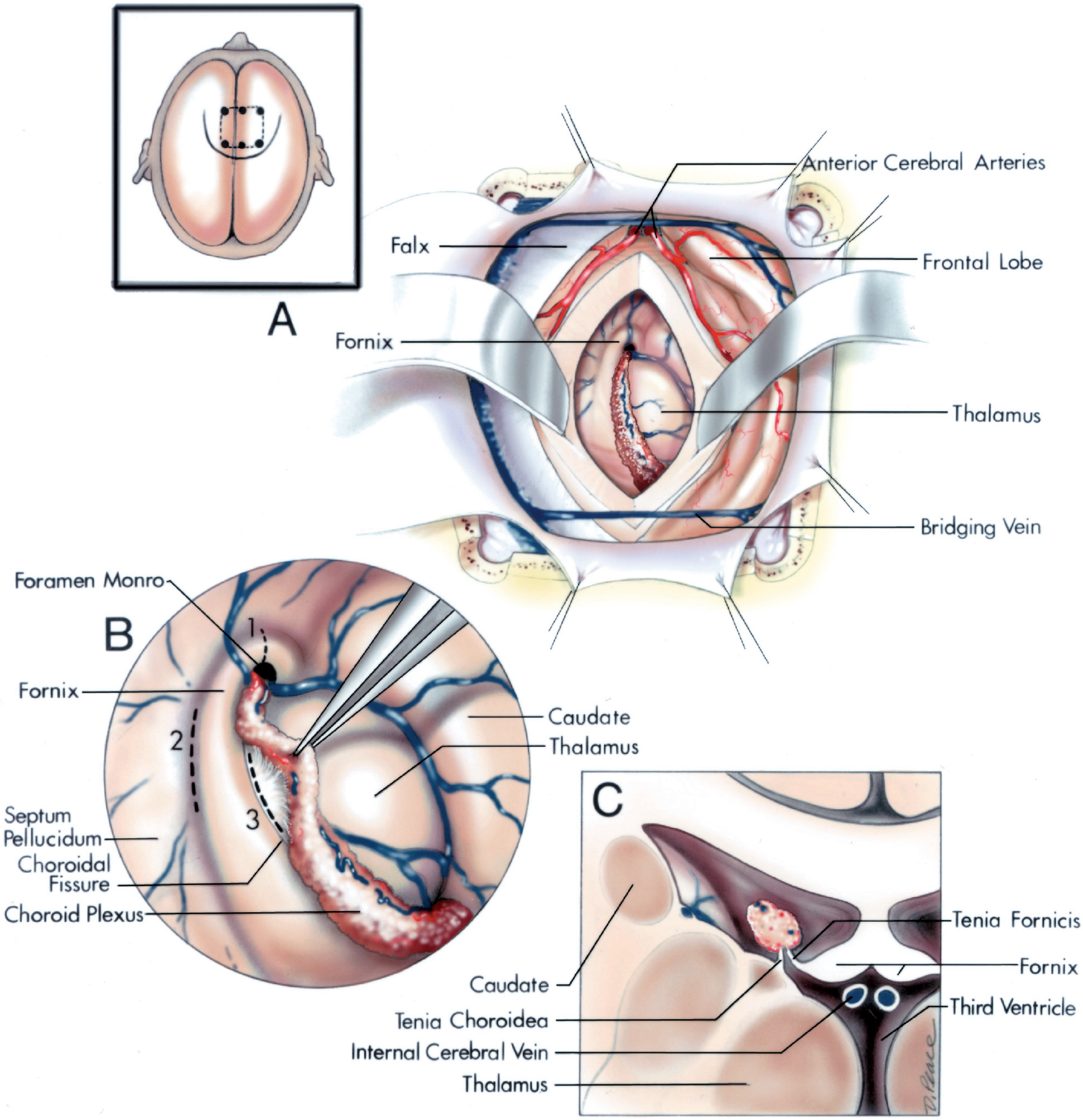


FIGURE 5.24. *Transcallosal approach to the lateral and third ventricles. A–C, normal ventricular anatomy. A, the body and frontal horn of the right lateral ventricle have been exposed through an incision in the anterior part of the corpus callosum. The* inset *on the upper left shows the head position, scalp incision (*solid line*) and bone flap (*broken line*). The bone flap extends across the superior sagittal sinus. An alternative would be to use a Souttar incision and to have the bone flap extend only to the lateral edge of the superior sagittal sinus. B, sites of incisions used to reach lesions in the third ventricle: (*No. 1*) the foramen of Monro may be enlarged by incising the ipsilateral column of the fornix, at the anterosuperior margin of the foramen of Monro; (*No. 2*) the transforniceal approach is completed using an incision along the body of the fornix in the midline; and (*No. 3*) the transchoroidal approach is completed by opening the choroidal fissure by incising along the tenia fornicis. C, the transchoroidal approach is completed by incision along the tenia fornicis rather than the tenia choroidea, also referred to as the tenia thalami, because more veins and arteries pass through the tenia choroidea than the tenia fornicis. The internal cerebral veins course in the roof of the third ventricle. D and F, removal of a large colloid cyst by the transchoroidal approach.*

margin of the foramen of Monro has also been advocated as an alternative to incising the fornix for enlarging the opening into the third ventricle; however, this may cause drowsiness, hemiplegia, and mutism, and occlusion of the veins of the foramen of Monro has caused hemorrhagic infarction of the basal ganglia.

In the transchoroidal approach, the third ventricle is exposed by opening the choroidal fissure along the tenia fornicis

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

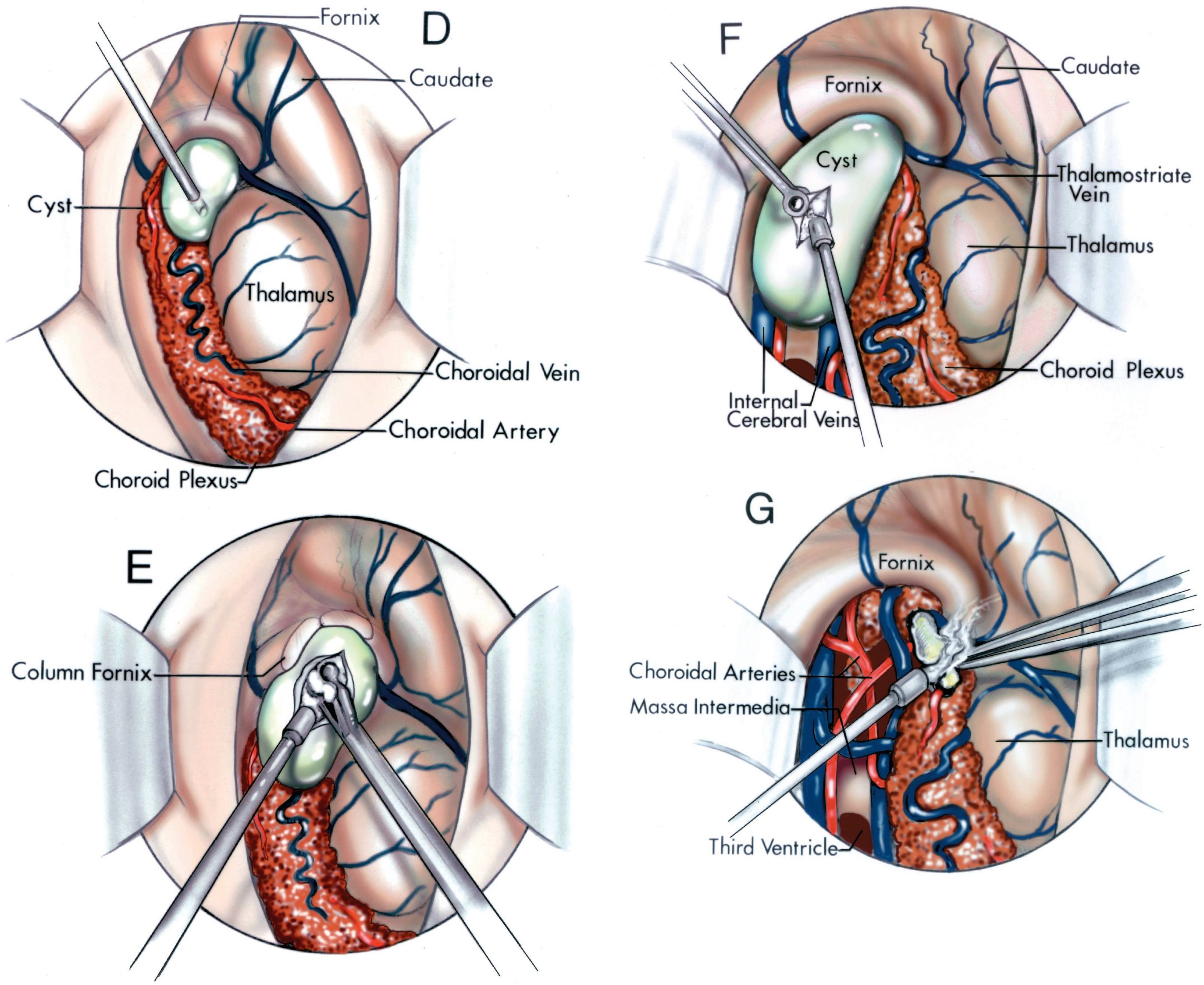


FIGURE 5.24. *Continued*
D, *a colloid cyst that obstructs the foramen of Monro is being aspirated with a needle.* E, *a colloid cyst that obstructs the foramen of Monro has been exposed by opening the choroidal fissure along the attachment of the choroid plexus to the fornix. The internal cerebral veins and medial posterior choroidal arteries are exposed behind the foramen of Monro. The cyst's contents are being removed with a suction.* F, *the final remnant of the attachment of the cyst to the choroid plexus is being coagulated.* G, *the column of the fornix has been divided to enlarge the foramen of Monro and the semigelatinous material within the cyst is being removed using a cup forceps and suction. (Legend continues on next page.)*

beginning at the posterior edge of the foramen of Monro and displacing the fornix to the opposite side, after which the roof of the third ventricle is entered by opening the layers of tela choroidea (*Figs. 5.23* and *5.24*). Opening 1 cm of the choroidal fissure beginning at the posterior edge of the foramen of Monro usually provides a view of the ventricular floor back to the aqueduct. It is safer to direct the transchoroidal approach through the tenia fornicis than through the tenia thalami because the large veins, like the thalamostriate vein that drains the internal capsule and central part of the hemisphere and the choroidal arteries, pass through the tenia thalami rather than through the tenia fornicis. The transchoroidal approach is especially well suited to lesions that are fed by the terminal branches of the choroidal arteries.

The roof of the third ventricle can commonly be entered without sacrificing any branches of the internal cerebral veins if the approach is directed between the veins; however, it is often necessary to sacrifice some of the branches of the internal cerebral vein if the third ventricle is entered on the lateral side of the internal cerebral vein between the vein and thalamus

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

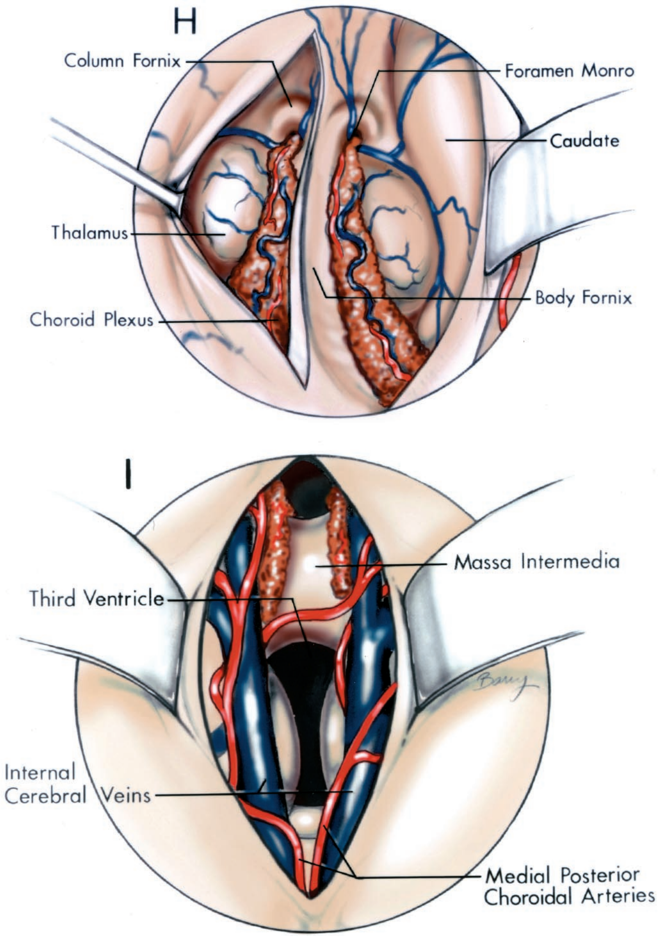


FIGURE 5.24. *Continued*
H, *the septum pellucidum has been opened to expose the frontal horns and bodies of both lateral ventricles. The columns of the fornix arch anterior and superior to the openings of the foramen of Monro into both lateral ventricles. The body of the fornix forms part of the roof of the third ventricle.* I, *the body of the fornix has been split in the midline to expose the third ventricle. The internal cerebral veins and medial posterior choroidal arteries course in the roof of the third ventricle. This transforniceal approach is suitable for exposing lesions located in the third ventricle behind the foramen of Monro.*

(*Figs. 5.12* and *5.23*). The tiny branches of the medial and lateral posterior choroidal arteries may cross the midline in the velum interpositum, but the risk of sacrificing these fine branches is minimal. After opening the lower layer of tela choroidea, the choroid plexus in the roof of the third ventricle, massa intermedia, and the floor of the third ventricle are encountered.

