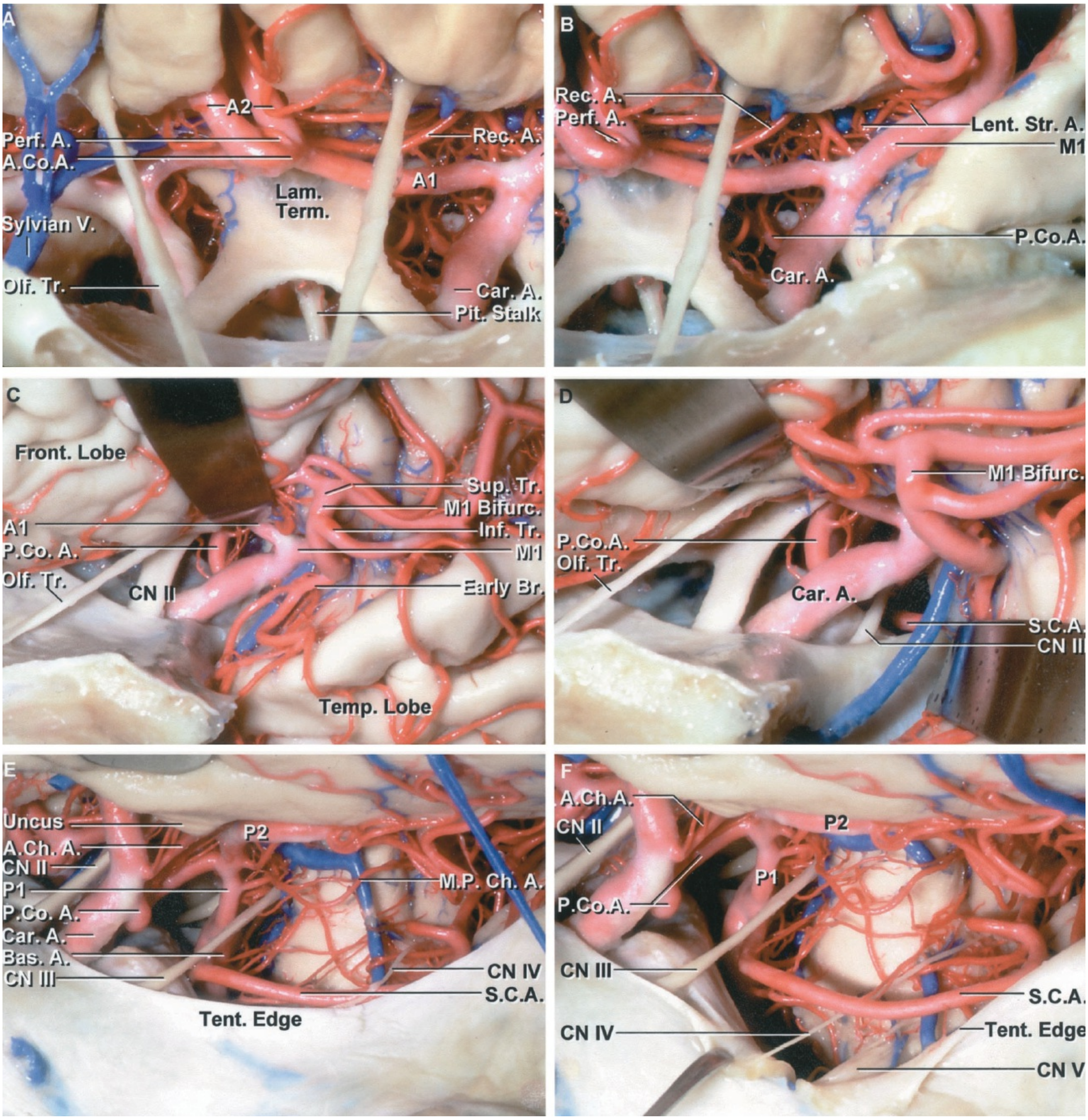
Supratentorial Arteries

Last Updated: April 7, 2021

Introduction

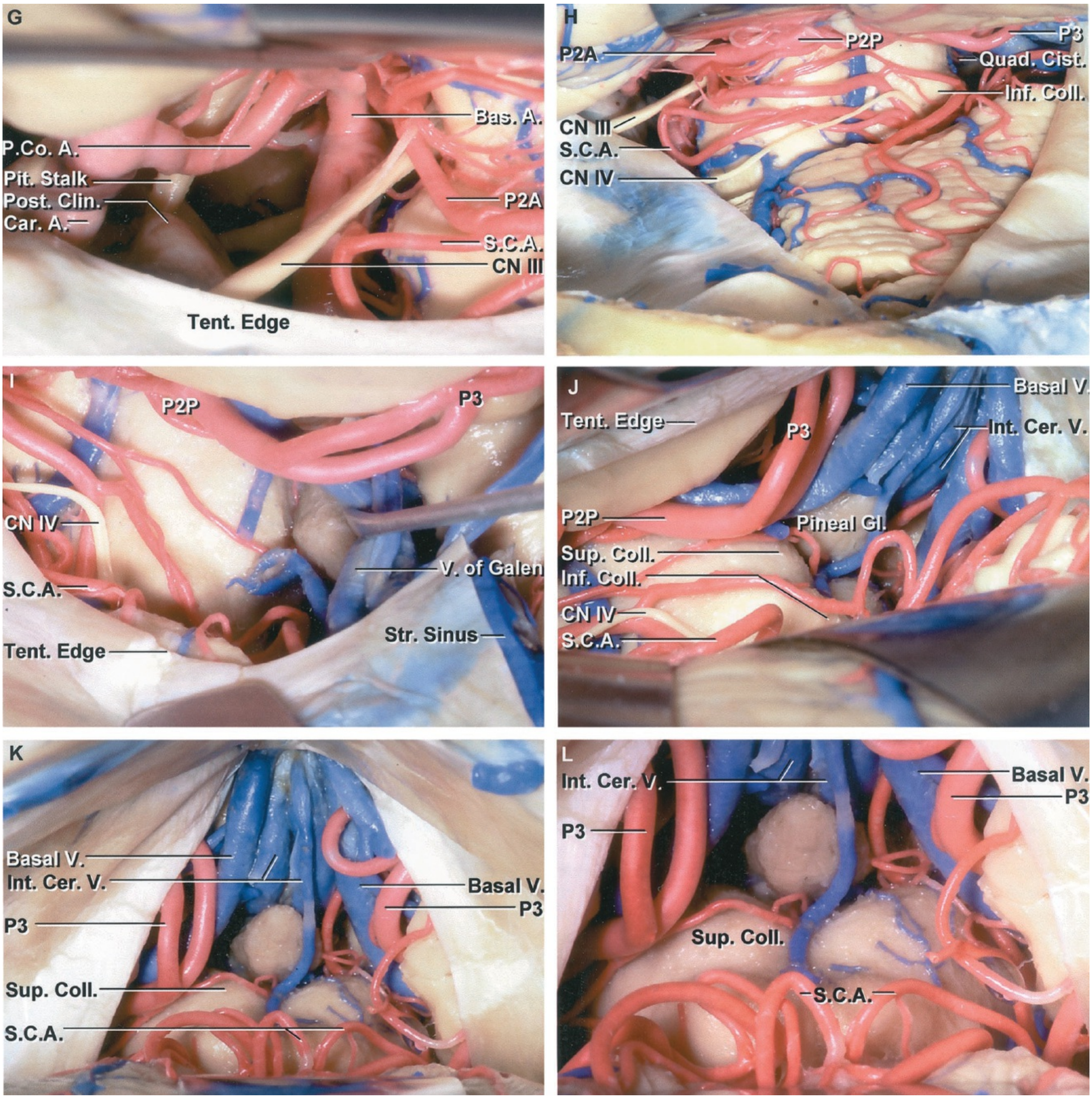
The supratentorial arteries include the supraclinoid portion of the internal carotid artery and its anterior and middle cerebral, ophthalmic, posterior communicating, and anterior choroidal branches, the components of the circle of Willis, which in the posterior midline includes the basilar apex, and finally, the posterior cerebral artery. The origin of all of these arteries is located deep under the center of the cerebrum and their proximal trunks are relatively inaccessible because they course in deep clefts like the sylvian or interhemispheric fissure or in the basal cisterns between the brainstem and temporal lobe (Fig. 2.1). Only the smaller terminal branches are accessible on lateral convexity and even there, these branches are often hidden in cortical sulci rather than coursing on the gyral surfaces. No single operative approach will access all of the branches of the three major cerebral arteries because of their long courses. Thus, each operative approach must be carefully tailored based on the relationships of the arterial segment involved. The relationship of these arteries to the common aneurysm sites and their operative exposure is reviewed in Chapter 3.



Click here to view the interactive module and related content for this image.

Figure 2.1 A-F. Arteries in the basal cisterns. A, anterior view. A1s of nearly equal size cross the front of the lamina terminalis. The right A2 enters the interhemispheric fissure in front of the left A2. The left recurrent artery arises near the level of the anterior communicating artery (AComA) and passes laterally below the anterior perforated substance. A perforating artery arises from the AComA. B, the view has shifted laterally above the carotid bifurcation. The recurrent artery passes laterally above the A1 and intermingles with the lenticulostriate

branches of the M1. The posterior communicating artery (PComA) is directed medially and is seen through the opticocarotid triangle located between the carotid artery, optic nerve, and the A1. C, anterolateral view. The PComA is seen through the opticocarotid triangle. The M1 bifurcates into superior and inferior trunks at the limen insula. D, the basal cisterns have been opened and the temporal pole retracted to expose the oculomotor nerve. The PComA is directed backward above and medial to the oculomotor nerve. The superior cerebellar artery courses below the oculomotor nerve. E, the temporal lobe has been elevated. The anterior choroidal artery (AChA) ascends on the medial side of the uncus. The PComA and the P1 join to form the P2, which continues backward on the medial side of the posterior part of the uncus. A medial posterior choroidal artery (MPChA) passes backward around the brainstem. The superior cerebellar artery passes below the oculomotor and trochlear nerves. The branches forming the P3 course through the quadrigeminal cistern. The P2 courses through the ambient and crural cisterns. A MPChA encircles the brainstem. F, the tentorium has been divided to expose the upper part of the basilar artery. The trigeminal nerve is exposed in the lateral margin of the tentorial opening. The posterior cerebral artery (PCA) courses above and the superior cerebellar artery courses below the oculomotor nerve.



Click here to view the interactive module and related content for this image.

Figure 2.1 G-L. G, subtemporal exposure in another specimen. The PComA is larger than shown in D and E. The oculomotor nerve passes forward between the PCA and the superior cerebellar arteries. H, the exposure has been extended further posteriorly along the side of the brainstem to the quadrigeminal cistern. The tentorium has been divided to expose the upper part of the cerebellum. The PCA and superior cerebellar artery encircle the brainstem to reach the quadrigeminal cistern. The P2 is divided into a P2A that courses in the crural cistern between the uncus and cerebral peduncle, and a P2P that courses in the

ambient cisterns between the parahippocampal gyrus on the midbrain. The P3 courses in the quadrigeminal cistern. The trochlear nerve arises below the inferior colliculus and crosses above the branches of the superior cerebellar artery. I, the exposure has been extended further posteriorly, above the tentorium to the left half of the quadrigeminal cistern. The tributaries of the vein of Galen have been retracted to expose the pineal. The PCA courses above the tentorium and the superior cerebellar artery below. The trochlear nerve arises below the inferior colliculus and passes around the brainstem. J, the exposure has been directed below the tentorium. The internal cerebral veins exit the roof of the third ventricle and the basal veins exit the basal cisterns to join and form the vein of Galen. The P3 courses through the quadrigeminal cistern. K, midline infratentorial exposure. The pineal is exposed between the posterior cerebral arteries and basal veins and below the internal cerebral veins. The exposure into the fissure between the cerebellum and midbrain is not as great as can be achieved when the exposure is directed off to the side of the vermian apex in a paramedian location as shown in J. L, enlarged view of the midline infratentorial exposure. A., artery, arteries; A.Co.A., anterior communicating artery; Bas., basilar; Bifurc., bifurcation; Br., branch; Car., carotid; Cer., cerebral; Cist., cistern; Clin., clinoid; CN, cranial nerve; Coll., colliculus; Front., frontal; Gl., gland; Inf., inferior; Int., internal; Lam., lamina; Lent. Str., lenticulostriate; M.P.Ch.A., medial posterior choroidal artery; Olf., olfactory; P.Co.A., posterior communicating artery; Perf., perforating; Pit., pituitary; Post., posterior; Quad., quadrigeminal; Rec., recurrent; S.C.A., superior cerebellar artery; Str., straight; Sup., superior; Temp., temporal; Tent., tentorial; Term., terminalis; Tr., tract, trunk; V., vein.

Supraclinoidal Portion of the Internal Carotid Artery

The supraclinoidal portion of the internal carotid artery (ICA) is a common site of intracranial aneurysms, and its branches are frequently stretched, displaced, or encased by cranial base tumors. The ICA and its major and perforating branches are frequently exposed during operations on aneurysms of the circle of Willis and tumors of the sphenoid ridge, anterior and middle cranial fossae, and suprasellar region. Agenesis or aplasia of the internal carotid artery is rare.