In earlier reports, the choroidal fissure was opened by incising the tenia thalami. This approach, referred to as the subchoroidal approach, risks damaging the thalamus and the vessels that pass through the thalamic side of the fissure by penetrating the tenia choroidea (6, 11, 13). We refer to the approach directed through the tenia fornix as the transchoroidal or suprachoroidal approach to distinguish it from the subchoroidal approach.

Opening the choroidal fissure carries the risk of damaging the fornix. However, unilateral damage to the fornix produces no deficit, and damage to the forniceal fibers from both hemispheres does not usually produce a memory loss. There is evidence that lesions in the crus and hippocampal commissure have a more deleterious effect on memory than lesions in the body or columns. In opening the body portion of the choroidal fissure, there is the risk of damage to the dorsomedial nucleus of the thalamus. This nucleus has afferent fibers stemming mainly from the amygdaloid complex and the temporal neocortex, and efferent fibers directed to the prefrontal cortex. Lesions in the dorsomedial nucleus produce emotional changes similar to those resulting from ablations of the orbitofrontal cortex (15, 28). The interforniceal approach, like the transchoroidal approach, can also be used to expose lesions located below the roof of the third ventricle and posterior to the foramen of Monro. The interforniceal incision extends posteriorly in the midline along the body of the fornix. The right and left halves of the body of the fornix are each displaced to the ipsilateral side, and the roof of the third ventricle below the fornix is opened. The interforniceal approach to a lesion of the third ventricle carries the potential risk for bilateral damage to the fornix, but the memory deficits resulting from use of this approach are usually transient (1, 2).

Anterior Transcortical Approach

This approach, directed through the interhemispheric fissure and the anterior part of the corpus callosum, is suitable for lesions in the anterior part of the lateral ventricle and the anterosuperior part of the third ventricle, especially if the tumor is situated predominantly in the lateral ventricle on the side of the approach (*Fig. 5.25*). It is more difficult to expose the anterior part of the lateral ventricle on the side opposite the approach through the transcortical than through the transcallosal approach. The transcortical approach is facilitated if the lateral ventricles are enlarged.

With the patient in the supine position, the head is rotated slightly to the side opposite the frontal lobe through which the ventricle is to be approached. The scalp and bone flaps are positioned over the central part of the middle frontal gyrus of the nondominant hemisphere. The dominant hemisphere is selected only if there is a major extension of the tumor into the lateral ventricle of the dominant hemisphere. If the approach is through the dominant hemisphere, care is taken to place the cortical incision above and anterior to the expressive speech centers on the inferior frontal gyrus and anterior to the precentral motor strip. The dilated frontal horn is reached through a small cortical incision located in the long axis of the middle frontal gyrus. The landmarks within the ventricle are described in the section on the transcallosal approach. It may be necessary to enlarge the opening into the third ventricle by opening the choroidal fissure. The transchoroidal opening provides a better view into the roof of the third ventricle than the interforniceal opening with the transcortical approach. For most lesions, opening the choroidal fissure is preferable to the interforniceal approach or sectioning the ipsilateral column of the fornix. Opening the septum pellucidum will provide access to both frontal horns and bodies.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

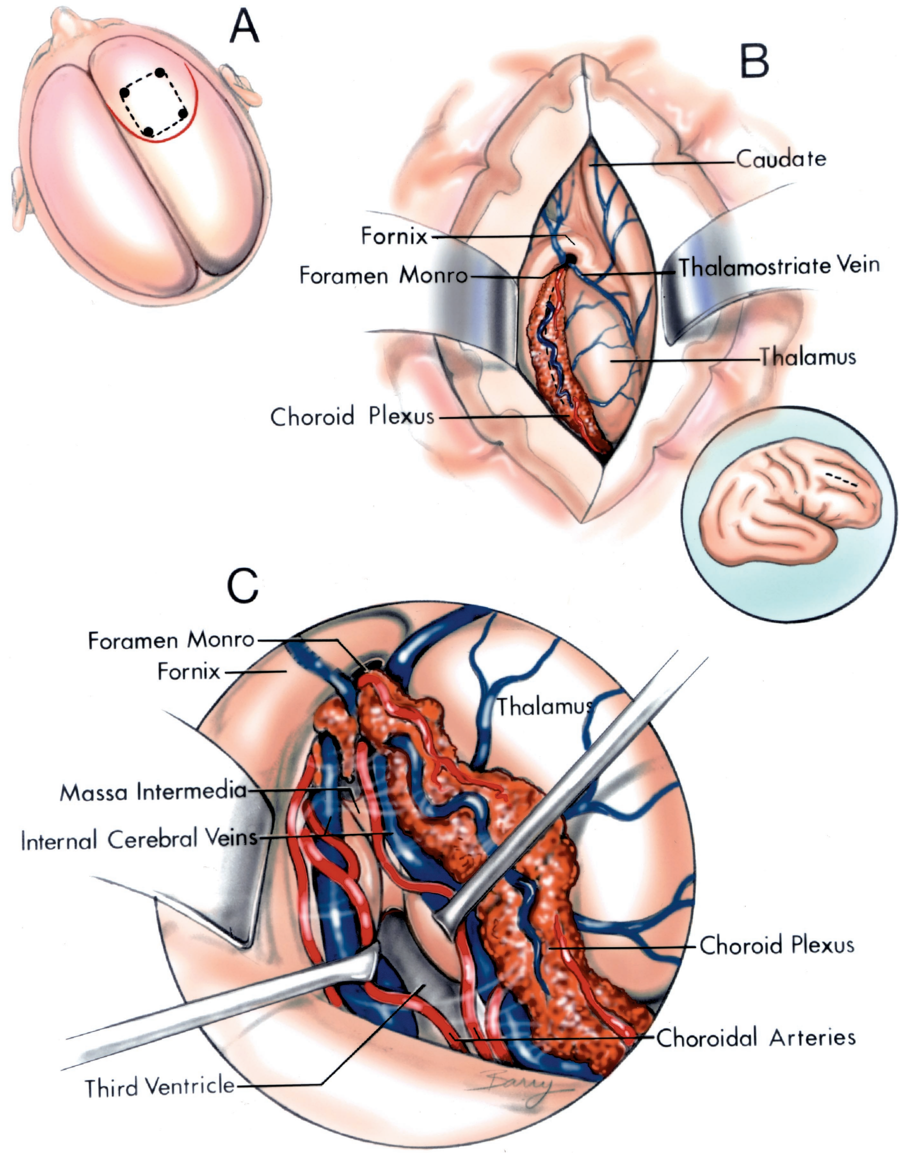


FIGURE 5.25. *Transcortical approach to the lateral and third ventricles.* A, *the scalp incision* (solid line) *and bone flap* (dotted line) *are centered over the middle frontal gyrus.* B *and* C, *normal ventricular anatomy.* B, *The cortical opening exposes the right lateral ventricle. The* inset *on the lower right shows the site of the cortical incision. The opening into the right lateral ventricle exposes the caudate nucleus, fornix, foramen of Monro, thalamus, and thalamostriate vein.* C, *the third ventricle has been exposed by opening the choroidal fissure along the site of the attachment of the choroid plexus to the fornix. This exposes the internal cerebral veins and medial posterior choroidal arteries in the roof of the third ventricle. (Legend continues on next page.)*

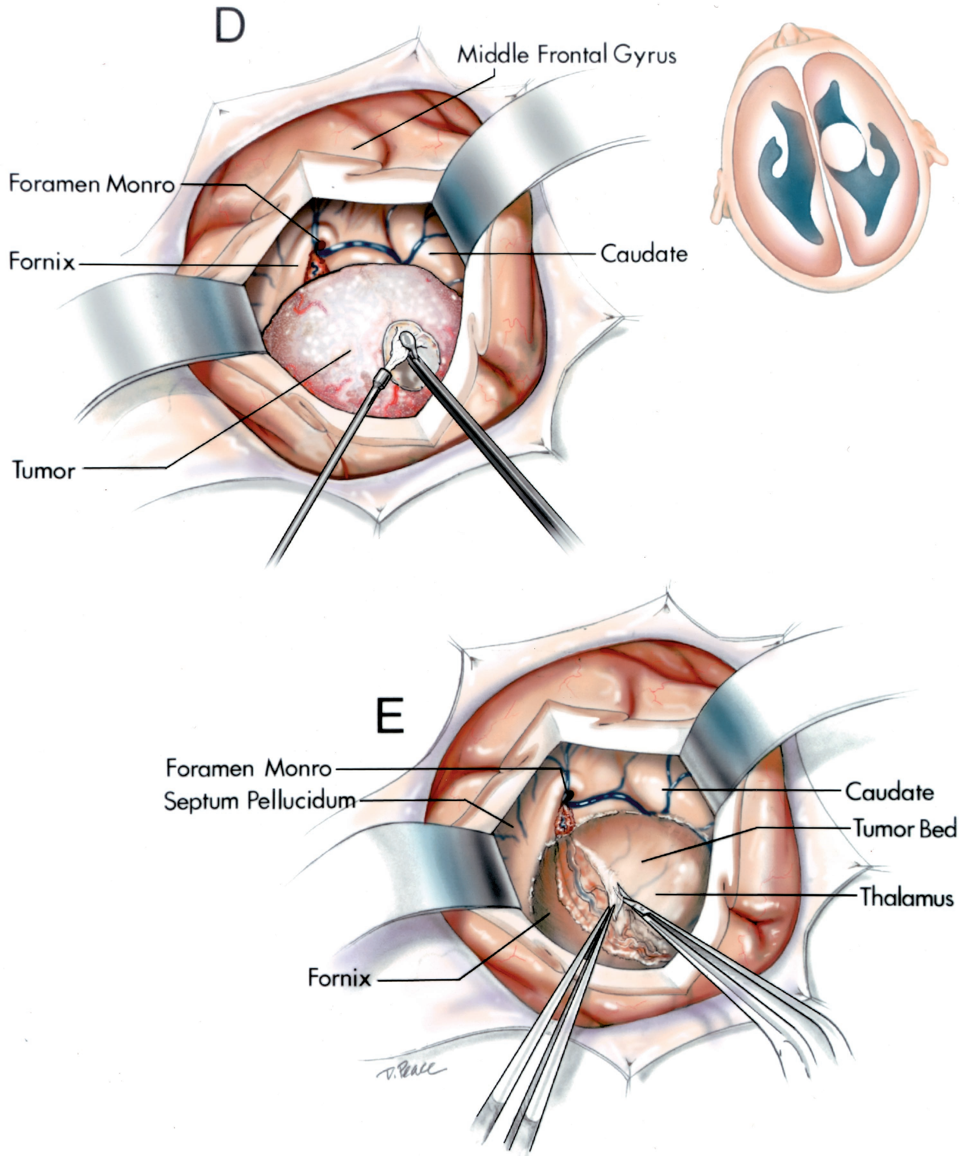
Anterior Frontal Approach

The anterior frontal approach may infrequently be considered for a lesion involving the structures forming the anteroinferior wall of the frontal horn and the adjacent part of the third ventricle (*Figs. 5.15* and *5.26*) (28). This approach would be adequate to expose lesions involving the floor and lower part of the anterior wall of the frontal horn or lesions that extend from the rostrum of the corpus callosum into the third ventricle behind the lamina terminalis. This approach is not suitable for reaching a lesion in the region of the posterior part of the frontal horn near the foramen of Monro, in the floor of the body of the lateral ventricle, or in the superior part of the third ventricle behind the foramen of Monro.