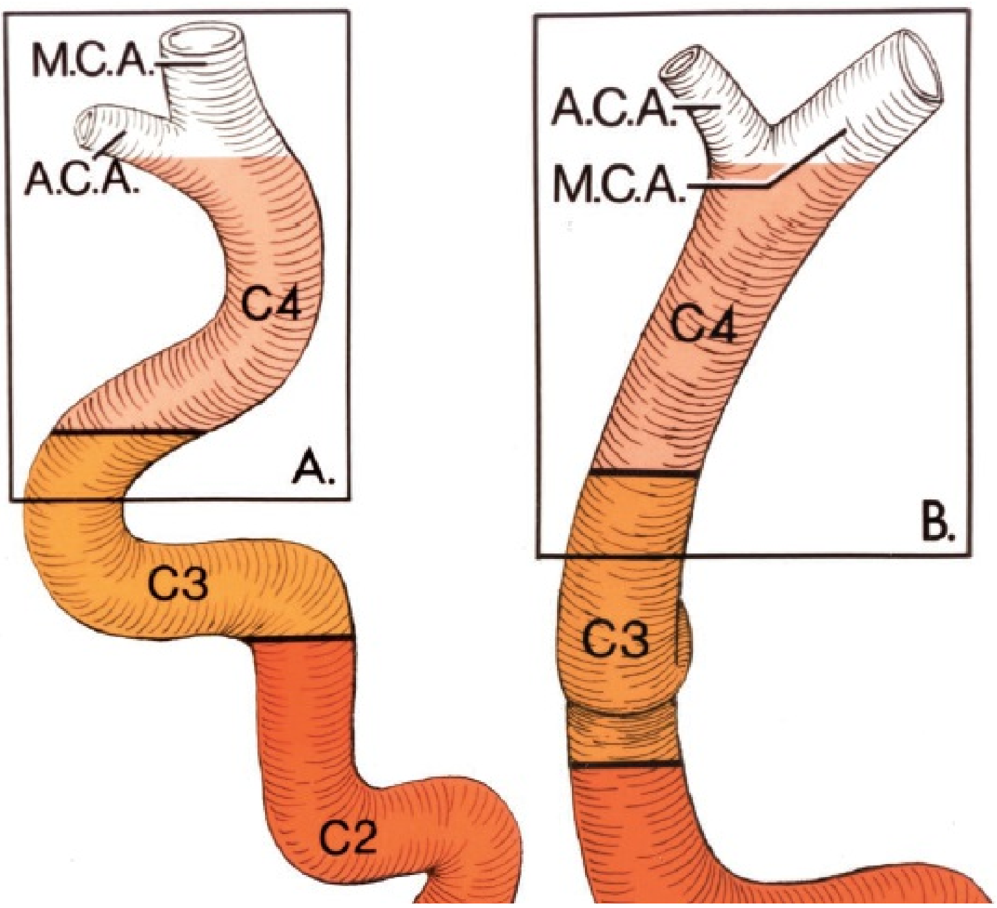
Segments of the Internal Carotid Artery

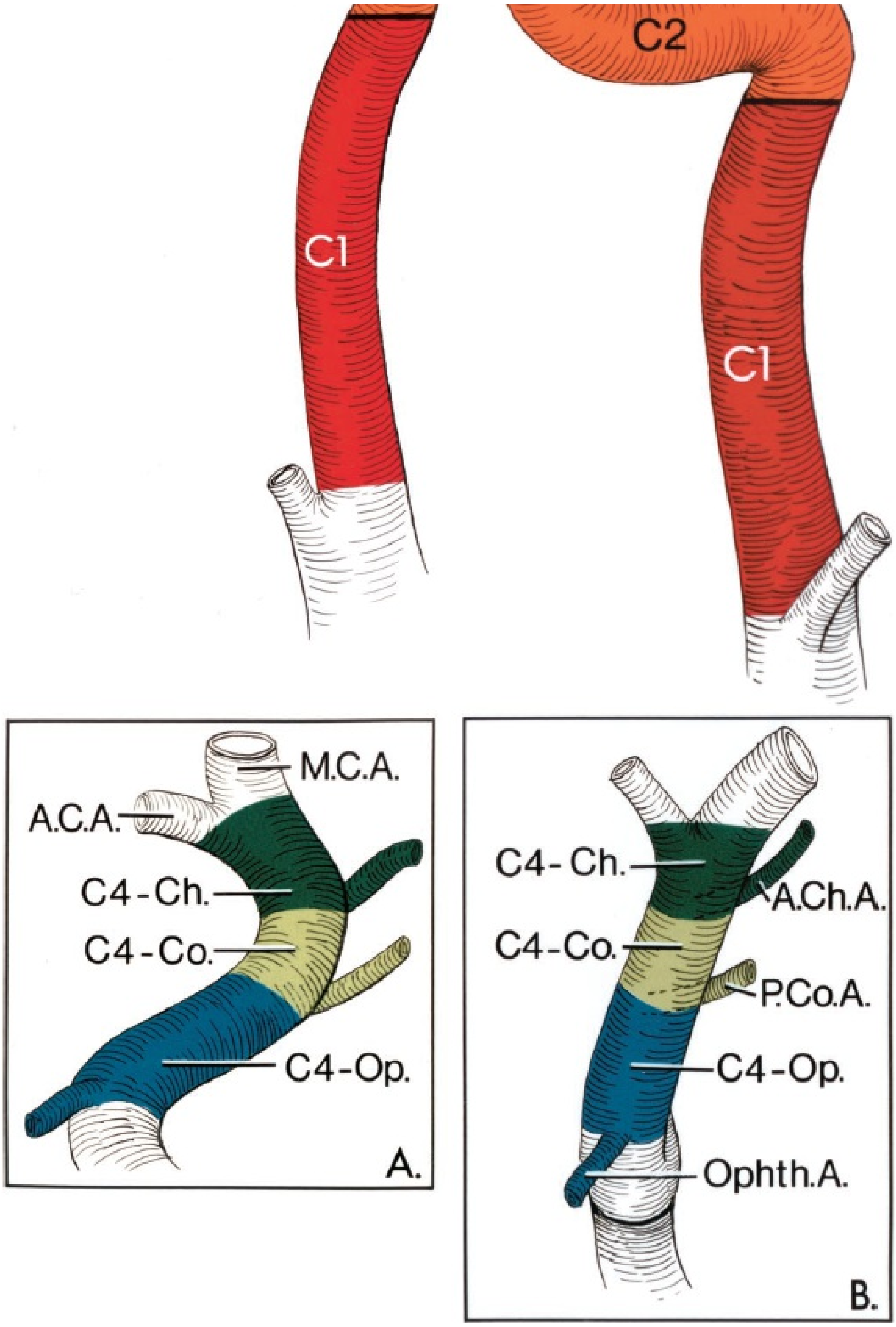
The ICA is divided into four parts: the C1 or cervical portion extends from its junction with the common carotid artery to the external orifice of the carotid canal; the C2 or petrous portion courses within the carotid canal and ends where the artery enters the cavernous sinus; the C3 or cavernous portion courses within the cavernous sinus and ends where the artery passes through the dura mater forming the roof of the cavernous sinus; and the C4 or supraclinoid portion begins where the artery enters the subarachnoid space and terminates at the bifurcation into the anterior (ACA) and middle cerebral arteries (MCA) (Fig. 2.2) (25, 36).

The C4 begins where the artery emerges from the dura mater, forming the roof of the cavernous sinus. It enters the cranial cavity by passing along the medial side of the anterior clinoid process and below the optic nerve. It courses posterior, superior, and slightly lateral to reach the lateral side of the optic chiasm and bifurcates below the anterior perforated substance at the medial end of the sylvian fissure to give rise to the ACA and MCA. The C4 segment is defined as including the crotch from which the MCA and ACA arise, and the branches originating from the apex of the wall between the origin of the ACA and MCA are considered to be branches of the ICA, just as aneurysms arising at this apex are considered to be aneurysms of the bifurcation of the ICA. When viewed from laterally, the cavernous (C3) and intracranial (C4) portions have several curves that form an S shape, and together these portions are called the carotid siphon. The lower half of the S, formed predominantly by the intracavernous portion, is convex anteriorly, and the upper half, formed by the supraclinoid portion, is convex posteriorly. The junction of the anteriorly and posteriorly convex segments passes along the medial side of the anterior clinoid process. The prebifurcation branches of the C4 are the ophthalmic, anterior choroidal (AChA), posterior communicating arteries (PComA), perforating, and superior hypophyseal arteries.

The intradural exposure of the C4 and the anterior portion of the circle of Willis is directed along the ipsilateral sphenoid ridge or orbital roof to the anterior clinoid process. In exposing the ICA, the approach is usually from proximal to distal, beginning with the ophthalmic segment and working distally toward the bifurcation. The ophthalmic artery is difficult to expose because of its short intradural length and its location under the optic nerve.

In exposing the C4 beyond the origin of the ophthalmic artery, the surgeon often sees the AChA before the PComA, although the AChA arises distal to the PComA (Figs. 2.1 and 2.3). This occurs because of three sets of anatomic circumstances. First, the C4 passes upward in a posterolateral direction, placing the origin of the AChA further lateral to the midline than the origin of the PComA. Second, the AChA commonly arises further laterally on the posterior wall of the C4 portion than the PComA. The site of origin of the AChA from the posterior wall of the C4 portion is lateral to the site of origin of the PComA in 94% of hemispheres (33). Third, the AChA pursues a more lateral course than the PComA; the former passes laterally around the cerebral peduncle and into the temporal horn, whereas the latter is most commonly directed in its initial course in a posteromedial direction above the oculomotor nerve toward the interpeduncular fossa.

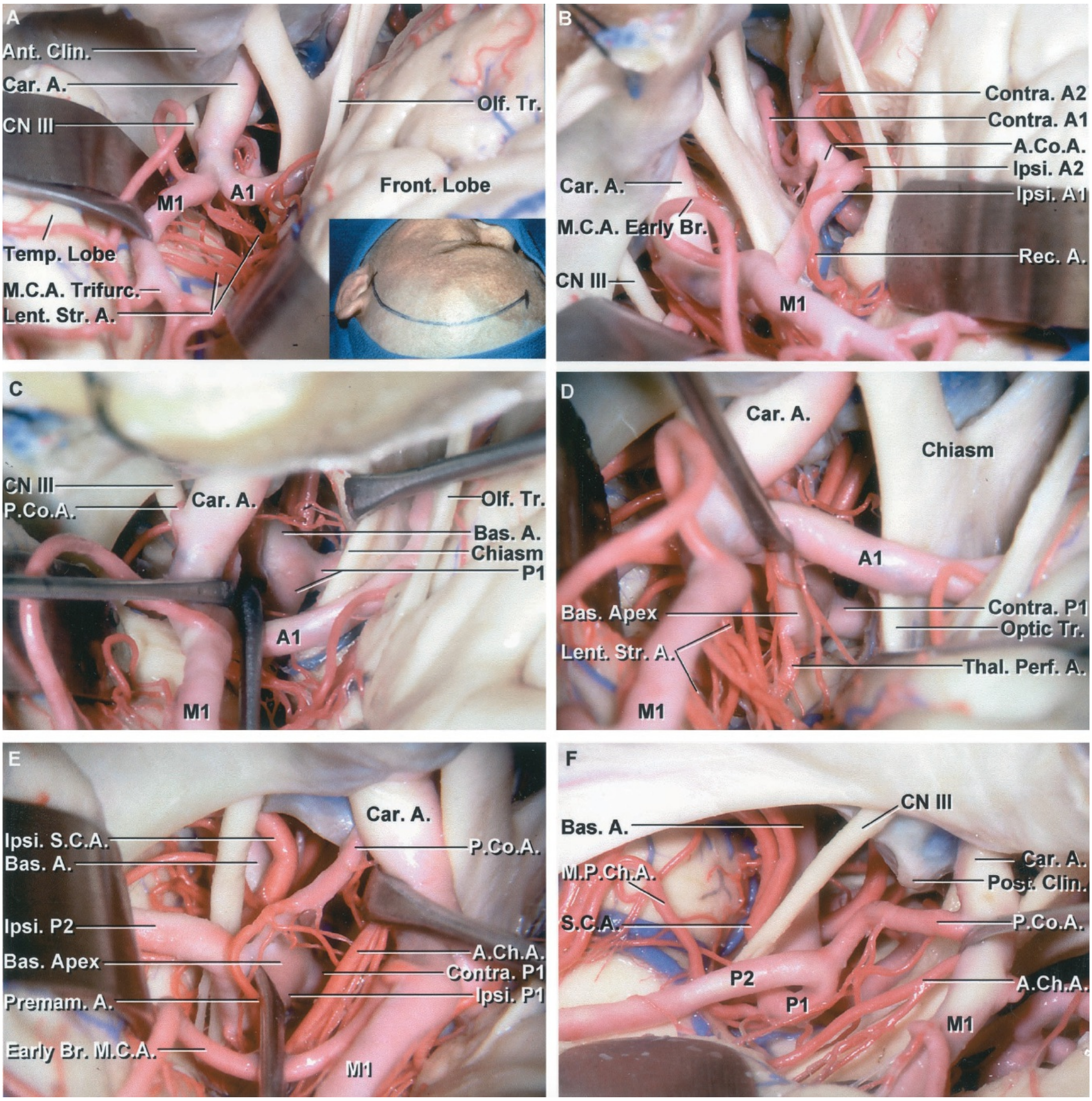




[Click here](#) to view the interactive module and related content for this image.

Figure 2.2. Lateral (left) and anterior views (right) of the left internal carotid artery (ICA) and A and B, segments of the supraclinoid (C4) portion. A, lateral view of the C4 portion. B, anterior view of the C4 portion. The ICA is divided into four parts. These parts, from proximal to

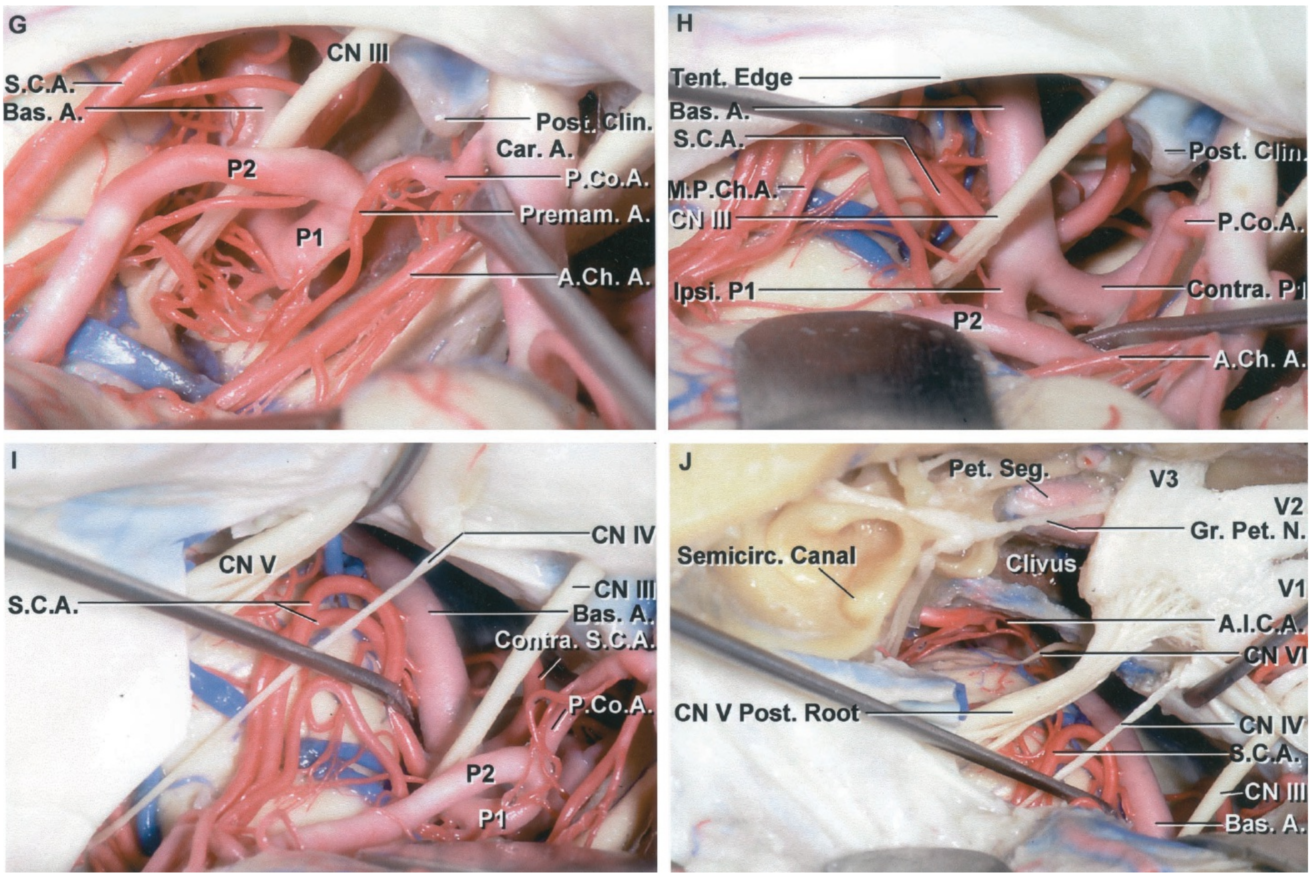
distal, are the C1 through the C4 portions. The cervical portion (C1, red) extends from the origin of the ICA to the external orifice of the carotid canal in the petrous temporal bone. The petrous portion (C2, orange) extends from the external orifice of the carotid canal to where the artery exits the carotid canal to enter the cavernous sinus. The cavernous portion (C3, yellow) begins where the artery enters the cavernous sinus and terminates where it emerges from the dura mater on the medial side of the anterior clinoid process to enter the intracranial cavity. The intracranial (supraclinoid) portion (C4, beige) begins where the artery enters the cranial cavity medial to the anterior clinoid process and terminates below the anterior perforated substance where the artery bifurcates into the anterior and middle cerebral arteries. The ICA gives rise to the ophthalmic, posterior communicating, anterior choroidal, anterior cerebral, and the middle cerebral arteries. The supraclinoid portion of the ICA is divided into three segments based on the origin of these branches. The ophthalmic segment (C4-Op., dark blue) extends from the origin of the ophthalmic artery to the origin of the PComA. The communicating segment (C4-Co., light green) extends from the origin of the PComA to the origin of the anterior choroidal artery. The choroidal segment (C4-Ch., dark green) extends from the origin of the anterior choroidal artery to the bifurcation of the internal carotid artery into the anterior and middle cerebral arteries. A., artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; Ch., choroidal; Co., communicating; M.C.A., middle cerebral artery; Op., ophthalmic; Ophth., ophthalmic; P.Co.A., posterior communicating artery. (From, Gibo H, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. J Neurosurg 55:560–574, 1981 [15].)