The patient is positioned supine with the face looking directly upward. A Souttar scalp incision is used. A unilateral bone flap extending up to the edge of the superior sagittal sinus is elevated on the side of the lesion. The bone flap is positioned in the interval between the supraorbital ridge and the coronal suture, depending on the site of the lesion. The lower margin of the flap will border the supraorbital ridge if the lesion is in the region of the rostrum and the adjacent part of the lamina terminalis, but will be placed higher on the forehead if the lesion is centered in the lower part of the genu of the corpus callosum. The dura mater is opened with the base on the superior sagittal sinus. Elevating the orbital surface of the frontal lobe will allow the arachnoid in front of the optic chiasm and along the medial part of the sylvian fissure to be opened to expose the supraclinoid portion of the internal carotid artery, the initial segments of the anterior and middle cerebral arteries, and the anterior communicating and recurrent arteries. One olfactory nerve may need to be divided above the cribriform plate to expose the area above the optic chiasm. Further retraction will expose the lamina terminalis above the optic chiasm and possibly the lower part of the

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

FIGURE 5.25. *Continued*
D, *a choroid plexus papilloma has been exposed using the transcortical approach. The* inset *on the upper right shows the site of the tumor and the position of the head for the operation. The tumor is being removed using a small cup forceps and suction.* E, *the last remnant of tumor is being removed from its attachment to the choroid plexus. The tumor has compressed the structures in the floor at frontal horn.*



rostrum. The medial surface of the frontal lobe is retracted away from the anterior part of the falx to expose the anterior part of the interhemispheric fissure in the region of the rostrum and genu of the corpus callosum. One or two small cortical veins entering the lateral margin of the superior sagittal sinus may need to be sacrificed to retract the frontal pole away from the falx. Small veins entering the anterior end of the inferior sagittal sinus may need to be obliterated and divided before the arachnoid in the depths of the interhemispheric fissure is opened. Opening the arachnoid will expose the A2 segments of the anterior cerebral arteries and their bifurcation into the pericallosal and callosomarginal arteries. The surgeon may need to push the anterior cerebral arteries toward their respective hemispheres or to one side to reach the rostrum part of the corpus callosum. Care should be taken to avoid occluding the perforating branches of the anterior communicating artery, which extend into the walls of the third ventricle to supply columns of the fornix. A vertical incision beginning in the lamina terminalis and extending upward into the rostrum of the corpus callosum will expose a lesion in the floor of the frontal horn formed by the anteroinferior part of the corpus callosum and straddling the lateral and third ventricular sides of the foramen of Monro.

Posterior Approaches

The approaches suitable for lesions in the posterior part of the lateral and third ventricles are the posterior transcortical, posterior transcallosal, occipital transtentorial, and infratentorial supracerebellar (*Figs. 5.21* and *5.22*). The posterior transcortical and transcallosal approaches are best suited to atrial lesions, but may be used for selected lesions that involve

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

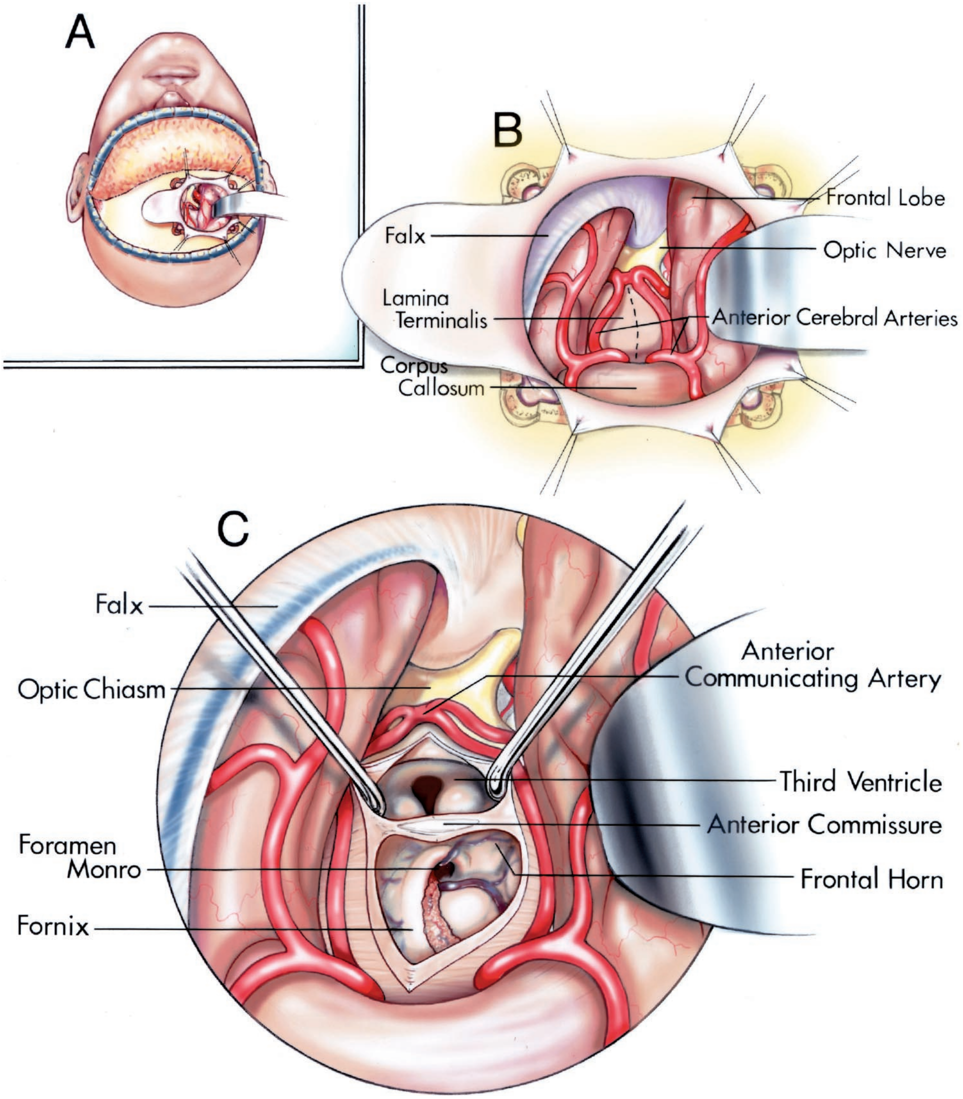


FIGURE 5.26. *Transfrontal approach to the anterior part of the lateral and third ventricles.* A, *site of scalp and bone flaps.* B, *the right frontal lobe has been retracted away from the falx to expose the optic nerves, lamina terminalis, rostrum of the corpus callosum, and the anterior cerebral arteries.* C, *normal ventricular anatomy. The lamina terminalis and rostrum of the corpus callosum have been opened to expose the third ventricle and the frontal horn. The anterior commissure and columns of the fornix have been preserved. (Legend continues on next page.)*

the medial wall of the atrium and extend into the quadrigeminal cistern and posterior third ventricle. The occipital transtentorial and infratentorial supracerebellar approaches are best suited to lesions in the posterior third ventricle and quadrigeminal cistern.

Lesions situated entirely within the atrium and posterior part of the body of the lateral ventricle are best exposed using the posterior transcortical approach. Selected lesions may be exposed by the posterior transcallosal or occipital interhemispheric approaches. The transcallosal approach is considered if the lesion involves the splenium of the corpus callosum and extends into the lateral ventricle from the roof or the upper part of the medial wall of the atrium. The occipital approach directed along the occipital pole and interhemispheric fissure would be used if a lesion involving the medial wall of the atrium extended into the third ventricle and medial wall of the quadrigeminal cistern.

Pineal tumors have been removed by a posterior transcortical approach directed through the medial wall of the atrium. However, this area is very narrow and is heavily vascularized, making it difficult to approach pineal tumors by this route. The occipital-transtentorial approach and the infratentorial-supracerebellar approaches are most commonly used for exposing pineal tumors.

Posterior Transcortical Approach

This approach, directed through a cortical incision in the superior parietal lobule, exposes the interior of the atrium and the posterior part of the body and may be the preferred approach for a lesion situated entirely within the atrium, or arising in the glomus of the choroid plexus or a lesion that involves the atrium, posterior third ventricle, and quadrigeminal cistern (*Fig. 5.27*).

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

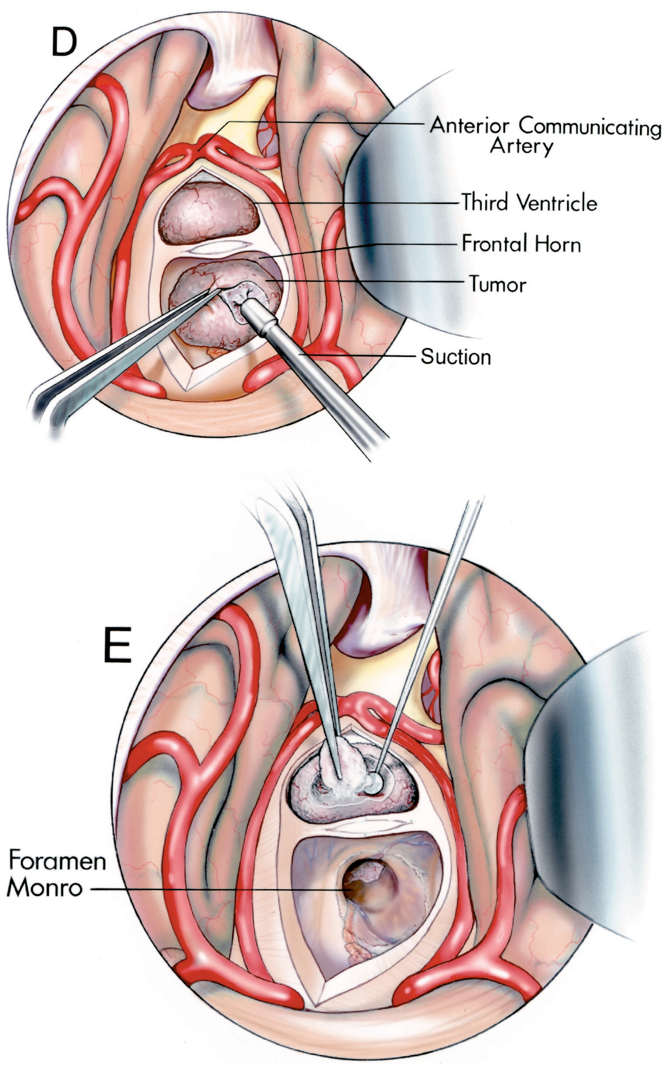


FIGURE 5.26. *Continued*
D, *a tumor that straddles the foramen of Monro and extends into both the frontal horn and third ventricle has been exposed. The portion of the tumor within the frontal horn is being removed using a suction and forceps.* E, *the part of the tumor within the third ventricle is being removed using a fine dissector.*

The patient is positioned in the three-quarter prone position with the face turned toward the floor so as to place the parietal area to be operated uppermost. A high posterior parietal bone flap, centered behind the postcentral gyrus over the superior parietal lobule, is elevated. The cortex is incised in the long axis of the superior parietal lobule in the region behind the postcentral gyrus, preferably in a sulcus crossing the lobule. This cortical incision avoids the visual pathways traversing the parietal lobe and the speech areas at the junction of the parietal and temporal lobes. The lateral ventricle is entered above the junction of the body and atrium and above the body and crus of the fornix (*Figs. 5.3, 5.6,* and *5.8*). The choroid plexus provides an orienting landmark. It forms a fringe attached to the superior and posterior surfaces of the thalamus along the lateral margin of the body and crus of the fornix. In this area, the body and crus of the fornix fill the interval between the choroid plexus and the lower surface of the corpus callosum. This approach will expose the calcar avis and bulb of the corpus callosum in the medial wall, the pulvinar in the anterior wall, and the collateral trigone in the floor. The hippocampal commissure is medial to the crus of the fornix.

After entering the atrium, the quadrigeminal cistern, pineal region, and posterior part of the third ventricle, which are medial to the atrium, can be reached by one of three routes: opening the choroidal fissure, opening along the crus fornix, or opening the occipital lobe forming the medial atrial wall. The choroidal fissure is opened by retracting the glomus of the choroid plexus laterally and opening along the tenia fornicis. Opening through the crus or the choroidal fissure will expose the posterior end of the internal cerebral vein in the velum interpositum or the basal, internal cerebral, and great veins in the quadrigeminal cistern. Retracting the crus medially and posteriorly exposes the quadrigeminal cistern and the caudal portion of the ambient cistern. The retraction should be carefully applied because it may damage the calcar avis and underlying visual cortex. Retraction of the pulvinar should be minimized to prevent language and speech disturbances in the dominant hemisphere, because the pulvinar is the main site of origin of the thalamic fibers to the association cortex and the junction of the parietal, temporal, and occipital lobes that are involved in speech and vision. An alternate route is to open through the thin medial wall of the atrium formed by the crus fornix by using an arcuate incision directed along the direction of the fibers in the crus. This incision opens into the quadrigeminal cisterns and provides a route to the roof of the third ventricle. This incision should spare the contralateral half of the fornix. However, avoiding the contralateral half of the fornix is easier in the atrium than in the body of the ventricle because the crura are more widely separated at the level of the atrium. If the pulvinar bulges too far posteriorly a supplemental horizontal incision in the medial wall of the atrium behind the crus may be needed to avoid retraction of the pulvinar. However, extending this incision posteriorly into the calcar avis will cause a visual field deficit, which increases in severity as the incision is increased further posteriorly. The internal cerebral and great veins and the medial posterior choroidal arteries commonly block the exposure. These vascular structures should be gently displaced after dividing only those branches required to expose and remove the tumor, rather than sacrificing their main trunks.

The lower part of the atrium may also be approached through cortical incisions in the superior and middle temporal gyri and the temporoparietal junction, although the preferred route is through the superior parietal lobule. The atrium was first approached through a parieto-occipital bone flap and a cortical incision extending from the posterior end of the superior temporal gyrus into the inferior part of the parietal lobe (34). Exposing the atrium through the temporoparietal junction may cause a homonymous visual field deficit due to the

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

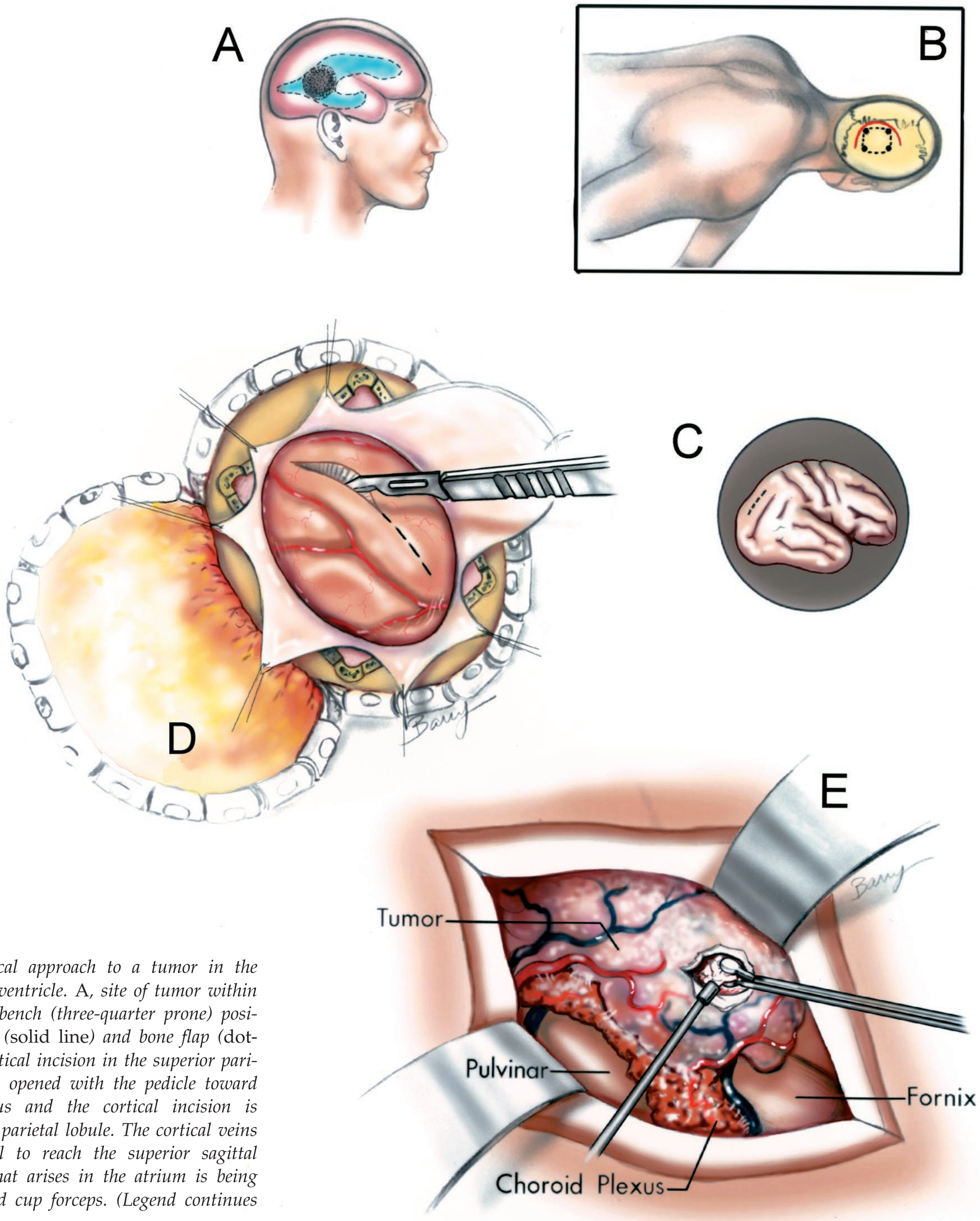


FIGURE 5.27. *Transcortical approach to a tumor in the atrium of the right lateral ventricle.* A, *site of tumor within the right atrium.* B, *park bench (three-quarter prone) position. Site of scalp incision (*solid line*) and bone flap (*dotted line*).* C, *site of the cortical incision in the superior parietal lobule.* D, *the dura is opened with the pedicle toward the superior sagittal sinus and the cortical incision is directed along the superior parietal lobule. The cortical veins pass forward at this level to reach the superior sagittal sinus.* E, *a meningioma that arises in the atrium is being debulked using suction and cup forceps. (Legend continues on next page.)*

interruption of the optic radiations in either hemisphere, disturbances of visuospatial function in the nondominant hemisphere, and aphasia and agnostic disorders in the dominant hemisphere (15, 24, 28, 33). Opening through the middle temporal gyrus might be considered for a lesion in the dominant hemisphere. However, cortical mapping during surgery has revealed an occasional extension of the speech representative into the middle temporal gyrus (16). The lower the approach, the more readily accessible is the anterior choroidal supply to tumors arising in the trigonal region. It is possible to slip beneath such tumors as meningiomas in the trigone by this route, after partially debulking them, to pick up the medial blood supply from the lateral posterior choroidal vessels.

The transcortical-transventricular exposures are more difficult to perform if the ventricles are not dilated. These approaches through the atrium do not provide satisfactory ex-

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

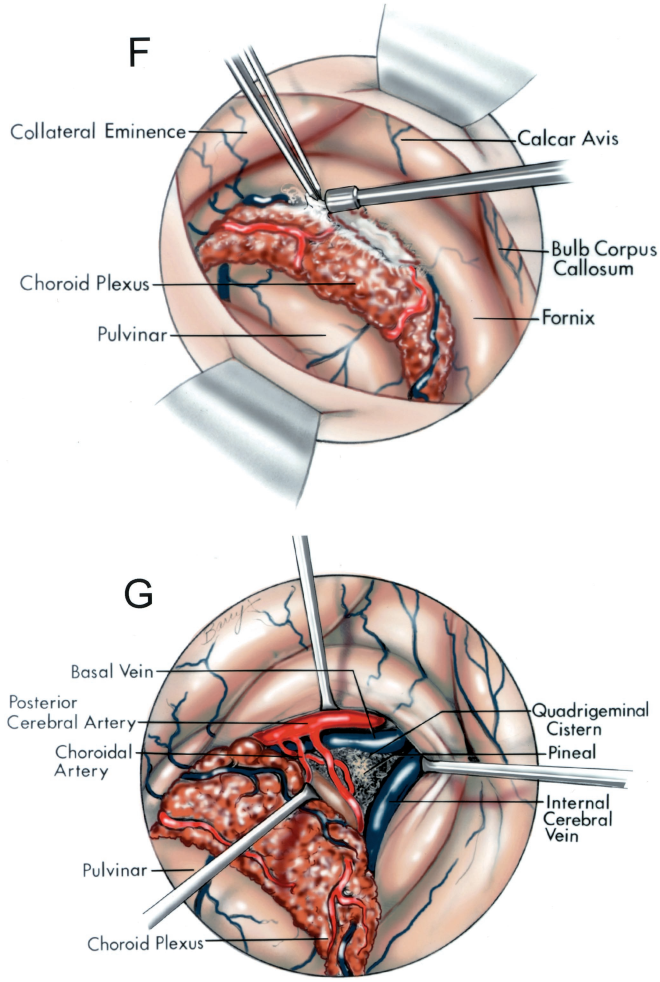


FIGURE 5.27. *Continued*
F, *the last remnant of tumor has been removed and its attachment to the choroid plexus is being coagulated.* G, *the choroidal fissure has been opened by incising along the attachment of the choroid plexus to the crus of the fornix. The choroid plexus has been retracted forward to expose the structures in the quadrigeminal cistern, which include the pineal body, posterior cerebral and choroidal arteries, and the internal cerebral and basal veins.*

posure of the typical midline pineal tumor and are unsuited to the pineal tumor that extends posteroinferiorly through the tentorial opening toward the quadrigeminal plate and the cerebellum. The posterior transcortical approach directed through the choroidal fissure is most commonly used for arteriovenous malformations or vascular tumors that are located behind the pulvinar and are fed and drained by vessels passing through the choroidal fissure. Pineal tumors have been removed by a transventricular approach directed through the medial wall of the atrium; however, the narrowness and heavy vascularization of the pineal area make it difficult to approach pineal tumors by this route. The occipital transtentorial approach and the infratentorial supracerebellar approaches are most commonly selected for exposing tumors in the pineal region.

Posterior Transcallosal Approach

This approach is best suited to lesions that extend upward from the atrium or third ventricle through the posterior part of the splenium or that arise in the splenium and extend into the atrium and third ventricle (*Fig. 5.28*). The approach, although used by Dandy (5) for pineal tumors, has been replaced in most cases by the occipital transtentorial or infratentorial supracerebellar approach.