Click here to view the interactive module and related content for this image.

Figure 2.3 A-F. Pterional exposure of the circle of Willis. A, a left frontotemporal bone flap has been elevated and the dura opened. The left frontal and temporal lobes have been retracted to expose the carotid artery entering the dura medial to the anterior clinoid process. The carotid bifurcation has been exposed. Lenticulostriate arteries arise from the M1. The M1 splits in a trifurcation pattern. B, the exposure has been extended between the chiasm and frontal lobe to the AComA and the contralateral A1 and A2s. A recurrent artery arising near the AComA passes laterally above the carotid bifurcation. C, the basilar bifurcation

has been exposed through the opticocarotid triangle located between the internal carotid artery, A1, and optic nerve. D, the carotid bifurcation has been depressed to expose the basilar apex in the interval between the carotid bifurcation and the lower margin of the optic tract. Perforating branches crossing the area can make the approach hazardous. A thalamoperforating artery arises from the ipsilateral P1. E, the temporal pole has been retracted posteriorly for a pretemporal exposure. The carotid and anterior choroidal arteries have been elevated to expose the PComA, which gives rise to a large perforating branch referred to as a premamillary artery. The M1 gives rise to an early branch proximal to the trifurcation. The P2 extends above and the superior cerebellar artery (SCA) extends below the oculomotor nerve. F, anterior subtemporal view. The temporal pole and the carotid artery have been elevated to the expose the origin of the normal-sized PComA. The AChA passes backward along the medial edge of the uncus. A large MPChA arises from the P1 and loops downward as it passes to the quadrigeminal cistern.



Click here to view the interactive module and related content for this image.

Figure 2.3 G-J. G, the AChA has been elevated to expose a large perforating branch of the PComA called a premamillary artery. H, the PComA has been elevated to provide an excellent exposure of the basilar apex and the P1s. The ipsilateral SCA arises as a duplicate artery. I, the tentorium has been divided behind where the trochlear nerve enters the edge. This increases the length of basilar artery exposed. The trunks of a duplicate superior cerebellar artery loop down toward the trigeminal nerve. J, the petrous apex has been removed to complete an anterior petrosectomy approach, which increases access to the front of the brainstem and the basilar artery. In this case, the labyrinth including the cochlea and semicircular canals, and the nerves in the internal acoustic meatus have been exposed to show the relationship of the drilling for the anterior petrosectomy in relationship to these structures. The drilling for an anterior petrosectomy is directed behind the petrous carotid artery medial to the labyrinth and proceeds medially to the inferior petrosal sinus and side of the clivus. The abducens nerve and the ICA are in the lower margin of the exposure. A., arteries, artery; A.Ch.A., anterior choroidal artery; A.Co.A., anterior communicating artery; A.I.C.A., anteroinferior cerebellar artery; Ant., anterior; Bas., basilar; Br., branch; Car., carotid; Clin., clinoid; CN, cranial nerve; Contra., contralateral; Front., frontal; Gr., greater; Ipsi., ipsilateral; Lent. Str., lenticulostriate; M.C.A., middle cerebral artery; M.P.Ch.A., medial posterior choroidal artery; N., nerve; Olf., olfactory; P.Co.A., posterior communicating artery; Pet., petrosal; Post., posterior; Premam., premamillary; Rec., recurrent; S.C.A., superior cerebellar artery; Seg., segment; Semicirc., semicircular; Temp., temporal; Tent., tentorial; Thal. Perf., thalamoperforating; Tr., tract; Trifurc., trifurcation.

Segments of the C4

The C4 is divided into three segments based on the site of origin of the ophthalmic, PComA, and AChA. The ophthalmic segment extends from the roof of the cavernous sinus and the origin of the ophthalmic artery to the origin of the PComA; the communicating segment extends from the origin of the PComA to the origin of the AChA; and the choroidal segment extends from the origin of the AChA to the terminal bifurcation of the ICA. The ophthalmic segment is the longest, and the communicating segment is the shortest (15).

C4 Perforating Branches

Each of the three C4 segments gives off a series of perforating branches with a relatively constant site of termination. An average of 8 (range, 3–12) perforating arteries (excluding the ophthalmic, PComA, and AChA) arise from the C4 (Figs. 2.4–2.6).

Ophthalmic Segment

An average of four (range, one to seven) perforating arteries arise from the ophthalmic segment. Most arise from the posterior or medial aspect of the artery. These branches are most commonly distributed to the infundibulum (stalk) of the pituitary gland, the optic chiasm, and less commonly, in descending order of frequency, to the optic nerve, premamillary portion of the floor of the third ventricle, and the optic tract. A few vessels terminate in the dura mater covering the anterior clinoid process, sella turcica, and tuberculum sellae. The arteries that arise from this segment and pass to the infundibulum of the pituitary gland are called the superior hypophyseal arteries (13, 15).

Communicating Segment

No perforating branches arise from the communicating segment in more than half of hemispheres, and if present, only one to three are found. They arise from the posterior half of the wall and terminate, in descending order of frequency, in the optic tract, premamillary part of the floor of the third ventricle, the optic chiasm, and infundibulum, and infrequently, enter the anterior or posterior perforated substance. The branches are often stretched around the neck of posterior communicating aneurysms.

Choroidal Segment

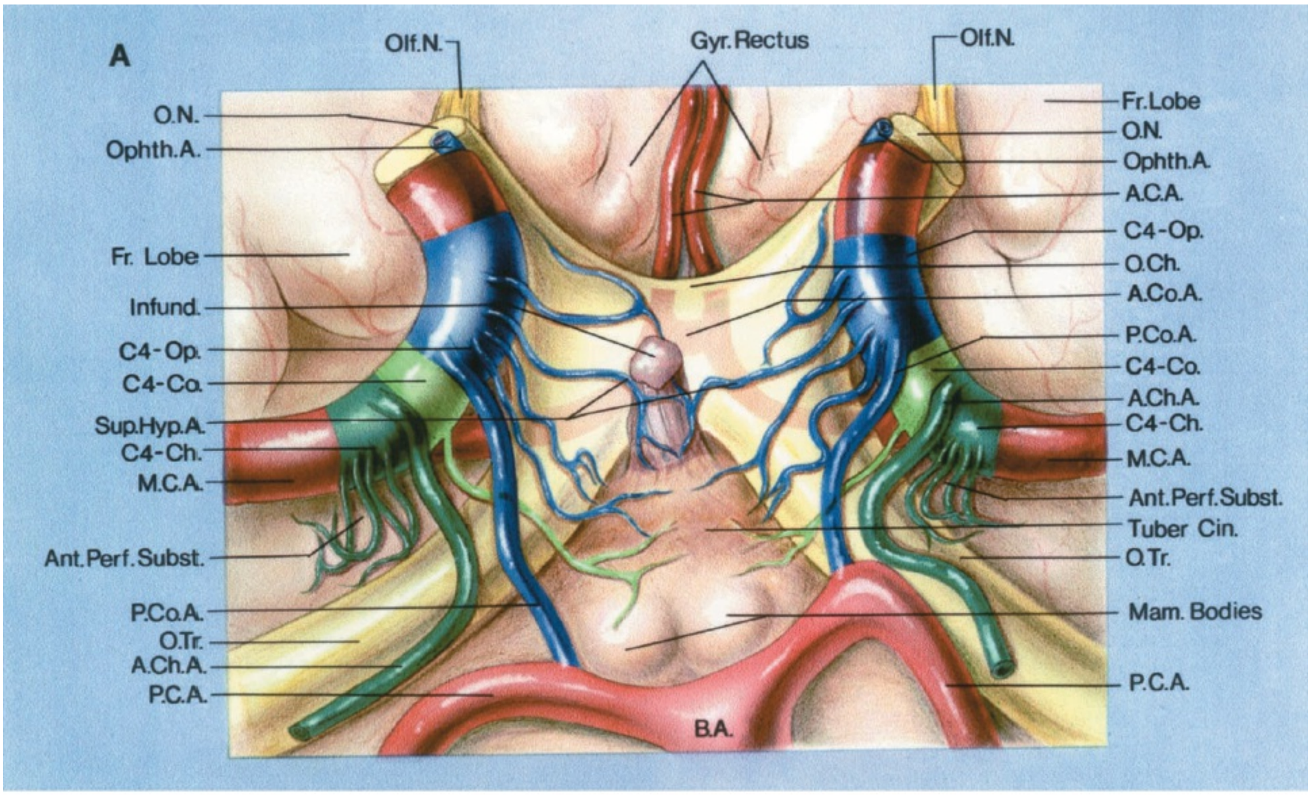
An average of four (range, one to nine) branches arise from the choroidal segment. Most branches arise from the posterior half of the arterial wall and terminate, in descending order of frequency, in the anterior perforated substance, optic tract, and uncus.

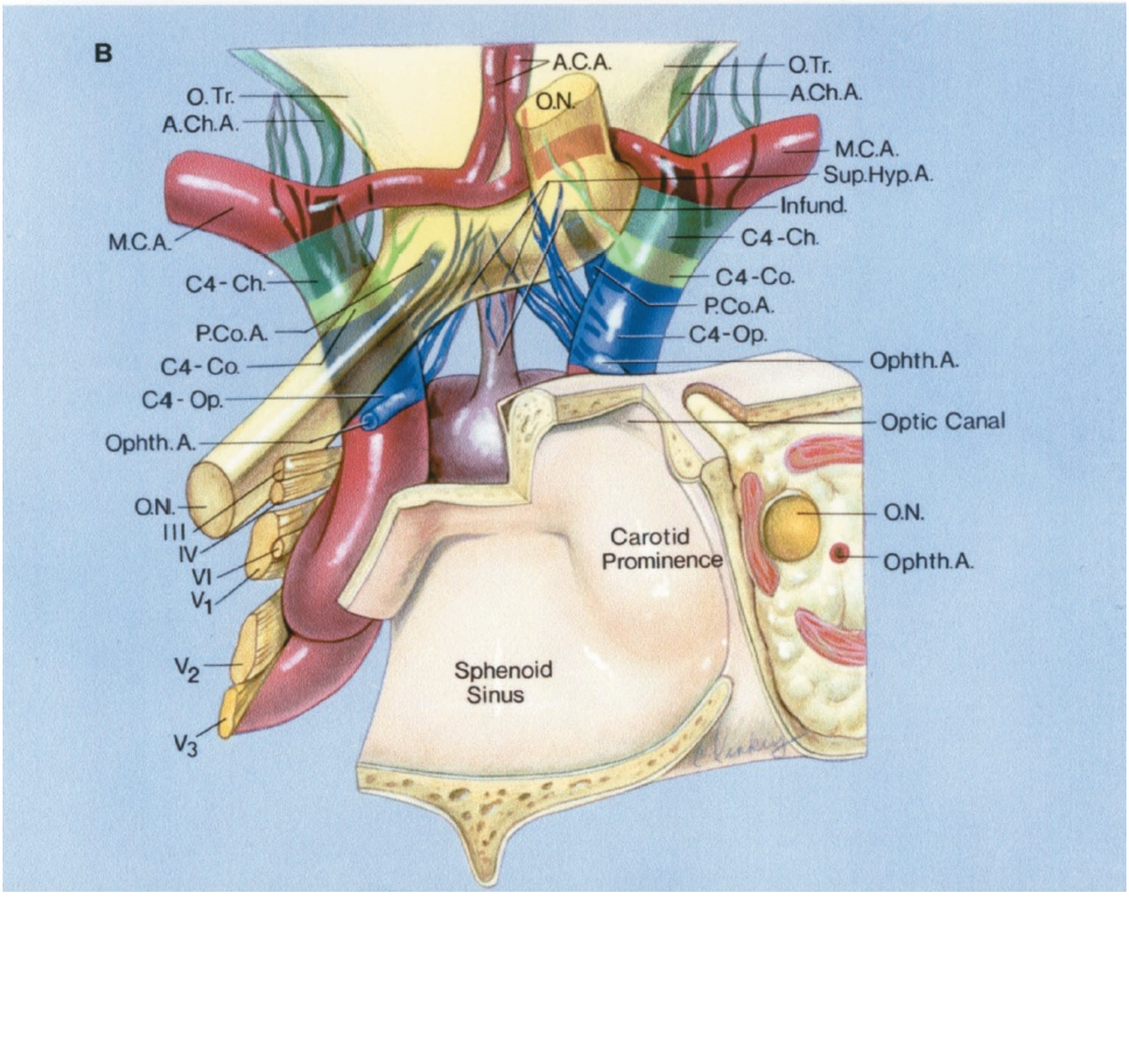
Superior Hypophyseal and Infundibular Arteries

The superior hypophyseal arteries are a group of one to five (average, two) small branches that arise from the C4's ophthalmic segment and terminate on the pituitary stalk and gland, but also send branches to the optic nerves and chiasm and the floor of the third ventricle (Figs. 2.4–2.6). The largest of the branches is often referred to as the superior hypophyseal artery. Most branches arise from the posteromedial, medial, or the posterior aspects of the artery. The infundibular arteries are a group of arteries that originate from the PComA and are distributed to the infundibulum. There are fewer infundibular arteries than superior hypophyseal arteries. One-quarter of hemispheres have one or two infundibular arteries and the remainder have none.