Although, the operation is commonly performed in the three-quarter prone position with the parietal region to be operated uppermost, a better alternative with some lesions is to place the side of the approach downward so that the medial surface of the hemisphere will fall away from the falx, thus reducing the need for retraction. The parieto-occipital scalp flap and the craniotomy extend to or across the superior sagittal sinus and have their anterior margin behind the postcentral gyrus and vein. The dura is reflected toward the sagittal sinus. Usually, no more than one vein entering the superior sagittal sinus behind the postcentral gyrus is divided so that the medial surface of the hemisphere may be retracted away from the falx. Opening the arachnoid below the falx exposes the distal branches of the anterior cerebral arteries and occasionally the splenial branches of the posterior cerebral arteries on the surface of the corpus callosum. The posterior part of the corpus callosum is incised in the midline. This callosal incision may divide the hippocampal commissure and open the lateral ventricle; however, it should be remembered that the ventricles have started to deviate laterally at this point. For this approach to be successful, the lesion should be positioned so that it comes into view as the splenium is exposed and opened. The junction of the internal cerebral veins with the great vein comes into view below the splenium and above the pineal gland. These veins may separate easily from the dorsal surface of a tumor lying within the third ventricle, but they also may be frequently so embedded within the upper surface of a tumor that their sacrifice is inescapable. Dandy (5), in some cases, resected the great and internal cerebral veins and the straight sinus in this region without neurological dysfunction; however, every effort should be made to spare these venous structures, because their obliteration may cause major deficits. The medial posterior choroidal and other branches of the posterior cerebral and superior cerebellar arteries, the trochlear nerves, the quadrigeminal plate, and the basal veins come into view in the depths of this exposure. The roof of the third ventricle will be encountered anterior to the pineal body. Opening the layers of tela choroidea in the roof of the third ventricle will expose the cavity of the third ventricle and the choroid plexus in the roof. The most dangerous dissection is in the area of the quadrigeminal plate, because some tumors are adherent to or embedded in this area. The tentorium may be divided longitudinally beside the straight sinus, and the falx may be split vertically to facilitate the exposure posteriorly and to the opposite side.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

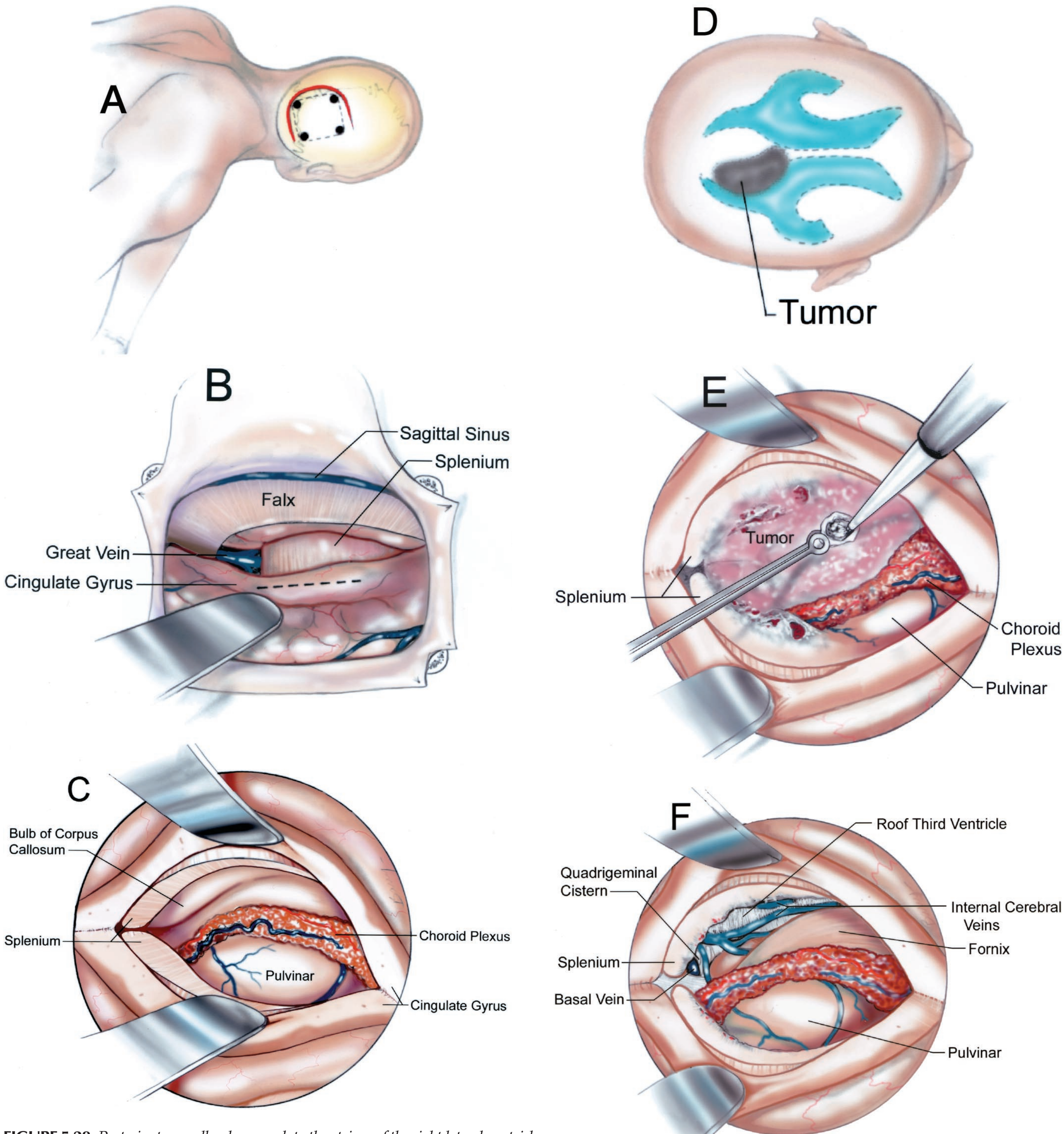
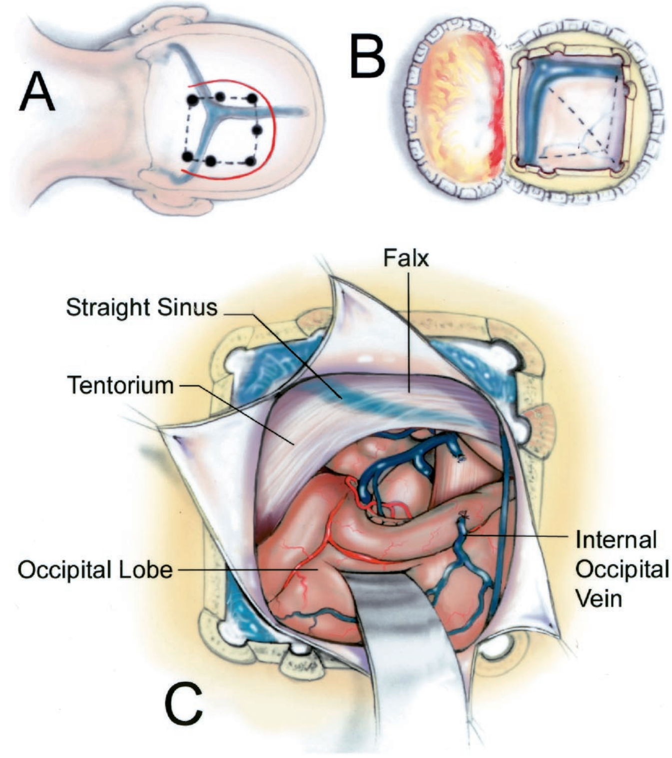


FIGURE 5.28. *Posterior transcallosal approach to the atrium of the right lateral ventricle.*
*A, three-quarter prone position. The side of the tumor is placed downward to facilitate the exposure along the interhemispheric fissure. The scalp incision (*solid line*) and the bone flap (*broken line*) extends up to or across the midline. B, the dura is open with the pedicle toward the superior sagittal sinus. The medial surface of the right parietal lobe has been retracted away from the falx. The cortical incision extends through the posterior part of the cingulate gyrus. The corpus callosum is opened to the right of the midline to expose the right atrium. C, normal ventricular anatomy. The opening through the cingulate gyrus encounters the lateral part of the splenium. Opening through the splenium in the midline would expose the roof of the third ventricle. The opening through the lateral part of the splenium into the atrium exposes the crus of the fornix, bulb of the corpus callosum, pulvinar, and choroid plexus. D, the glial tumor is situated in the forceps major and the bulb of the corpus callosum. E, the tumor is being removed with an ultrasonic aspirator. The choroid plexus and pulvinar are pushed forward by the tumor. F, the tumor has been removed. Removing the bulb of the corpus callosum exposes the internal cerebral veins in the roof of the third ventricle and the quadrigeminal cistern. Residual tumor is present in the corpus callosum.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.



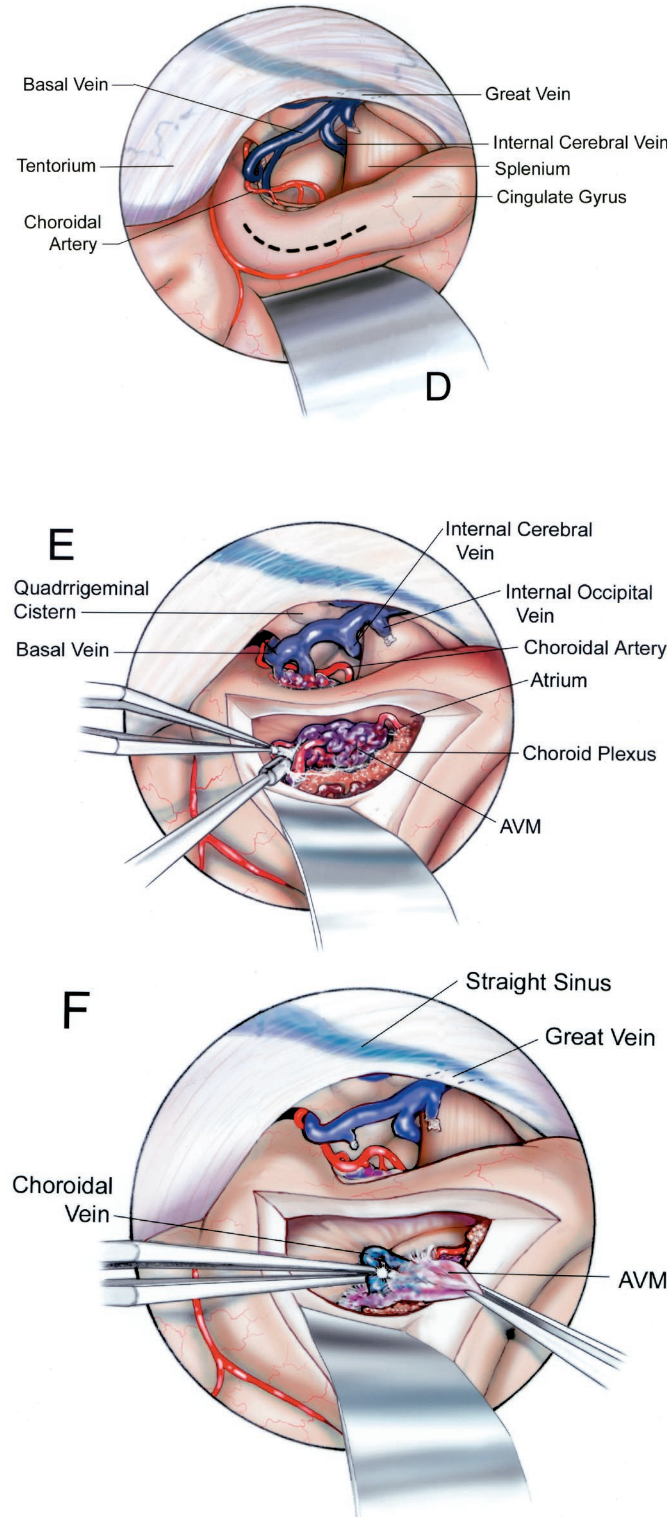


FIGURE 5.29. *Occipital-transcingulate approach to an arteriovenous malformation of the right atrium. The down side is the one harboring the lesion. A, right occipital scalp (*solid line*) and bone flaps (*broken line*) are elevated. The bone flap extends up to or across the margin of the transverse and sagittal sinuses. B, the dura is opened with pedicles on the transverse and sagittal sinuses. C, the right occipital lobe is retracted and allowed to settle downward away from the falx to expose the isthmus of the cingulate gyrus. An internal occipital vein is often sacrificed to reach this area. D, enlarged view. The* broken line *shows the site of the cortical incision through the isthmus of the cingulate gyrus. The internal cerebral, basal, and great veins are exposed in the quadrigeminal cistern. E, the malformation is situated in the choroid plexus. The arteries entering and the veins exiting the malformation pass through the choroidal fissure to reach the quadrigeminal cistern. F, the choroidal arteries that feed the malformation have been coagulated and divided and the last draining vein from the malformation is being obliterated with bipolar coagulation.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

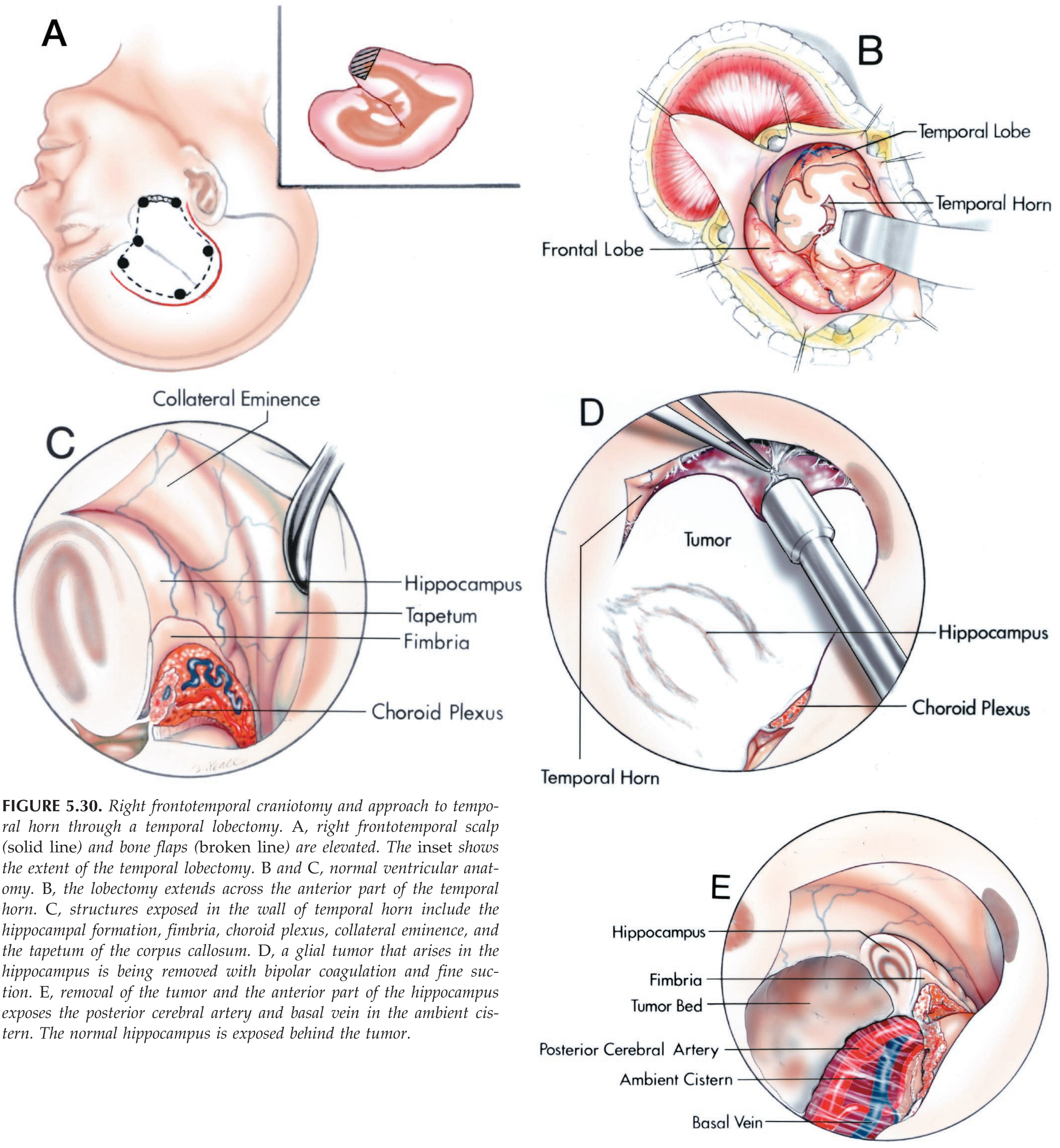


FIGURE 5.30. *Right frontotemporal craniotomy and approach to temporal horn through a temporal lobectomy.* A, *right frontotemporal scalp (*solid line*) and bone flaps (*broken line*) are elevated. The* inset *shows the extent of the temporal lobectomy.* B *and* C, *normal ventricular anatomy.* B, *the lobectomy extends across the anterior part of the temporal horn.* C, *structures exposed in the wall of temporal horn include the hippocampal formation, fimbria, choroid plexus, collateral eminence, and the tapetum of the corpus callosum.* D, *a glial tumor that arises in the hippocampus is being removed with bipolar coagulation and fine suction.* E, *removal of the tumor and the anterior part of the hippocampus exposes the posterior cerebral artery and basal vein in the ambient cistern. The normal hippocampus is exposed behind the tumor.*

For the approach to the atrium, an incision is made in the cingulate gyrus behind the posterosuperior part of the corpus callosum. This cortical incision is directed obliquely forward through the lateral part of the splenium to enter the atrium just above the bulb of the corpus callosum. The landmarks within the ventricle are described above, under the posterior transcortical approach.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

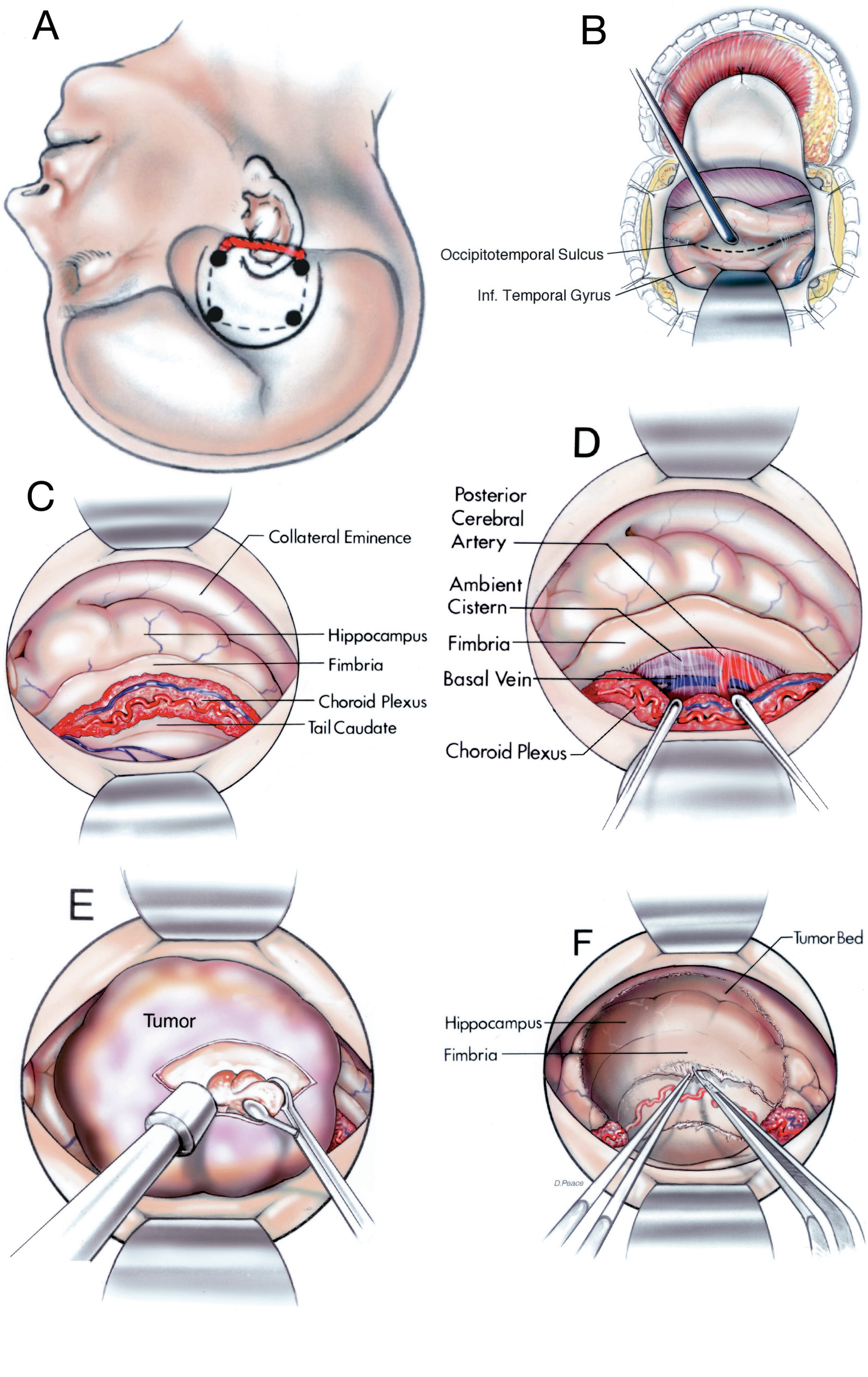


FIGURE 5.31. *Subtemporal approach to the temporal horn and basal cisterns.* A, *right temporal scalp* (solid line) *and bone flaps* (broken line) *are elevated. A small craniectomy* (cross-hatched area) *at the lower margin of the exposure gives access to the floor of the middle fossa.* B, *the dura has been opened with the pedicle inferiorly. The temporal horn is approached through a cortical incision* (broken line) *in the occipitotemporal sulcus between the inferior temporal and occipitotemporal gyri.* C and D, *normal anatomy of the temporal horn and ambient cistern.* C, *the temporal horn has been opened to expose the collateral eminence, hippocampus, fimbria, choroid plexus, and the tail of the caudate nucleus.* D, *the choroidal fissure has been opened by incising the attachment of the choroid plexus to the fimbria to expose the posterior cerebral artery and basal veins in the ambient cistern.* E, *an epidermoid tumor in the temporal horn has been opened and the intracapsular contents are being removed using a suction and cup forceps.* F, *a remnant of tumor capsule attached to the choroid plexus and adjacent part of the fimbria is being excised.* Inf., *inferior.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

Occipital Approach

This approach is suitable for tumors situated in the pineal region and the part of the pulvinar, medial occipital lobe, and medial atrial wall facing the quadrigeminal cistern (*Figs. 4.24 and 5.29*). See also *Figure 5.10* in the Millennium issue of *Neurosurgery* (25). It is preferred over the infratentorial supracerebellar approach for a pineal region tumor centered at the tentorial edge or above if there is no major extension to the opposite side or into the posterior fossa. It might also be considered for a lesion such as an arteriovenous malformation in which it is desirable to expose the feeding choroidal arteries in the quadrigeminal cistern before exposing the lesion in the atrium.

The patient is positioned in the three-quarter prone position with the occipital area to be operated lowermost and the face turned toward the floor. This allows the medial occipital surface along which the approach is directed to relax away from the falx, thus reducing the need for brain retraction. The procedure was first performed with the patient in a sitting position (22, 34). Some surgeons who use the park bench position place the patient's left side down and the face turned toward the floor to bring the right occipital area along which the tumor is approached uppermost (12). The occipital scalp flap and craniotomy are placed so that they will expose the margins of the transverse and sagittal sinuses and the torcular herophili. The dura mater is opened using two flaps, one based on the superior sagittal sinus and the other on the transverse sinus. The medial surface of the occipital pole is gently retracted away from the falx. The occipital pole can usually be retracted from the falx without sacrificing any bridging veins because frequently there are no bridging veins from the occipital lobe entering the part of the superior sagittal sinuses behind the lambdoid suture and parieto-occipital sulcus. The anterior calcarine (internal occipital) vein, which crosses from the anteromedial surface of the occipital lobe to the quadrigeminal cistern, is transected only when necessary because its division may produce a homonymous hemianopia.

For a tumor in the posterior third ventricle, the tentorium may be divided lateral and parallel to the straight sinus from the free edge to near the transverse sinus. The tentorium can be reflected laterally or a wedge of tentorium removed to increase the exposure. The arachnoid over the ambient and quadrigeminal cisterns is opened. A disadvantage of this approach is that the vein of Galen and internal cerebral veins are above and obstruct the approach to the pineal region, but this becomes less of a disadvantage after the tentorium is divided. The lower portion of the splenium is divided if necessary, but the splenium is usually thinned and elevated by the tumor and therefore it can routinely be spared. The ipsilateral basal vein, medial posterior choroidal and posterior cerebral arteries, and thalamus are lateral to the tumor. This exposure provides only a limited view of the contralateral half of the quadrigeminal cistern and the opposite thalamus. Meticulous attention is directed to separating the tumor from the thalamus and the quadrigeminal plate.