The superior hypophyseal and infundibular arteries pass medially below the chiasm to reach the tuber cinereum. They intermingle and form a fine anastomotic plexus around the pituitary stalk called the circuminfundibular anastomosis. These arteries and the circuminfundibular plexus are distributed to the pituitary stalk and anterior lobe. The inferior hypophyseal branch of the meningohypophyseal trunk of the intracavernous carotid perfuses the posterior lobe. The capsular arteries also arise from the intracavernous carotid and supply the capsule of the pituitary gland (16).

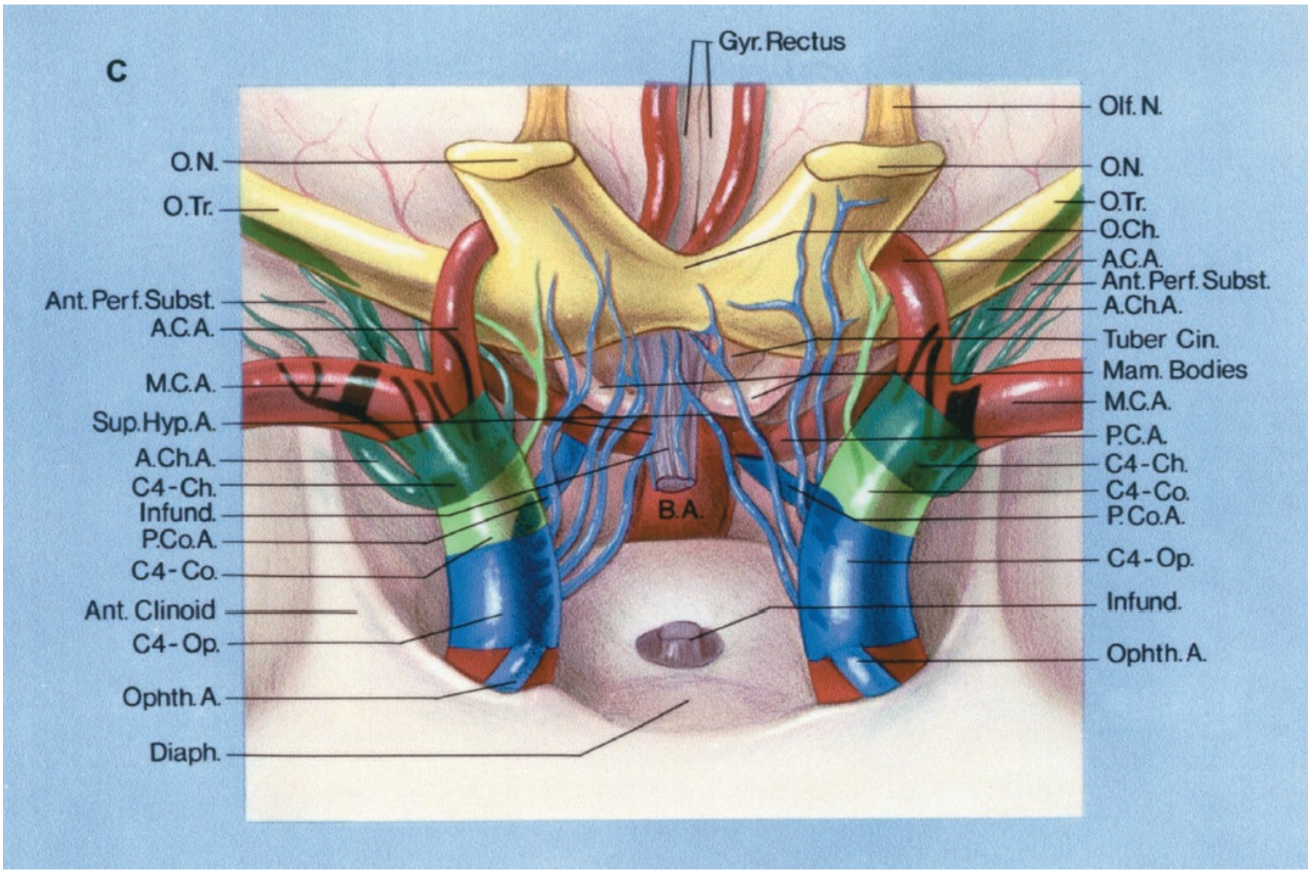
This circuminfundibular plexus gives rise to ascending and descending arteries. The descending arteries include shortstalk and superficial arteries. The short-stalk arteries penetrate the infundibulum and form capillaries that lead into sinusoids running down the stalk. The superficial arteries course inferiorly on the outside of the stalk in the subarachnoid space and penetrate the anterior lobe. The ascending arteries supply the tuber cinereum, median eminence, and the inferior surface of the optic chiasm. The superior hypophyseal arteries also send branches to the chiasm and proximal portions of the optic nerves.





Click here to view the interactive module and related content for this image.

FIGURE 2.4 A-B. Perforating branches of the ICA. A, inferior view. The internal carotid artery gives rise to the ophthalmic, posterior communicating, anterior choroidal, anterior cerebral, and the middle cerebral arteries. The supraclinoid portion of the ICA is divided into three segments based on the origin of these branches: an ophthalmic segment (C4-Op., blue) that extends from the origin of the ophthalmic artery to the origin of the PComA; a communicating segment (C4-Co., light green) that extends from the origin of the PComA to the origin of the AChA; and a choroidal segment (C4-Ch., dark green) that extends from the origin of the AChA to the bifurcation of the ICA into the anterior and middle cerebral arteries. The perforating branches arising from the ophthalmic segment extend to the optic nerve, optic chiasm and the optic tracts, and the floor of the third ventricle around the infundibulum and tuber cinereum. The superior hypophyseal arteries arise from the ophthalmic segment and extend to the infundibulum of the pituitary gland. The branches arising from the communicating segment reach the optic tracts, floor of the third ventricle, and the area around the mamillary bodies. The perforating branches of the choroidal segment pass upward and enter the anterior perforated substance. The posterior cerebral arteries arise from the basilar artery and pass backward below the optic tracts. The ACA and AComA course above the optic chiasm and pass between the frontal lobes. The olfactory nerves are lateral to the gyrus rectus. B, anterior view. The left optic nerve has been divided near its entrance into the optic canal and elevated to give a clearer view of the perforating branches. The ophthalmic artery arises above the cavernous sinus. The carotid artery courses through the cavernous sinus and then laterally and produces a prominence in the wall of the sphenoid sinus before giving rise to the ophthalmic artery. The oculomotor, trochlear, abducens, and the ophthalmic, maxillary, and mandibular divisions of the trigeminal nerve pass lateral to the sphenoid sinus in the walls of the cavernous sinus. The superior hypophyseal arteries arise from the ophthalmic segment.



Click here to view the interactive module and related content for this image.

FIGURE 2.4 C. C, anterior view with both optic nerves divided and elevated to show the lower surface of the floor of the third ventricle and the perforating branches passing to it. The infundibulum has been divided above the diaphragma sellae. A., artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; A.Co.A., anterior communicating artery; Ant., anterior; Ch., choroidal; Cin., cinereum; Co., communicating; Diaph., diaphragm; Fr., frontal; Gyr., gyrus; Hyp., hypophyseal; Infund., infundibulum; M.C.A., middle cerebral artery; Mam., mamillary; N., nerve; O., optic; Olf., olfactory; Op., ophthalmic; Ophth., ophthalmic; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Perf., perforated; Subst., substance; Sup., superior; Tr., tract. (From, Gibo H, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. J Neurosurg 55:560–574, 1981 [15].)

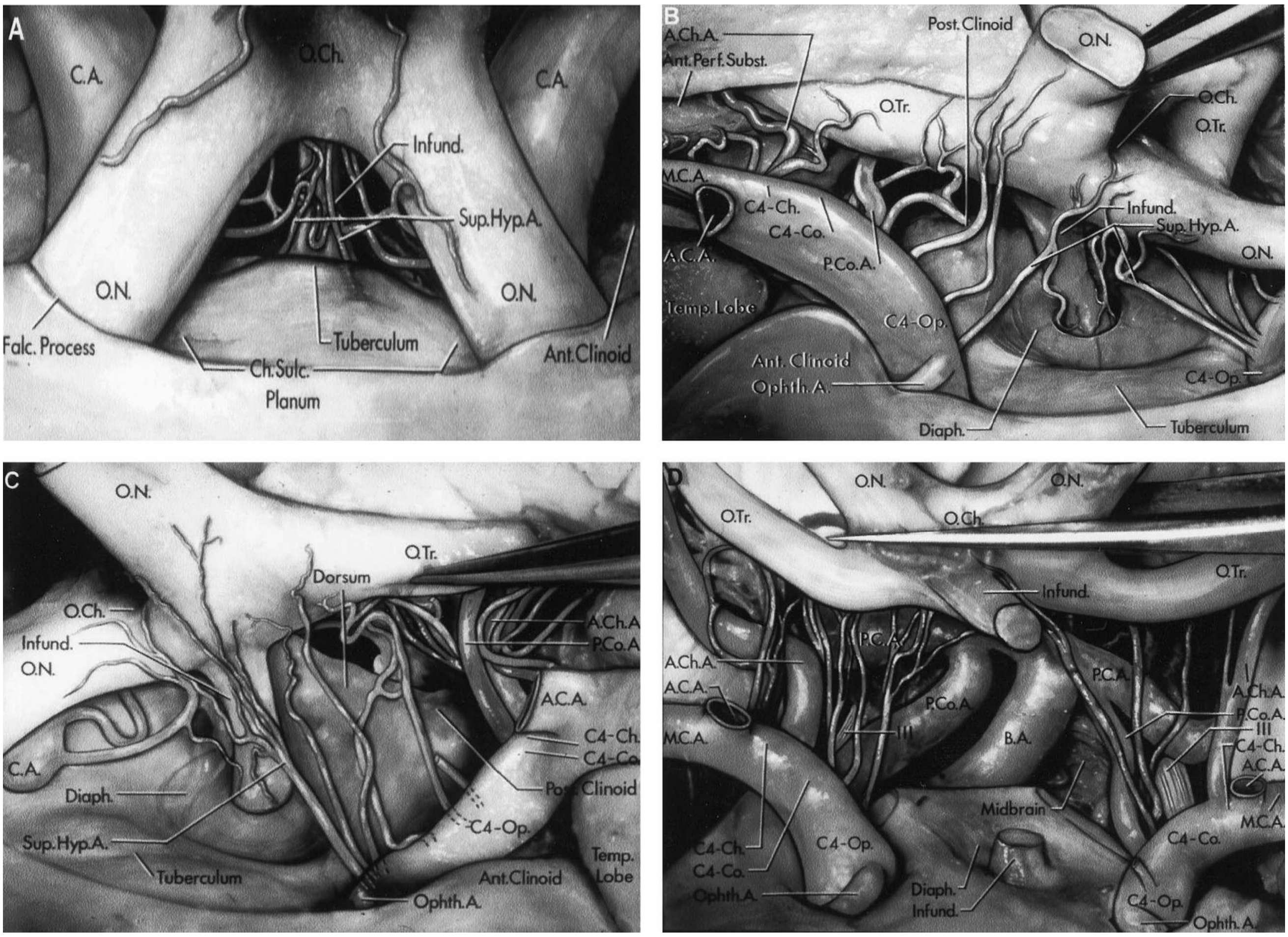


FIGURE 2.5. Anterior and anteroinferior views of the supraclinoid portion of the internal carotid artery. A, anterior view. The optic nerves enter the optic canals medial to the anterior clinoid processes. The infundibulum passes inferiorly below the optic chiasm to the pituitary gland. The carotid arteries are posterior to the optic nerves. The planum sphenoidal is anterior to the chiasmatic sulcus and the tuberculum sellae. The perforating branches of the carotid artery pass medially in the subchiasmatic space. The superior hypophyseal arteries arise from the carotid artery and pass to the infundibulum. The falciform process is a fold of dura mater that passes above the optic nerve proximal to the optic foramen. B, the right optic nerve has been divided at the optic foramen and elevated to show the perforating branches of the supraclinoid portion of the carotid arteries. The right anterior cerebral artery was divided at its origin so that the optic nerve and chiasm could be elevated. The carotid artery gives rise to multiple perforating branches as well as the ophthalmic, posterior communicating, anterior choroidal, and the middle cerebral arteries. The supraclinoid portion of the ICA is divided into three segments based on the origin of its major branches: the ophthalmic segment (C4-Op.) extends from the origin of the

ophthalmic artery to the origin of the PComA, the communicating segment (C4-Co.) extends from the origin of the PComA to the origin of the AChA, and the choroidal segment (C4-Ch.) extends from the origin of the AChA to the bifurcation of the carotid artery. The perforating branches arising from the ophthalmic segment pass to the optic nerve, chiasm, infundibulum, and the floor of the third ventricle. The perforating branches arising from the communicating segment pass to the optic tract and the floor of the third ventricle. The perforating branches arising from the choroidal segment pass upward and enter the brain through the anterior perforated substance. The diaphragma sellae surrounds the infundibulum above the pituitary gland. The temporal lobe is below the middle cerebral artery. C, the left optic nerve has been divided at the optic foramen and the anterior cerebral artery divided near its origin so that both optic nerves and the chiasm and tract could be elevated to show the perforating branches of the carotid artery. The Liliequist membrane is posterior to the infundibulum and hides the basilar artery, but not the posterior cerebral artery. The perforating branches of the ophthalmic segment pass upward to the infundibulum and the optic nerve, chiasm, and tract. D, both optic nerves and both ACAs and the infundibulum have been divided to permit the optic nerves and chiasm to be elevated with a forceps for this view under the optic chiasm and across the diaphragma sellae and dorsum to the upper part of the basilar artery and the oculomotor nerves. The oculomotor nerves pass forward below the PCAs. The perforating branches of the supraclinoid segment of the carotid artery pass upward to supply the infundibulum, the optic chiasm and tracts, and the floor of the third ventricle; some enter the brain through the anterior perforated substance. The right AChA is very large. A., artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; Ant., anterior; B.A., basilar artery; C.A., carotid artery; Ch., choroidal; Ch., chiasm, chiasmatic; Co., communicating; Diaph., diaphragm; Falc., falciform; Hyp., hypophyseal; Infund., infundibulum; M.C.A., middle cerebral artery; N., nerve; O., optic; Op., Ophth., ophthalmic; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Perf., perforated; Post., posterior; Subst., substance; Sulc., sulcus; Sup., superior; Temp., temporal; Tr., tract. (From,

Gibo H, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. J Neurosurg 55:560–574, 1981 [15].)

Ophthalmic Artery

The ophthalmic artery is the first branch of the C4. Most ophthalmic arteries arise below the optic nerve in the supraclinoid area above the dural roof of the cavernous sinus and pass anterolaterally below the optic nerve to enter the optic canal and orbit. The distal course is reviewed in Chapter 7. Eight percent of ophthalmic arteries originate within the cavernous sinus. The ophthalmic artery may rarely arise from the clinoid segment of the ICA located on the medial side of the anterior clinoid process or from the middle meningeal artery (16, 20, 29). It is rarely absent. The ophthalmic arteries uncommonly give rise to intracranial perforating branches and, if present, these branches run posteriorly and are distributed to the ventral aspect of the optic nerve and chiasm and the pituitary stalk.

The ophthalmic artery usually arises from the medial third of the superior surface of the C4 immediately distal to the cavernous sinus in the area below the optic nerve. In our earlier study, it arose above the medial third of the superior surface of the C4 in 78% of hemispheres and above the middle third of the superior surface in 22% of cases (15). None arise from the lateral third of the superior surface. It may kink laterally, infrequently presenting a short segment lateral to the optic nerve before entering the optic canal. The origin varies from as far as 5 mm anterior to 7 mm posterior to the tip of the anterior clinoid process and from 2 to 10 mm medial to the clinoid process (16). Most ophthalmic arteries arise anterior to the tip of the anterior clinoid process, approximately 5 mm medial to the anterior clinoid.

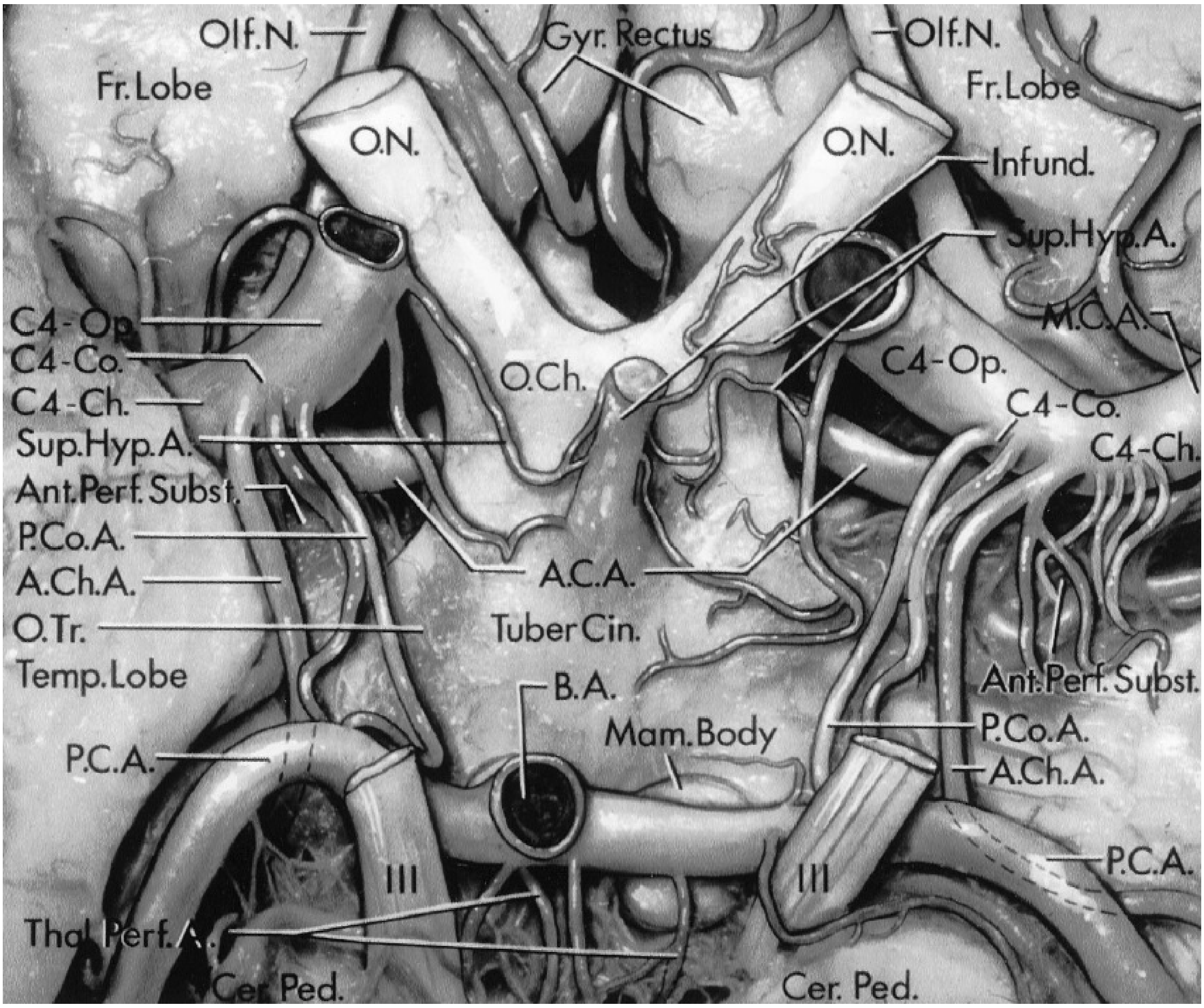
The intracranial segment of the ophthalmic artery is usually very short. In a previous study from this laboratory, 14% of the segments were found to exit the ICA and immediately enter the optic canal; in the remaining 86%, the maximum length of the preforaminal segment was 7.0 mm, and the mean length was 3.0 mm (16). The intracranial segment usually arises from the medial third of the superior surface of the ophthalmic segment under the optic nerve and commonly enters the optic foramen within 1 to 2 mm of its origin. The exposure of the ophthalmic artery is facilitated by removing the anterior clinoid process and roof of the optic canal, and incising the falciform process, a thin fold of dura mater that extends medially from the anterior clinoid process and covers a 0.5- to 11-mm (average, 3.5 mm) segment of the optic nerve immediately proximal to the optic foramen (16).

Posterior Communicating Artery

The PComA, which forms the lateral boundary of the circle of Willis, arises from the posteromedial surface of the C4 approximately midway between the origin of the ophthalmic artery and the terminal bifurcation (Figs. 2.1, 2.3, and 2.6–2.8). It sweeps backward and medially below the tuber cinereum, above the sella turcica, and slightly above and medial to the oculomotor nerve to join the posterior cerebral artery (PCA). In the embryo, the PComA continues as the PCA, but in the adult, the latter artery is annexed by the basilar system. If the PComA remains the major origin of the PCA, the configuration

is termed fetal. If the PComA is of small or normal size, it courses posteromedially to join the PCA above and medial to the oculomotor nerve, but if it is of a fetal type, it courses further laterally above or lateral to the oculomotor nerve.

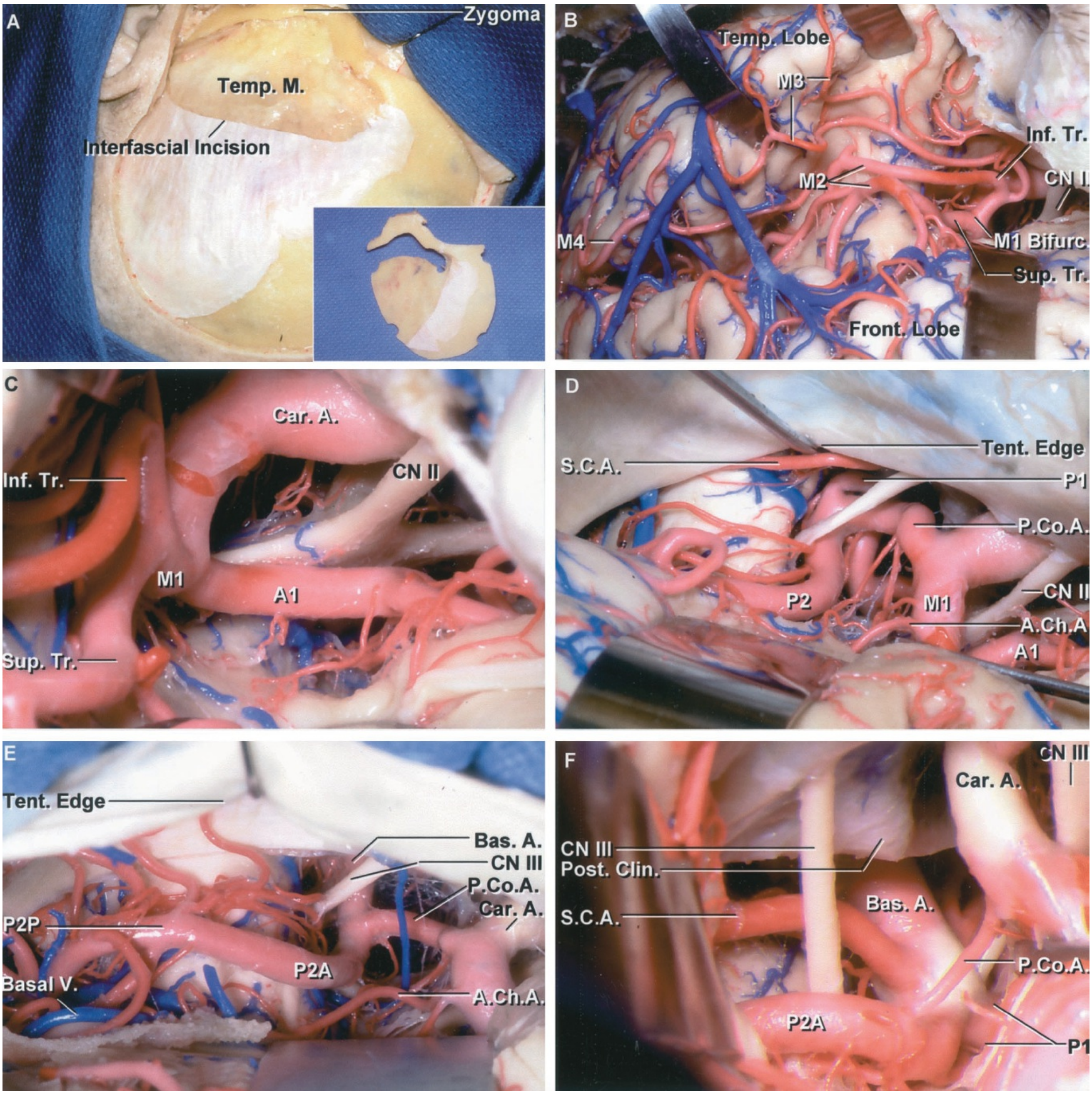
The PComA usually arises from the posteromedial or posterior aspect of the C4. The diameter at the carotid origin is slightly larger than at the junction with the PCA, but the difference is not usually more than 1 mm. Dilations of the origin of the PComA from the C4, known as functional dilatation or infundibular widening, are found in approximately 6% of hemispheres. Such dilation may be difficult to distinguish from an aneurysm. Some authors regard it as an early stage of aneurysm formation because the histological appearances are identical with those of aneurysms, but other authors, based on histological techniques, conclude that the junctional dilations are neither aneurysmal nor preaneurysmal (9, 17).



Click here to view the interactive module and related content for this image.

FIGURE 2.6. Inferior view of the perforating branches of the supraclinoid portion of the internal carotid artery. The supraclinoid portion of the artery gives rise to the posterior communicating, anterior choroidal, middle cerebral, and anterior cerebral arteries. The supraclinoid portion of the artery is divided into three segments based on the site of origin of these branches: an ophthalmic segment (C4-Op.) that extends from the origin of the ophthalmic artery (not shown because the ICA was divided above the level of origin of the ophthalmic artery) to the origin of the PComA; a communicating segment (C4-Co.) that extends from the origin of the PComA to the origin of the AChA; and a choroidal segment (C4-Ch.) that extends from the origin of the AChA to the level of the bifurcation of the ICA into the anterior cerebral and middle cerebral