An atrial tumor that extends into the medial occipital cortex, near the junction of the vein of Galen and straight sinus, can be exposed from this approach by opening through the isthmus of the cingulate gyrus in front of the calcarine sulcus. The opening enters the medial wall of the atrium behind the choroidal fissure. The branches of the posterior cerebral artery and its bifurcation into the calcarine and parietooccipital branches course lateral to the pineal region tumor and medial to an atrial tumor. The lateral posterior choroidal arteries pass through the choroidal fissure in this area, and the medial posterior choroidal arteries and basal vein will be seen beside the pineal gland. The quadrigeminal plate, trochlear nerve, superior cerebellar artery, and precentral cerebellar vein may be seen in the depths of the exposure.

Infratentorial Supracerebellar Approach

This approach is suitable for tumors in the pineal region that are midline and that grow into both the posterior part of the third ventricle and the posterior fossa, displacing the quadrigeminal plate and the anterior lobe of the cerebellum. An advantage of this approach is that the deep venous system that caps the dorsal and lateral aspects of most pineal tumors does not obstruct access to the tumor (*Fig. 4.24*). *Figure 5.10* in Chapter 5 on the tentorial incisura in the Millennium issue of *Neurosurgery* also provides a review of this approach (25).

The operation is performed with the patient in the three-quarter prone position, although some may be performed in the semi-sitting or full prone position. The neck is flexed to optimize the view under the tentorium. A vertical midline incision is used. The suboccipital craniectomy extends above the lower edge of the torcular herophili and both transverse sinuses. A Y-shaped dural incision, with upper limits that extend up to the inferior margin of the transverse sinus near the midline, allows the midline dura to be reflected upward without impediment. The straight sinus and tentorium may be elevated with a retractor, and the vermis may be retracted gently downward. Bridging veins over the superior surface of the cerebellum may be transected with minimal risk. This exposure may be enlarged beyond the tentorial notch by sectioning the tentorial edge through the infratentorial approach. Incision of the arachnoid over the quadrigeminal cistern brings the deep venous system and the tumor into view. The vein of Galen and the internal cerebral veins are above the pineal gland; the superior vermian vein is posterior; the thalamus, the medial posterior choroidal and posterior cerebral arteries, and the basal veins are lateral; and the quadrigeminal plate, trochlear nerves, superior cerebellar arteries, and superior vermis are below.

The superior vermian vein may need to be transected. The superior vermis, particularly the culmen, often conceals the quadrigeminal plate when the view is directed over the apex of the tentorial cerebellar surface, but moving the retractor lateral to the apex of the tentorial surface provides a better view around the culmen to the quadrigeminal plate. Most pineal tumors are not highly vascular. Their arterial supply is from the medial and lateral posterior choroidal branches of the posterior cerebral arteries and occasionally from the superior cerebellar arteries. The tumor is removed according to the principles outlined previously. The most difficult dissection is

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

often along the quadrigeminal plate. The tumor removal may extend into the posterior third ventricle, thus communicating the ventricle with the quadrigeminal cistern. This approach permits the placement of a Silastic tube from the posterior part of the third ventricle to the cisterna magna if the third ventricle is opened.

Lateral Approaches

The lateral approaches directed through the lower part of the lateral hemispheric surface or below the lateral hemispheric border are the frontotemporal (pterional), posterior frontotemporal, transtemporal, and subtemporal approaches (*Fig. 5.21*). The posterior frontotemporal approach exposes the anterior temporal pole and permits the anterior part of the temporal horn to be exposed through a small cortical incision or a temporal lobectomy. The transtemporal and subtemporal exposures conducted through a posterior frontotemporal craniotomy or a temporal craniotomy centered above the ear permit the full length of the temporal horn to be exposed through the lateral or inferior surfaces of the temporal lobe.

Frontotemporal (Pterional) and Posterior Frontotemporal Exposures

The frontotemporal (pterional) craniotomy may be selected for the removal of some third ventricular tumors (*Fig. 5.30*). The posterior frontotemporal approach is similar to the conventional pterional craniotomy, except that it extends further posteriorly in the temporal region. We would use these approaches only if a tumor involving the third ventricle is centered lateral to the sella or extends into the middle cranial fossa. The posterior frontotemporal exposure is selected if an anterior transtemporal or anterior subtemporal exposure is needed.

For the frontotemporal approach, the patient is placed in the supine position and the head is tilted a bit backward and turned 30 degrees away from the side of operation. Small scalp and bone flaps are elevated for the frontotemporal (pterional) approach. For the posterior frontotemporal approach, the flap extends further posteriorly above the ear. The scalp, temporalis muscle and fascia, and pericranium may be reflected as a single layer but more commonly an interfascial approach in which the scalp, galea, and lower part of the superficial temporal fascia with the superficial fat pad and nerves to the frontalis muscle are reflected as one layer and the temporalis muscle is reflected as a second layer. The lateral aspect of the sphenoid ridge is removed with a rongeur or a drill. The dura is opened, with the main flap pulled down anteroinferiorly along the region of the pterion. The frontal and temporal lobes are elevated to expose the area along the sphenoid ridge. The bridging veins from the sylvian fissure and temporal tip are coagulated and divided only if necessary. It may be possible to preserve these bridging veins if the frontotemporal approach is entirely above the sphenoid ridge or if the subtemporal approach is entirely below the sphenoid ridge. The arachnoid membrane is opened to expose the carotid artery, optic nerve, and origin of the posterior communicating and anterior choroidal arteries. The tumor is exposed through the triangle between the optic nerve and the internal carotid and anterior cerebral arteries in the frontotemporal approach or below the floor of the third ventricle through the interval between the carotid artery and the oculomotor nerve. The third ventricle may be entered through the floor if the nuclear masses are pushed laterally by the tumor and the floor consists of only a glial membrane.

The posterior frontotemporal approach is used for a lesion involving the anterior portion of the temporal horn that can be exposed through an anterior temporal lobectomy or a small cortical incision in the anterior part of the temporal lobe or a lesion involving the third ventricle extends laterally below the temporal lobe. The patient is placed in the supine position with a sandbag under the shoulder on the side to be operated. The head is tilted a bit backward and turned 45 degrees away from the side of the operation. The scalp incision begins in the frontal area and extends in a question-mark configuration back to the area above the ear and then downward to the zygoma in front of the ear. The scalp, temporalis muscle and fascia, and pericranium are reflected as a single layer. A free frontotemporal bone flap that will expose the anterior half of the lateral surface of the temporal lobe is elevated, and the lateral aspect of the sphenoid ridge is removed with a rongeur or a drill. The dura mater is opened with the main flap pulled anteroinferior along the region of the pterion. The tip of the temporal lobe may be elevated to expose the edge of the tentorium cerebelli. The temporal lobe may be elevated in the subtemporal approach to expose as far posterior as the anterior and lateral aspect of the midbrain and the upper part of the basilar artery. The tumor, once exposed, is removed according to the principles outlined previously. A decision is made as to whether to enter the temporal horn through a cortical incision or through a temporal lobectomy. The cortical incision would be selected if the lesion is strictly localized to the region of the tip of the temporal lobe. The temporal lobectomy would be considered if the lesion not only involved the temporal pole but also extended into the temporal horn. For the transcortical approach, the lower part of the middle temporal gyrus or the upper part of the inferior temporal gyrus is opened in the long axis of the gyrus and the incision is directed backward through the temporal lobe to the anterior part of the temporal horn.

To use a temporal lobectomy, the vertical incision through the temporal lobe would be situated no more than 4 cm from the temporal tip to avoid the optic radiations; the horizontal incision paralleling the sylvian fissure is directed medially through the lower part of the superior temporal gyrus or the upper part of the middle temporal gyrus. Medially, an incision through the superior temporal gyrus encounters the pia arachnoid on the medial surface of the lower lip of the sylvian fissure that covers the lower branches of the middle cerebral artery as they course over the insula. This incision paralleling the sylvian fissure is extended anteriorly and medially into the temporal pole just below the sylvian fissure and sphenoid ridge. The depths of the cortical incision will encounter the uncus and the parahippocampal gyrus, which are removed

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

using subpial dissection to avoid injury to the branches of the middle cerebral artery that supply the internal capsule. The cortical incision extending around the temporal tip can often be completed without sacrificing the major sylvian veins, which usually enter the sphenoparietal sinus just below the edge of the sphenoid ridge. These approaches will expose the anterior part of the temporal horn as far back as the site where the anterior choroidal artery passes through the choroidal fissure near the inferior choroidal point. The prominence over the hippocampus and the collateral eminence will be seen in the floor of the temporal horn, and the inferior ventricular vein may be seen in the roof. The amygdala lies directly anterior and slightly above the tip of the temporal horn and is directly lateral to the cisternal surface of the uncus. This exposure is sufficiently anterior that it does not permit more than minimal opening of the choroidal fissure to expose the ambient cistern. It will expose the anterior choroidal artery passing through the inferior choroidal point behind the head of the hippocampus. It is satisfactory for removing a lesion in the region of the anterior wall of the temporal horn and the amygdala. Opening through the amygdala and uncus exposes the structures in the crural and ambient cisterns.

Transtemporal and Subtemporal Approaches

A temporal craniotomy and a transtemporal or subtemporal cortical incision are used for a lesion in the middle or posterior third of the temporal horn or for selected lesions of the third ventricle that extend into the ambient and crural cisterns (*Fig. 5.31*). For the temporal craniotomy centered above the ear, the patient is positioned in the supine position with the shoulder on the side of the lesion elevated and the head tilted 60 to 80 degrees away from the side of the operation. The scalp incision extends from above the zygoma anterior to the ear to the area above the ear and then posteriorly and downward to the region of the asterion posterior to the ear. The scalp, temporalis muscle and fascia, and pericranium are reflected as a single layer. The bone flap is cut low or a small craniectomy below the flap is carried down to the floor of the fossa. This may open the mastoid air cells. Care should be taken not to open the attic of the middle ear. Transient deafness from effusion of fluid into the middle ear may follow this approach. The temporal horn of the nondominant hemisphere may be exposed using a cortical incision in the middle or inferior temporal gyrus anterior to the optic radiations. An alternative and often preferable route, which minimizes the possibility of damage to the optic radiations and speech centers of the dominant hemisphere, is the subtemporal route, in which an incision is made in the inferior temporal or occipitotemporal gyrus or the collateral sulcus on the lower surface of the temporal lobe. The risk of hemorrhage, venous infarction, and edema after retraction of the temporal lobe is reduced by avoiding occlusion of the bridging veins, especially the vein of Labbé.

The opening into the temporal horn will expose the choroidal fissure and the branches of the anterior and lateral posterior choroidal arteries as they enter the choroid plexus (*Figs. 5.3, 5.6,* and *5.9*). An approach through the temporal part of the choroidal fissure is used for lesions in the medial part of the temporal lobe and ambient cistern. The choroid plexus is elevated toward the thalamus and the fissure is opened by incising along the tenia fimbriae, thus avoiding damage to vessels that pass through the tenia thalami. Opening the choroidal fissure between the tenia fimbriae and the choroid plexus permits the arteries and veins that pass through the tenia thalami, and are larger than those passing through the tenia fornix, to be preserved and retracted upward with the choroid plexus. The main advantage of this approach is that it exposes the posterior cerebral and the anterior and posterior choroidal arteries, and the basal vein without extensive retraction of the temporal lobe. The approach is especially useful for exposing arteriovenous malformations of the temporal horn, hippocampus, and medial part of the temporal lobe that are fed by the arteries entering and drained by the veins exiting the choroidal fissure (17, 22, 31). The transchoroidal approach to the basal cisterns reduces the risks of injury to the vein of Labbé and the swelling and hematoma of the temporal lobe that may result from the extensive retraction required to reach the ambient cistern by the subtemporal extracerebral approach.

SELECTION OF OPERATIVE APPROACHES

The selection of the best operative approach for a tumor of the lateral and third ventricle depends on the site of origin, path of growth, and location of the tumor, the site of compression of the third ventricle, and whether there is ventricular obstruction (*Figs. 5.21* and *5.22*). Lesions within the anterior portion of the lateral and anterosuperior part of the third ventricles are most commonly reached by the anterior transcallosal and anterior transcortical approaches. This anterior transcallosal approach is suitable for lesions in the frontal horn and body of the lateral ventricles and for reaching the anterosuperior part of the third ventricle through the lateral ventricle. The transcallosal approach is easier to perform than the transcortical approach if the ventricles are of a normal size or are minimally enlarged. The transcortical approach is suitable for reaching tumors in the anterior part of the ipsilateral lateral ventricle and the anterosuperior part of the third ventricle. It is more difficult to expose the lateral ventricle on the opposite side through the transcortical than through the transcallosal approach. The transcortical approach is facilitated if the lateral ventricles are enlarged.