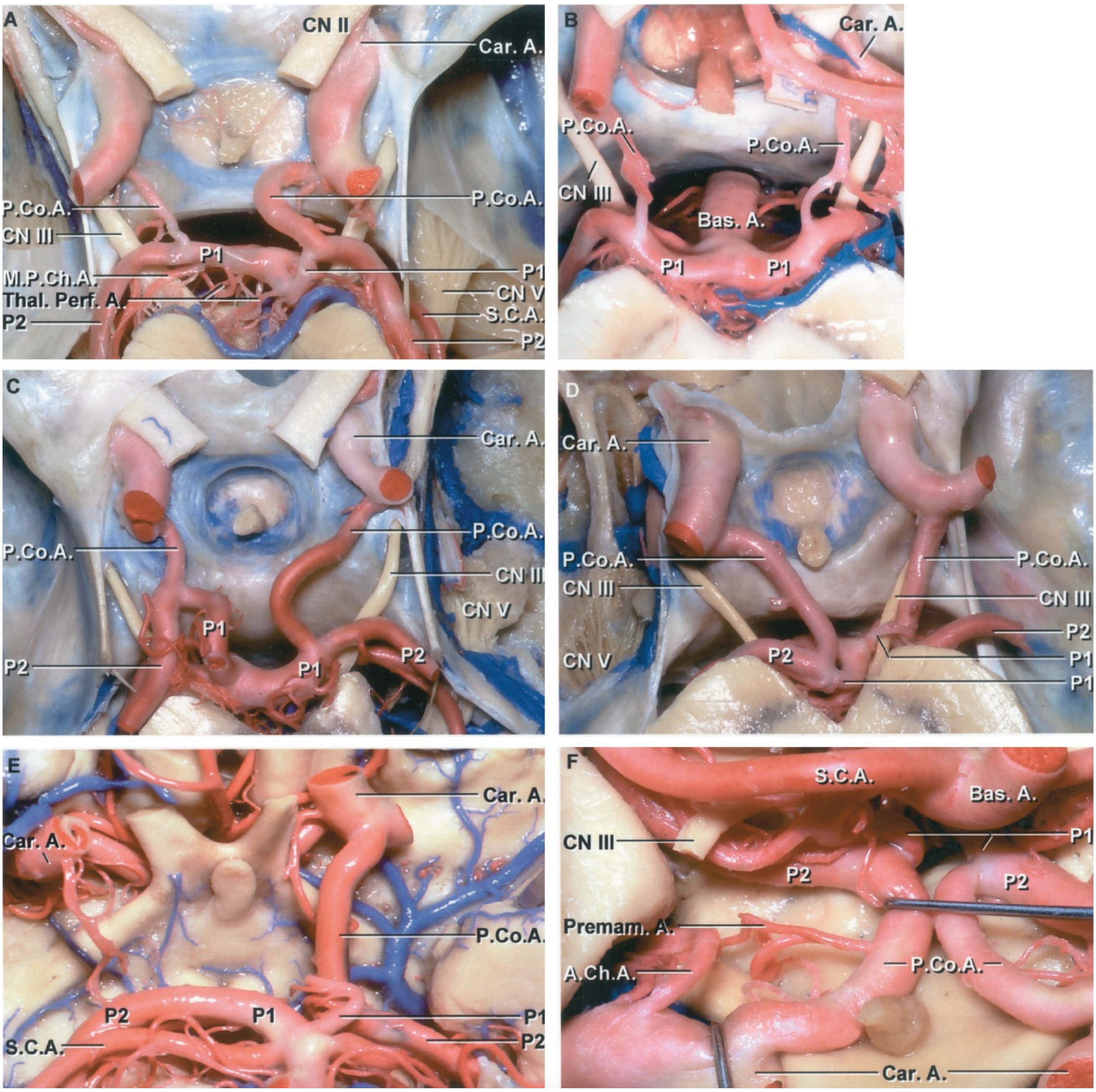
arteries. The ophthalmic segment sends perforating branches to the optic nerves, optic chiasm, and the tuber cinereum. The superior hypophyseal arteries pass to the infundibulum of the hypophysis. The communicating segment sends one perforating branch on each side to the optic tracts and the region around the mamillary bodies. The perforating arteries are as large as the adjacent AChA and PComA. The choroidal segment sends its perforating branches into the anterior perforated substance. The posterior cerebral arteries arise from the basilar artery and pass laterally around the cerebral peduncles. The temporal lobe is lateral to the carotid artery. The frontal lobes, gyrus rectus, and olfactory nerves are above the optic nerves. The thalamoperforating arteries pass posteriorly between the oculomotor nerves. A., artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; Ant., anterior; B.A., basilar artery; Cer.A., cerebral artery; Ch., chiasm, choroidal; Co., communicating; Fr., frontal; Gyr., gyrus; Hyp., hypophyseal; Infund., infundibulum; M.C.A., middle cerebral artery; Mam., mamillary; N., nerve; O., optic; Olf., olfactory; Op., ophthalmic; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Ped., peduncle; Perf., perforated; Subst., substance; Sup., superior; Temp., temporal; Thal. Perf., thalamoperforating; Tr., tract; Tuber Cin., tuber cinereum. (From, Gibo H, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. J Neurosurg 55:560–574, 1981 [15].)



Click here to view the interactive module and related content for this image.

FIGURE 2.7. Orbitozygomatic exposure of the arteries forming the circle of Willis including three variants (D, E, and F) in the size of the PComA. A, the scalp flap has been elevated and the interfascial incision has been completed so that the fat pad containing the branches of the facial nerve to the forehead can be folded downward with the scalp flap. The one-piece orbitozygomatic bone flap is shown in the inset. B, the sylvian fissure has been opened. The M1 bifurcates to form superior and inferior trunks of similar size. The branches forming the M2 begin at the limen insula and cross the insula. The branches forming the M3 loop over the

opercular lips, and the M4 branches course on the lateral convexity. C, enlarged view of the carotid bifurcation. The M1 divides into superior and inferior trunks before reaching the limen insula, which is located at the lateral edge of the anterior perforated substance. A large A1 passes medially above the chiasm. D, the exposure has been directed under the temporal lobe. A large PComA of the fetal type provides the majority of flow to the P2 segment. As the PComA increases in size, it tends to shift laterally. The junction of the posterior communicating and P2 is situated medial to the oculomotor nerve. The tentorial edge has been depressed to expose the superior cerebellar artery. E, another subtemporal exposure showing a configuration in which the P1 and PComA are of approximately equal size. F, exposure oriented like C, showing a small PComA with the predominant P2 origin being from the P1. A., artery; A.Ch.A., anterior choroidal artery; Bas., basilar; Bifurc., bifurcation; Car., carotid; Clin., clinoid; CN, cranial nerve; Front., frontal; Inf., inferior; M., muscle; P.Co.A., posterior communicating artery; Post., posterior; S.C.A., superior cerebellar artery; Sup., superior; Temp., temporal, temporalis; Tent., tentorial; Tr., trunk; V., vein.



Click here to view the interactive module and related content for this image.

FIGURE 2.8. Variations in the posterior circle of Willis include differing lengths and diameters of the PComAs or P1s. A, superior view. The left PComA is hypoplastic and the right is larger than its corresponding P1. The left PComA is straight and short and the right is long and convex medially. The right P2 segment is a direct continuation of the PComA. An MPChA courses medial to the left P2. Thalamoperforating branches arise at the basilar bifurcation. B, both P1s arise predominantly from the basilar artery. The hypoplastic PComAs course above and medial to the oculomotor nerves. C, the right PComA and P1 are of approximately

equal size, and the junction of the PComA and the P2 is sharply angulated. The left P1 is directed anterior before joining the junction of the P2 and the PComA. The right PComA is much longer than the left. D, the right P1 arises predominantly from the PComA. The right P1 segment is small and short, being only long enough to reach above the oculomotor nerve. The left PComA and P1 are of approximately equal size, but the left P1 is short. The junction of the PComAs and the P2s are sharply angulated on both sides. E, inferior view. The left P1 is hypoplastic and the left P2 arises mainly from the PComA. The right PCA arises predominantly from the basilar artery. F, large tortuous PComAs almost touch in the midline. The P2s arise predominantly from the large PComAs, which are larger than the P1 segments. Premamillary perforating branches of the PComA arise on both sides. A., artery; A.Ch.A., anterior choroidal artery; Bas., basilar; Car., carotid; CN, cranial nerve; M.P.Ch.A., medial posterior choroidal artery; P.Co.A., posterior communicating artery; Premam., premamillary; S.C.A., superior cerebellar artery; Thal. Perf., thalamoperforating.

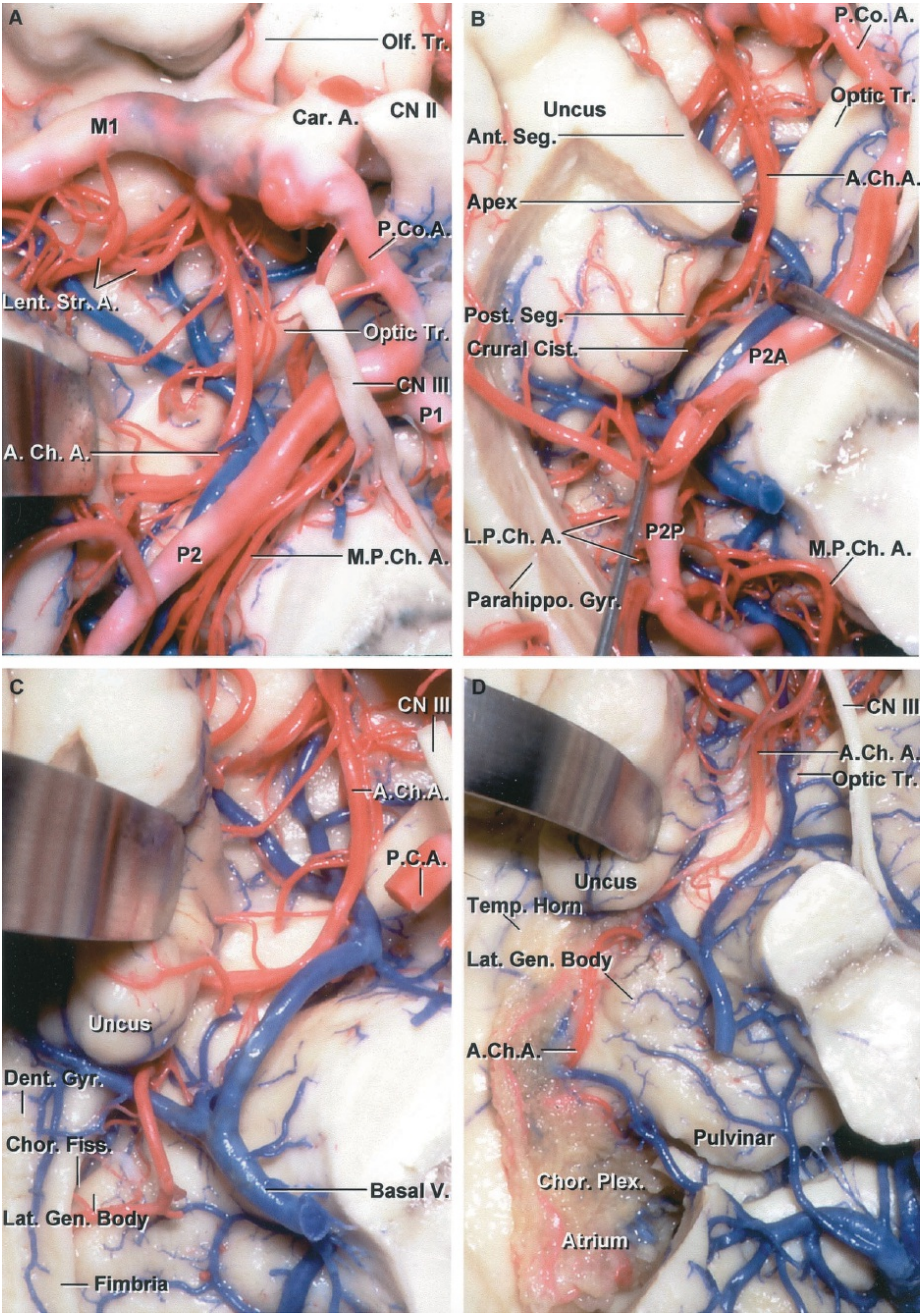
PComA Branches

An average of 8 (range, 4–14) perforating branches arise from the PComA, mostly from the superior and lateral surfaces, and course superiorly to penetrate, in decreasing order of frequency, the tuber cinereum and premamillary part of the floor of the third ventricle, the posterior perforated substance and interpeduncular fossa, the optic tract, the pituitary stalk, and the optic chiasm, to reach the thalamus, hypothalamus, subthalamus, and internal capsule (37). Branch origins are distributed relatively evenly along the course of the artery, with the anterior half having slightly more branches than the posterior half.

The premamillary artery is the largest branch that arises from the PComA. It enters the floor of the third ventricle in front of or beside the mamillary body between the mamillary body and optic tract (Fig. 2.3). There are commonly two or three branches terminating in the premamillary area, but only the largest branch is referred to as the premamillary artery. The premamillary artery has also been referred to as the anterior thalamoperforating artery. The premamillary artery most commonly originates on the middle third of the communicating artery, but can also arise on the anterior or posterior third. It supplies the posterior hypothalamus, anterior thalamus, posterior limb of the internal capsule, and subthalamus. The anterior group of PComA perforating branches supplies the hypothalamus, ventral thalamus, anterior third of the optic tract, and posterior limb of the internal capsule; the posterior group reaches the posterior perforated substance and subthalamic nucleus. Occlusion of the branches to the subthalamic nucleus leads to contralateral hemiballism.

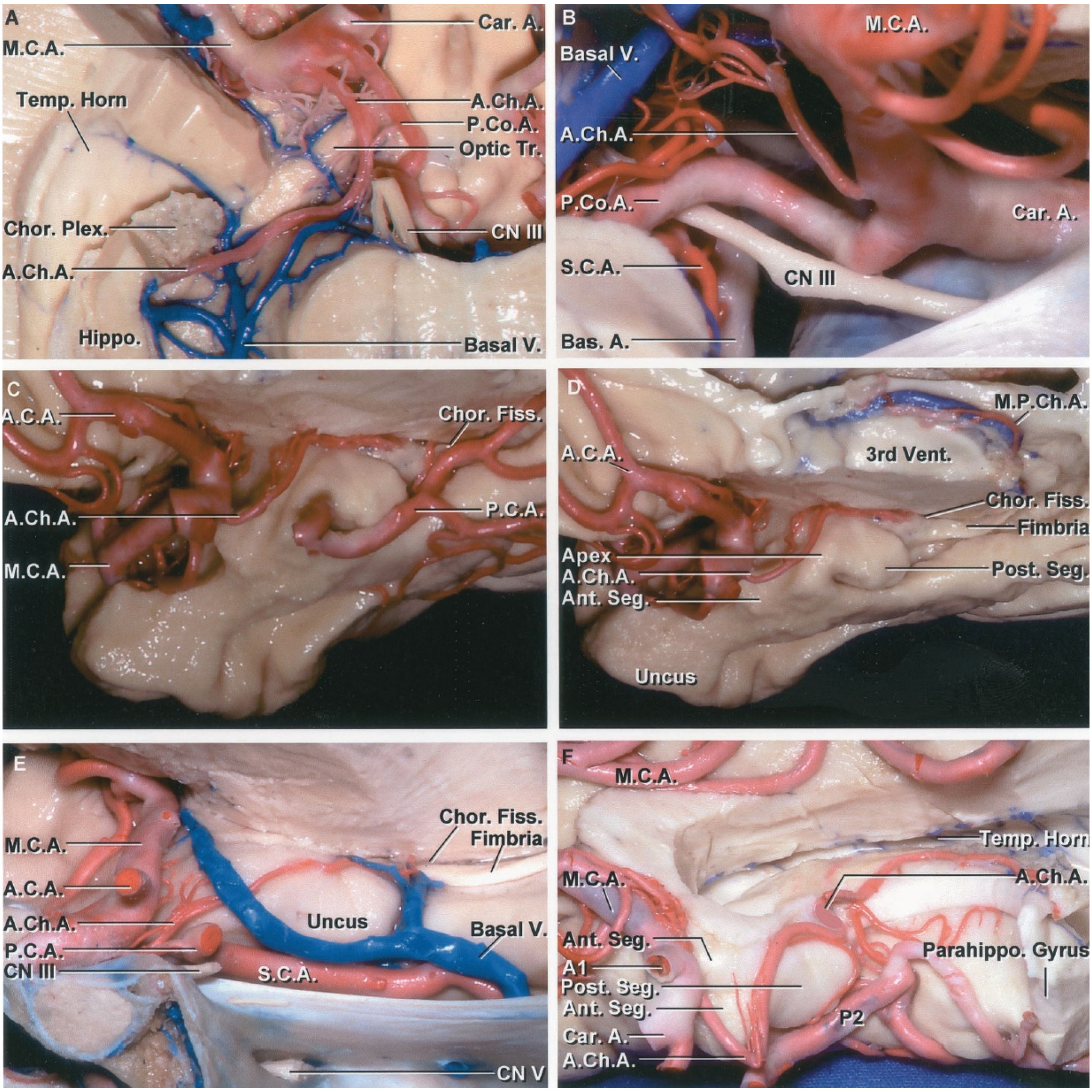
Anterior Choroidal Artery

The AChA usually arises from the C4 as a single artery, with the majority arising nearer the origin of the PComA than to the carotid bifurcation (Figs. 2.1, 2.9, and 2.10). It may infrequently arise from the C4 as two separate arteries or as a single artery that divides immediately into two trunks (47% of hemispheres) (33, 37). Infrequent origins, occurring in less than 1%, include the MCA and PComA. Its origin is similar in diameter to that of the ophthalmic artery, but smaller than tthose of the PComA, unless the PComA is small or hypoplastic. The origin of a fetal-type PComA may be more than twice the diameter of the AChA. The AChA is the first branch on the C4 distal to the PComA in two-thirds of hemispheres and the second, third, or even the fourth branch after one or more perforating branches, in descending order of frequency, in the remainder. The perforating branches arising between the PComA and AChA most commonly terminate in the optic tract, medial temporal lobe, and posterior perforated substance.



Click here to view the interactive module and related content for this image.

FIGURE 2.9. Anterior choroidal artery. Inferior views. A, the right AChA arises from the posterior wall of the ICA above the origin of the PComA and passes backward below the optic tract and lateral to the PCA. It ascends around the medial surface of the uncus as it travels posteriorly. B, the medial part of the parahippocampal gyrus has been removed. The AChA courses backward medial to the anterior segment of the uncus to reach the uncal apex located at the junction of the anterior and posterior uncal segments where it turns laterally along the upper margin of the posterior uncal segment to reach the choroidal fissure. C, the posterior uncal segment has been retracted. The AChA passes above the posterior uncal segment and enters the temporal horn by passing through the choroidal fissure located between the thalamus above and fimbria of the fornix below. The lateral geniculate body forms the part of the thalamus above where the artery enters the choroidal fissure. The dentate gyrus is located at the lower edge of the fimbria. D, the floor of the temporal horn and the fimbria have been removed to expose the AChA entering the choroid plexus of the temporal horn by passing through the choroidal fissure just behind the posterior segment of the uncus. The lower end of the choroidal fissure and the site where the artery passes through the fissure are called the inferior choroidal point. A., arteries, artery; A.Ch.A., anterior choroidal artery; Ant., anterior; Car., carotid; Chor., choroid, choroidal; Cist., cistern; CN, cranial nerve; Dent., dentate; Fiss., fissure; Gen., geniculate; Gyr., gyrus; L.P.Ch.A., lateral posterior choroidal artery; Lat., lateral; Lent. Str., lenticulostriate; M.P.Ch.A., medial posterior choroidal artery; Olf., olfactory; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Parahippo., parahippocampal; Plex., plexus; Post., posterior; Seg., segment; Temp., temporal; Tr., tract; V., vein.



Click here to view the interactive module and related content for this image.

FIGURE 2.10. Anterior choroidal artery. A, inferior view. The lower part of the right temporal pole has been removed to expose the AChA, which passes backward to reach the medial side of the optic tract where it turns laterally, passing again below the optic tract and around the uncus to enter the temporal horn. B, lateral view. The right AChA arises above the origin of the PComA and passes upward and backward around the uncus to reach the temporal horn. C, medial side of the right uncus. The AChA passes around the medial aspect of the uncus to reach the lower end of the choroidal fissure where it enters the temporal horn. The PCA courses

along the posterior aspect of the uncus. D, the PCA has been removed. The AChA ascends along the anterior segment of the uncus to reach the uncal apex where it turns laterally above the posterior uncal segment to enter the inferior choroidal point at the lower end of the choroidal fissure located just behind the posterior uncal segment and the head of the hippocampus. The anterior uncal segment contains the amygdala and the posterior segment is formed predominantly by the head of the hippocampus. E, medial view of the right AChA in another specimen. The cross section extends through the midline of the sella. The view is directed laterally over the top of the sella to the medial aspect of the internal carotid artery, uncus, and the origin of the AChA. The AChA passes around the uncus to reach the lower end of the choroidal fissure. F, medial view of another temporal lobe. The AChA pursues an angulated course, descending along the anterior segment of the uncus, but at the uncal apex it turns sharply upward, reaching the upper part of the posterior uncal segment before entering the temporal horn. A., artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; Ant., anterior; Bas., basilar; Car., carotid; Chor., choroid, choroidal; CN, cranial nerve; Fiss., fissure; Hippo., hippocampus; M.C.A., middle cerebral artery; M.P.Ch.A., medial posterior choroidal artery; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Parahippo., parahippocampal; Plex., plexus; Post., posterior; S.C.A., superior cerebellar artery; Temp., temporal; seg., segment; Tr., tract; V., vein; Vent., ventricle.

Course

The initial segment of the AChA is directed posteromedial behind the internal carotid artery. On the anteroposterior angiogram, the initial segment of the AChA is seen medial to the internal carotid artery. The origin of the artery is lateral to the optic tract, but the initial segment crosses from the lateral to the medial side of the optic tract in many hemispheres, only infrequently remaining lateral to the optic tract throughout its course. It passes below or along the medial side of the optic tract to reach the lateral margin of the cerebral peduncle. The average length that the artery follows the optic tract is 12 mm (range, 5–

25 mm) (33). At the anterior margin of the lateral geniculate body, the AChA again crosses the optic tract from medial to lateral and passes posterolateral through the crural cistern, located between the cerebral peduncle and uncus, to arrive superomedial to the uncus, where it passes through the choroidal fissure to enter the choroid plexus within the temporal horn. It courses along the medial border of the choroid plexus in close relation to the lateral posterior choroidal branches of the PCA. In some cases, it can pass dorsally along the medial border of the plexus, reaching the foramen of Monro.

Segments

The artery is divided into cisternal and plexal segments (33). The cisternal segment extends from the origin to the choroidal fissure and is divided at the anterior margin of the lateral geniculate body into a proximal and distal portion. The plexal segment is composed of one or more branches that pass through the choroidal fissure to branch and enter the choroid plexus of the temporal horn. The length from its origin to its passage through the choroidal fissure averages 2.4 cm (range, 20–34 mm). If there is a double artery, the distal branch usually terminates in the temporal lobe and the proximal branch nourishes the remaining anterior choroidal field.

Branches

The branches, which average 9 (range, 4–18), are divided on the basis of whether they arise from the cisternal or plexal segment. The branches from the cisternal segment penetrate, in decreasing order of frequency, the optic tract, uncus, cerebral peduncle, temporal horn, lateral geniculate body, hippocampus, dentate gyrus and fornix, and anterior perforated substance. These branches more commonly supply the optic tract, lateral part of the geniculate body, posterior two-thirds of the posterior limb of the internal capsule, most of the globus pallidus, the origin of the optic radiations, and the middle third of the cerebral peduncle. Less commonly supplied structures include part of the head of the caudate nucleus, pyriform cortex, the uncus, posteromedial part of the amygdaloid nucleus, substantia nigra, red nucleus, subthalamic nucleus, and the superficial aspect of the ventrolateral nucleus of the thalamus (1). None of these structures is always supplied by the artery, but, in approximately two-thirds of the hemispheres, it supplies the medial part of the globus pallidus, the posterior limb and retrolenticular part of the internal capsule, the optic tract and the lateral geniculate body. No structure other than the choroid plexus of the temporal horn received branches in every case. In approximately half of the hemispheres, it supplies the lateral part of the globus pallidus and the caudate tail; in one-third, it supplies the thalamus, hypothalamus, and subthalamus.

There is a marked interchangeability of the field of supply of the AChA and the nearby branches of the C4, PCA, PComA, and MCA. The C4 frequently gives rise to small arteries distributed to the areas commonly supplied by the proximal branches of the AChA. These arteries, as many as four, arising from the posterior wall of the carotid artery between the PComA and AChA, also frequently terminate, in decreasing order of frequency, in the optic tract, anterior perforated substance, uncus, hypothalamus, pituitary stalk, and cerebral peduncle (37).

Another example of the interchangeability of field occurs within the internal capsule. If the PComA is small, the anterior choroidal artery may take over its normal area of supply to the genu and the anterior third of the internal capsule, or if the AChA is small, the field of supply of the PComA may enlarge to supply the greater part of the posterior limb of the internal capsule (1). Such inverse relationships, in which one artery's field of supply enlarges as the other's contracts, occur between the PCA and AChA in the supply to the cerebral peduncle, substantia nigra, red nucleus, subthalamic nucleus, optic tract, and lateral geniculate body. A large AChA is usually associated with a small PComA on that side.

The plexal segment, in most cases, originates as a single branch of the AChA, which passes through the choroidal fissure. Additional smaller branches to the choroid plexus may arise proximal to the choroidal fissure. These plexal branches divide and enter the medial border of the choroid plexus of the temporal horn to course in close relation to and frequently anastomose with branches of the lateral posterior choroidal arteries. Some branches of the AChA pass posteriorly into the choroid plexus in the atrium and then forward above the thalamus to supply the choroid plexus of the body as far forward as the foramen of Monro.

Nearly half of hemispheres have anastomoses between the PCA and AChA. The richest anastomoses are those located on the surface of the choroid plexus with the lateral posterior choroidal branches of the PCA. Anastomoses between the AChA and PCA are also found on the lateral surface of the lateral geniculate body and on the temporal lobe near the uncus. These complex and variable anastomoses make it difficult to predict the effects of occlusion of a single AChA, but explain some of the inconsistent results of AChA occlusion.

Clinical Features

The classic reported clinical features of occlusion of the AChA are contralateral hemiplegia, hemianesthesia, and hemianopsia (1, 11). The contralateral hemiplegia and hemianesthesia (to all sensory modalities) results from infarction in the posterior two-thirds of the posterior limb of the internal capsule and the middle third of the cerebral peduncle. The homonomous hemianopsia of varying degrees results from interruption of the supply to the origin of the optic radiations, the optic tract, and part of the lateral geniculate body. Infarction found in the globus pallidus seems to produce no symptoms.

Inconstant results, including absence of deficit, have followed surgical occlusion for the treatment of Parkinson's disease (5, 28). In 1952, while performing a pedunculotomy on a patient incapacitated with Parkinsonism, Coopers tore and had to clip the AChA (4, 5). The operation was terminated without cutting the peduncle. Postoperatively, there was disappearance of tremor and rigidity from the involved extremities, with preservation of voluntary motor function. This beneficial effect was presumed to be caused by ischemic necrosis of the globus pallidus. This represented a case of known occlusion of the AChA with none of the classic symptoms. The sparing of motor function was presumed to be caused by anastomosis over the lateral geniculate body and in the choroid plexus, which provided a collateral source for the capsular branches.

Surgical occlusions were then made by Cooper and his associates in 50 patients with Parkinsonism (4, 5). Each artery was clipped twice: once at its origin and once 1.5 cm from the origin, just distal to the pallidal branches. This distal clip was applied to prevent retrograde filling into the pallidal branches through the anastomosis in the choroid plexus. This was

thought to isolate the pallidum and its efferent fiber tracts from their normal antegrade blood supply and from retrograde supply through anastomosis with the lateral posterior choroidal and other arteries. At the same time, it allowed the more distal structures, such as the internal capsule, the benefit of this retrograde collateral circulation. Cooper reported good relief of tremor and rigidity, a 20% morbidity, and 6% mortality in this group. Postoperative complications included a hemiplegia in three patients, a partial aphasia in one, and a homonymous quadrantanopsia in one. Twelve patients studied in detail had no visual defects. Several patients developed a memory loss and became confused, and it was not uncommon for the patients to remain somnolent for 1 to 10 days. Cooper assumed that collateral circulation spared the corticospinal fibers and the optic radiations, while failing to preserve the pallidum and / or its efferent fibers.

Rand et al. (28) later reported the results of occlusion of six arteries in five cases. Although finding no therapeutic value of AChA occlusion, these authors agreed that the artery could be occluded with little resultant damage. In four patients there was no effect on the Parkinsonism and no neurological deficit after the occlusion, but the fifth patient developed a contralateral

hemiparesis after occlusion of the artery. A homonymous visual field defect occurred in two patients. In two cases, in which the brain became available for pathological examination, small and inconstant lesions were found within the areas supplied by the artery. The inconstant symptoms and infarction after AChA occlusion are attributed to collateral circulation through anastomoses with adjacent arteries and variations in the area of supply of the artery.

Middle Cerebral Artery

The MCA is the largest and most complex of the cerebral arteries. Some of its branches are exposed in most operations in the supratentorial area, whether the approach is to the cerebral convexity, parasagittal region, or along the cranial base (Figs. 2.1, 2.3, and 2.7). In the past, surgical interest in the MCA has been directed at avoiding damage to its branches during operations within its territory, but micro-operative techniques have now made reconstruction of and bypass to the MCA an important method of preserving and restoring blood flow to the cerebrum.

The MCA arises as the larger of the two terminal branches of the internal carotid artery. The diameter of the MCA at its origin ranges from 2.4 to 4.6 mm (average, 3.9 mm), roughly twice that of the anterior cerebral artery. Its origin is at the medial end of the sylvian fissure, lateral to the optic chiasm, below the anterior perforated substance, and posterior to the division of the olfactory tract into the medial and lateral olfactory striae. From its origin, it courses laterally below the anterior perforated substance and parallel, but roughly 1 cm posterior, to the sphenoid ridge. As it passes below the anterior perforated substance, it gives rise to a series of perforating branches referred to as lenticulostriate arteries. It divides within the sylvian fissure and turns sharply posterosuperiorly at a curve, the genu, to reach the surface of the insula. At the periphery of the insula, the branches pass to the medial surface of the opercula of the frontal, temporal, and parietal lobes. Its branches pass around the opercula to reach the cortical surface and supply most of the lateral surface and some of the basal surface of the cerebral hemisphere.