Routes through the lateral ventricles to the anterior part of the third ventricle, other than by incising the ipsilateral column of the fornix, are by the transchoroidal approach in which the choroidal fissure is opened along the tenia fornix, thus allowing the fornix to be pushed to the opposite side to expose the structures in the roof of the third ventricle, and the interforniceal approach in which the body of the fornix is split longitudinally in the midline. The transchoroidal approach is preferable to those approaches involving an incision in the fornix. The transchoroidal approach has the advantage of allowing access to the central portion of the third ventricle behind the foramen of Monro by displacing, rather than transecting, the fibers in the fornix. The transchoroidal and transforniceal routes provide a satisfactory view into the third

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

ventricle when the ventricle is exposed through the corpus callosum. The transchoroidal opening provides a better view into the third ventricle than the transforniceal approach when the ventricle is exposed through the middle frontal gyrus.

An anterior interhemispheric approach may infrequently be considered for a lesion involving the rostrum and lower half of the genu of the corpus callosum or for a lesion that extends from the rostrum into the third ventricle behind the lamina terminalis. This approach is not suitable for reaching a lesion in the region of the posterior part of the frontal horn near the foramen of Monro, in the floor of the body of the lateral ventricle, or in the superior part of the third ventricle behind the foramen of Monro.

The posterior transcortical approach directed through the superior parietal lobule is the preferred route for exposing lesions situated within the posterior part of the body and the atrium or arising in the glomus of the choroid plexus. It may also be selected for a tumor involving the posterior third ventricle if it extends into the posterior thalamic surface facing the atrium and quadrigeminal cistern. Selected lesions within the atrium may be exposed by the posterior transcallosal or the occipital interhemispheric approaches. The posterior transcortical approach, directed through the superior parietal lobule, exposes the interior of the atrium and posterior part of the body and the thalamic surface facing the posterior third ventricle, atrium, and quadrigeminal cisterns. The posterior transcallosal approach directed along the medial occipital surface may be selected for a lesion that extends upward from the atrium through the posterior part of the splenium, or that arises in the splenium and extends into the roof or the upper part of the medial wall of the atrium, or that arises in the splenium and extends into the posterior third ventricle.

Tumors in the posterior part of the third ventricle are usually approached by the occipital transtentorial or infratentorial supracerebellar approaches, but they may also be reached through the posterior part of the lateral ventricle or corpus callosum if they also involve the medial atrial wall or corpus callosum. The infratentorial supracerebellar approach is best suited to tumors in the midline below the vein of Galen that grow into both the posterior part of the third ventricle and the posterior fossa, displacing the quadrigeminal plate and the anterosuperior part of the cerebellum. An advantage of this approach to pineal tumors is that the deep venous system that caps the dorsal and lateral aspects of pineal tumors does not obstruct access to the tumor. A disadvantage of the approach, especially if it is directed over the apex of the vermis, is that it is difficult to expose the area deep in the fissure between the midbrain and cerebellum behind the colliculi; however, the exposure in this deep cleft can be increased by directing the exposure over the cerebellar hemisphere in a paramedian site lateral to the cerebellar apex (25). The infratentorial supracerebellar approach is not well suited to the tumor with a significant extension above the tentorium or growing from the thalamus or corpus callosum into the third ventricle. The occipital transtentorial approach is preferred for tumors centered at or above the tentorial edge if there is not a major extension of tumor to the opposite side or into the posterior fossa and for those located above the vein of Galen.

The temporal horn and selected lesions of the third ventricle may be approached by the frontotemporal (pterional), posterior frontotemporal, temporal, or subtemporal approach. The frontotemporal approach is selected for a lesion involving the third ventricle that extends into the interval between the optic nerve and carotid artery or between the carotid artery and oculomotor nerve. The posterior frontotemporal approach, in which the pterional flap is extending backward to the area above the ear, is used for a lesion involving the anterior portion of the temporal horn, which can be exposed through a small cortical incision in the anterior part of the temporal lobe or through a temporal lobectomy. The temporal and subtemporal routes to the temporal horn are used for a lesion in the middle or posterior third of the temporal horn or for selected lesions in the cisterns medial to the temporal horn. In the direct transtemporal approach, the temporal horn of the nondominant hemisphere is exposed by an incision in the middle or inferior temporal gyrus anterior to the optic radiations. A preferable route is the subtemporal route, which minimizes the possibility of damage to the optic radiations and speech centers of the dominant hemisphere. In the subtemporal approach, the cortical incision is in the occipitotemporal gyrus, or collateral sulcus, on the inferior surface of the temporal lobe. The opening into the temporal horn will expose the choroidal fissure. Opening through the choroidal fissure in the temporal horn by incising the tenia fornix will provide transventricular access to the area along the posterior cerebral artery and basal vein in the ambient cistern.

The most common third ventricular tumors begin in the pituitary gland and grow upward to compress the anteroinferior part of the third ventricle. The transsphenoidal approach is preferred for all tumors involving the anteroinferior part of the third ventricle that are located above a pneumatized sphenoid sinus and extend upward out of an enlarged sella turcica. The subfrontal intracranial approach is used for those tumors involving the anteroinferior part of the third ventricle that are not accessible by the transsphenoidal route because they do not extend into the sella turcica, are separated from the sella by a layer of neural tissue, are located entirely within the third ventricle, extend upward out of a normal or small sella, or are located above a nonpneumatized (conchal) type of sphenoid sinus. The subfrontal and transsphenoidal approaches, are reviewed in Chapter 8.

REFERENCES

1. Apuzzo MLJ, Giannotta SL: Transcallosal interforniceal approach, in Apuzzo MLJ (ed): *Surgery of the Third Ventricle*. Baltimore, Williams & Wilkins, 1987, pp 354–379.
2. Apuzzo MLJ, Chikovani OK, Gott PS, Teng EL, Zee CS, Giannotta SL, Weiss MH: Transcallosal, interfornicial approaches for lesions affecting the third ventricle: Surgical considerations and consequences. **Neurosurgery** 10:547–554, 1982.
3. Dandy WE: An operation for the removal of pineal tumors. **Surg Gynecol Obstet** 33:113–119, 1921.
4. Dandy WE: *Benign Tumors in the Third Ventricle of the Brain: Diagnosis and Treatment*. Springfield, Charles C Thomas, 1933.
5. Dandy WE: Operative experience in cases of pineal tumor. **Arch Surg** 33:19–46, 1936.
6. Delandsheer JM, Guyot JF, Jomin M, Scherpereel B, Laine E: Interthalamo-trigonal approach to the third ventricle [in French]. **Neurochirurgie** 24:419–422, 1978.

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.

7. Fujii, K, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the choroidal arteries: Lateral and third ventricles. **J Neurosurg** 52:165–188, 1980.
8. Gibo H, Carver CC, Rhoton AL Jr, Lenkey C, Mitchell RJ: Microsurgical anatomy of the middle cerebral artery. **J Neurosurg** 54:151–169, 1981.
9. Gibo H, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. **J Neurosurg** 55:560–574, 1981.
10. Hardy DG, Peace DA, Rhoton AL Jr: Microsurgical anatomy of the superior cerebellar artery. **Neurosurgery** 6:10–28, 1980.
11. Hirsch JF, Zouaoui A, Renier D, Pierre-Kahn A: A new surgical approach to the third ventricle with interruption of the striothalamic vein. **Acta Neurochir (Wien)** 47:135–147, 1979.
12. Jamieson KG: Excision of pineal tumors. **J Neurosurg** 35:550–553, 1971.
13. Lavyne MH, Patterson RH Jr: Subchoroidal trans-velum interpositum approach to mid-third ventricular tumors. **Neurosurgery** 12:86–94, 1983.
14. Matsushima T, Rhoton AL Jr, de Oliveira EP, Peace DA: Microsurgical anatomy of the veins of the posterior fossa. **J Neurosurg** 59:63–105, 1983.
15. Nagata S, Rhoton AL Jr, Barry M: Microsurgical anatomy of the choroidal fissure. **Surg Neurol** 30:3–59, 1988.
16. Narabayashi H, Nagao T, Saito Y, Yoshida M, Nagahara M: Stereotactic amygdalotomy for behavior disorders. **Arch Neurol** 9:1–16, 1983.
17. Oka K, Rhoton AL Jr, Barry M, Rodriguez R: Microsurgical anatomy of the superficial veins of the cerebrum. **Neurosurgery** 17:711–748, 1985.
18. Ono M, Ono M, Rhoton AL Jr, Barry M: Microsurgical anatomy of the region of the tentorial incisura. **J Neurosurg** 60:365–399, 1984.
19. Ono M, Rhoton AL Jr, Peace D, Rodriguez RJ: Microsurgical anatomy of the deep venous system of the brain. **Neurosurgery** 15:621–657, 1984.
20. Perlmutter D, Rhoton AL Jr: Microsurgical anatomy of the anterior cerebral-anterior communicating-recurrent artery complex. **J Neurosurg** 45:259–272, 1976.
21. Perlmutter D, Rhoton AL Jr: Microsurgical anatomy of the distal anterior cerebral artery. **J Neurosurg** 49:204–228, 1978.
22. Poppen JL: The right occipital approach to a pinealoma. **J Neurosurg** 25: 706–710, 1966.
23. Renn WH, Rhoton AL Jr: Microsurgical anatomy of the sellar region. **J Neurosurg** 43:288–298, 1975.
24. Rhoton AL Jr: Microsurgical anatomy of the region of the third ventricle, in Apuzzo MLJ (ed): *Surgery of the Third Ventricle*. Baltimore, Williams & Wilkins, 1987, pp 92–166.
25. Rhoton AL Jr: Tentorial incisura. **Neurosurgery** 47[Suppl 1]:S131–S153, 2000.
26. Rhoton AL Jr, Fujii K, Fradd B: Microsurgical anatomy of the anterior choroidal artery. **Surg Neurol** 12:171–187, 1979.
27. Rhoton AL Jr, Hardy DG, Chambers SM: Microsurgical anatomy and dissection of the sphenoid bone, cavernous sinus and sellar region. **Surg Neurol** 12:63–104, 1979.
28. Rhoton AL Jr, Yamamoto I, Peace DA: Microsurgery of the third ventricle: Part 2—Operative approaches. **Neurosurgery** 8:357–373, 1981.
29. Rosner SS, Rhoton AL Jr, Ono M, Barry M: Microsurgical anatomy of the anterior perforating arteries. **J Neurosurg** 61:468–485, 1984.
30. Saeki N, Rhoton AL Jr: Microsurgical anatomy of the upper basilar artery and the posterior circle of Willis. **J Neurosurg** 46:563–578, 1977.
31. Shucart WA, Stein BM: Transcallosal approach to the anterior ventricular system. **Neurosurgery** 3:339–343, 1978.
32. Symon L: The intracranial approach to tumours in the area of the sella turcica, in Symon L (ed): *Operative Surgery: Neurosurgery*. London, Butterworth, 1979, pp 181–186.
33. Timurkaynak E, Rhoton AL Jr, Barry M: Microsurgical anatomy and operative approaches to the lateral ventricles. **Neurosurgery** 19:685–723, 1986.
34. VanWagenen WP: A surgical approach for the removal of certain pineal tumors. **Surg Gynecol Obstet** 53:216–220, 1931.
35. Viale GL, Turtas S, Pau A: Surgical removal of striate arteriovenous malformations. **Surg Neurol** 14:321–324, 1980.
36. Wen HT, Rhoton AL Jr, de Oliveira EP: Transchoroidal approach to the third ventricle: An anatomic study of the choroidal fissure and its clinical application. **Neurosurgery** 42:1205–1219, 1998.
37. Yamamoto I, Rhoton AL Jr, Peace DA: Microsurgery of the third ventricle: Part 1—Microsurgical anatomy. **Neurosurgery** 8:334–356, 1981.
38. Zeal AA, Rhoton AL Jr: Microsurgical anatomy of the posterior cerebral artery. **J Neurosurg** 48:534–559, 1978.

Figure from D'Agoty Gautier's Essai d'anatomie, en tableaux imprimés. *Paris, 1748.*

Copyright © Congress of Neurological Surgeons. Unauthorized reproduction of this article is prohibited.