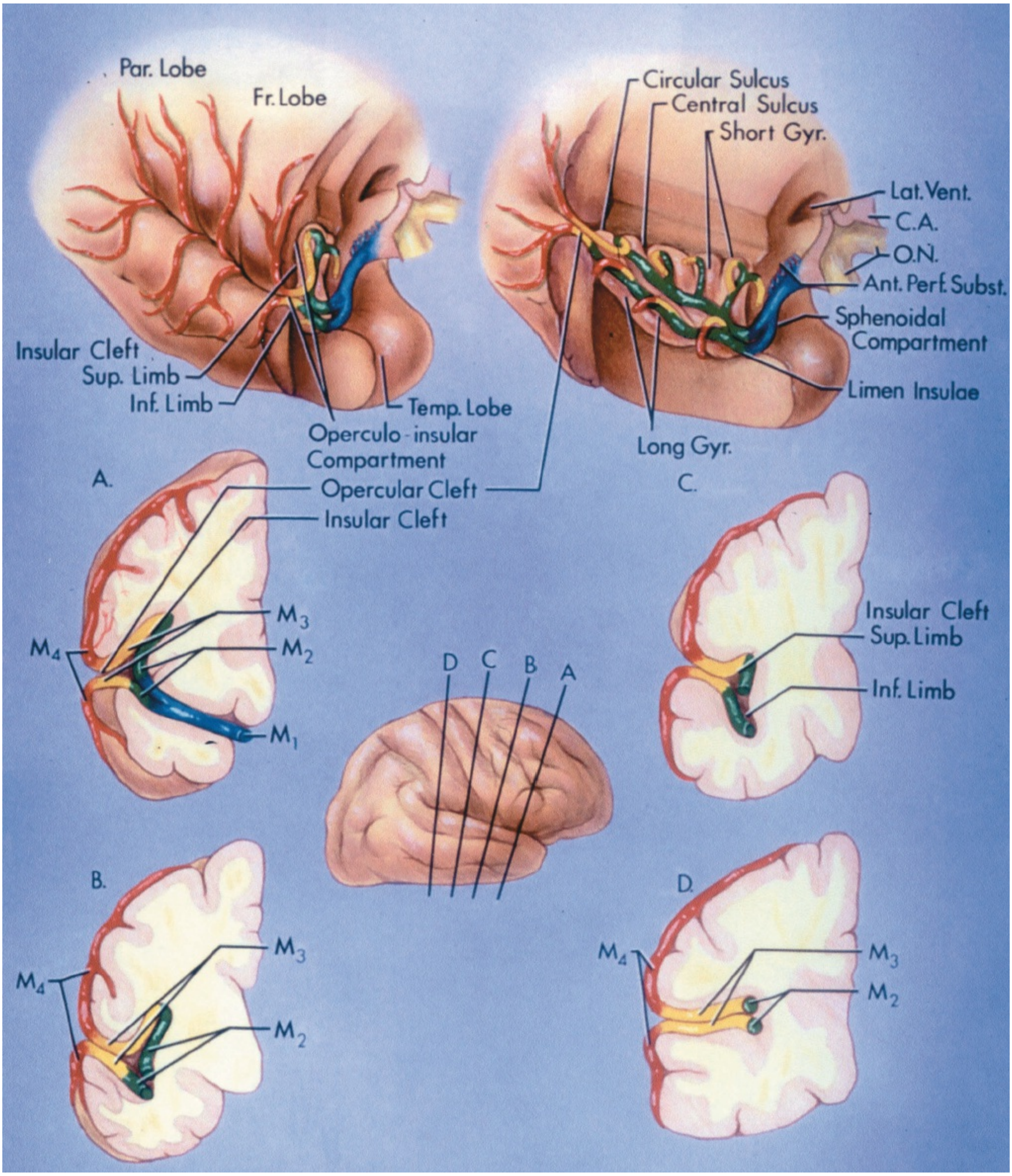
Segments

The MCA is divided into four segments: MI (sphenoidal), M2 (insular), M3 (opercular), and M4 (cortical) (Figs. 2.11– 2.14). The M1 begins at the origin of the MCA and extends laterally within the depths of the sylvian fissure. It courses laterally, roughly parallel to and approximately 1 cm (range, 4.3–19.5 mm) posterior to the sphenoid ridge in the sphenoidal compartment of the sylvian fissure. This segment terminates at the site of a 90-degree turn, the genu, located at the junction of the sphenoidal and operculoinsular compartments of the sylvian fissure. The M1 is subdivided into a prebifurcation and postbifurcation part. The prebifurcation segment is composed of a single main trunk that extends from the origin to the bifurcation. The postbifurcation trunks of the M1 segment run in a nearly parallel course, diverging only minimally before reaching the genu. This bifurcation occurs proximal to the genu in nearly 90% of hemispheres (14). The small cortical branches arising from the main trunk proximal to the bifurcation are referred to as early branches.

The M2 segment includes the trunks that lie on and supply the insula (Fig. 2.15). This segment begins at the genu where the MCA trunks passes over the limen insulae and terminates at the circular sulcus of the insula. The greatest branching of the MCA occurs distal to the genu as these trunks cross the anterior part of the insula. The branches passing to the anterior cortical areas have a shorter path across the insula than those reaching the posterior cortical areas. The branches to the anterior frontal and anterior temporal areas cross only the anterior part of the insula, but the branches supplying the posterior cortical areas course in a nearly parallel but diverging path across the length of the insula. The frontal branches cross only the short gyri before leaving the insular surface, whereas the branches supplying the posterior parietal or angular regions pass across the short gyri, the central sulcus, and the long gyri of the insula before leaving the insular surface.

The M3 segment begins at the circular sulcus of the insula and ends at the surface of the sylvian fissure. The branches forming the M3 segment closely adhere to and course over the surface of the frontoparietal and temporal opercula to reach the superficial part of the sylvian fissure. The branches directed to the brain above the sylvian fissure undergo two 180-degree turns. The first turn is located at the circular sulcus, where the vessels coursing upward over the insular surface turn 180 degrees and pass downward over the medial surface of the frontoparietal operculum. The second 180-degree turn is located at the external surface of the sylvian fissure, where the branches complete their passage around the inferior margin of the frontoparietal operculum and turn in a superior direction on the lateral surface of the frontal and parietal lobes. The arteries supplying the cortical areas below the sylvian fissure pursue a less tortuous course. These branches, on reaching the circular sulcus, run along its inferior circumference before turning upward and laterally on the medial surface of the temporal operculum, thus producing a less acute change in course at the inferior margin of the circular sulcus. On reaching the external surface of the sylvian fissure, these branches are directed downward and backward on the surface of the temporal lobe.

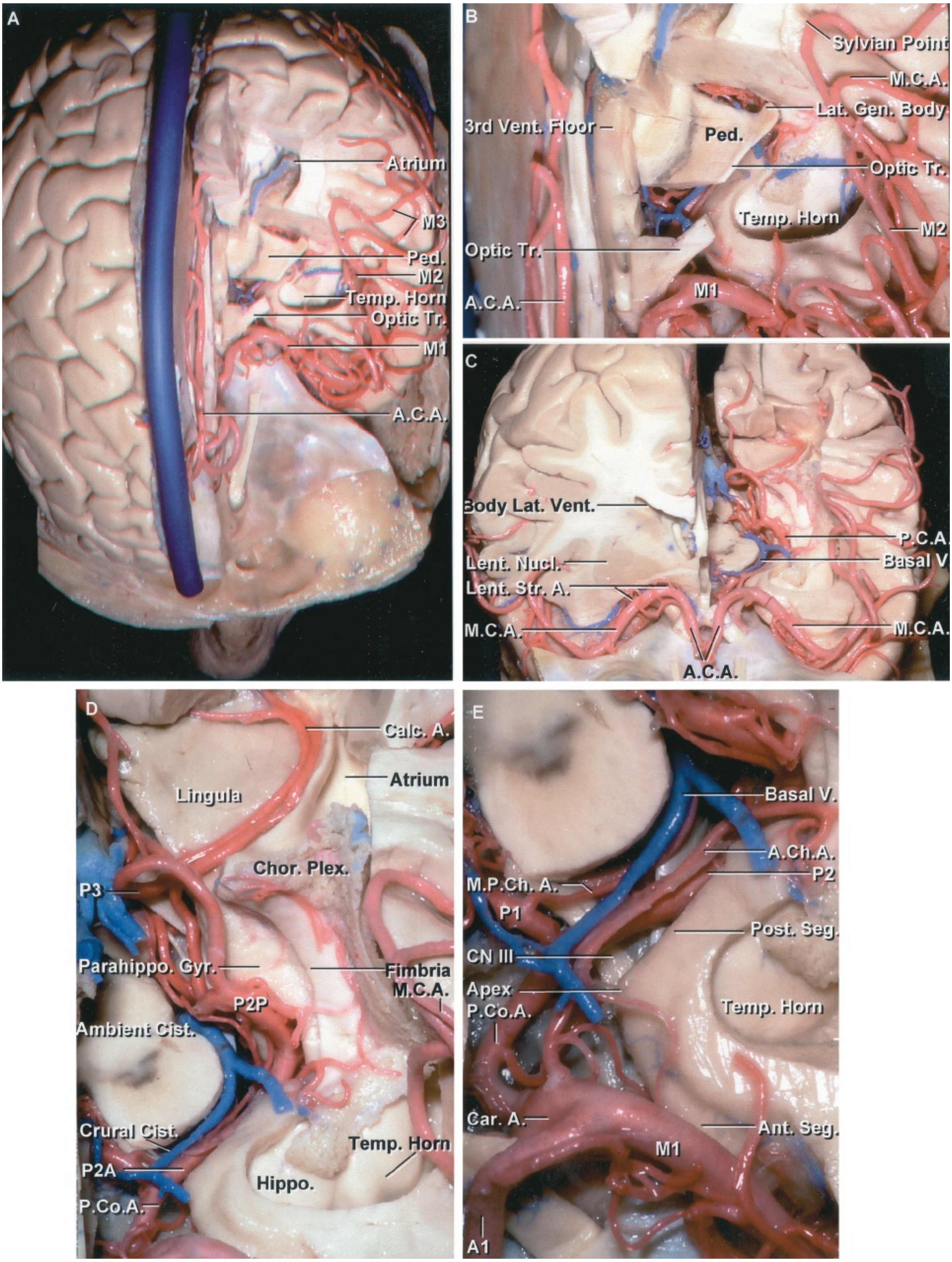
The M4 is composed of the branches to the lateral convexity. They begin at the surface of the sylvian fissure and extend over the cortical surface of the cerebral hemisphere. The more anterior branches turn sharply upward or downward after leaving the sylvian fissure. The intermediate branches follow a gradual posterior incline away from the fissure, and the posterior branches pass backward in nearly the same direction as the long axis of the fissure.



Click here to view the interactive module and related content for this image.

FIGURE 2.11. Relationship of the M1 (blue), M2 (green), M3 (yellow), and M4 (red) segments of the middle cerebral arteries to the insula and sylvian fissure. Upper left and right, superolateral views of the right cerebral hemisphere with the anterior half of the frontal lobe and part of the frontoparietal and temporal opercula removed. Upper left, the

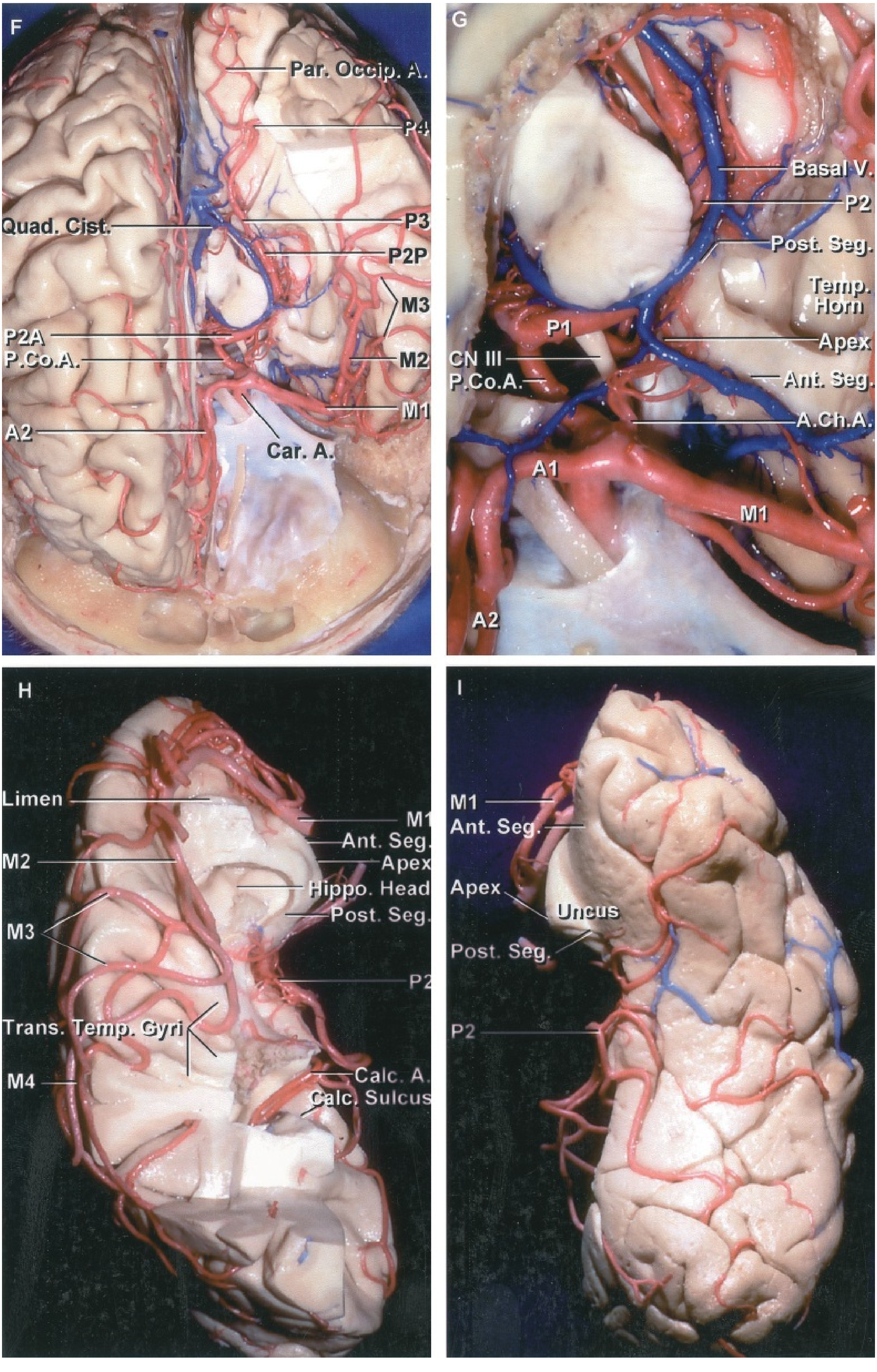
removal exposes the anterior quarter of the insula. Upper right, the removal exposes the whole surface of the insula. The sylvian fissure is divided into sphenoidal and operculoinsular compartments. The sphenoidal compartment, in which the M1 segment courses, is located posterior to the sphenoid ridge. The M2 and M3 segments course in the operculoinsular compartment of the sylvian fissure. The operculoinsular compartment is divided into an insular and an opercular cleft. The opercular cleft is located between the frontoparietal and the temporal opercula. The insular cleft is located between the insula and the opercula. The insular cleft is divided into a superior limb, located medial to the frontoparietal operculum, and an inferior limb, located medial to the temporal operculum. The circular sulcus is located at the periphery of the insula. The short gyri of the insula are located above the central sulcus of the insula and the long gyri are located below. The carotid arteries and anterior perforated substance are at the medial end of the sylvian fissure. The lateral ventricles are above the optic nerves. A–D, anterior views of coronal sections of the right cerebral hemisphere. The central diagram shows the level of the sections. A, coronal section at the level of the M1 segment. The M1 segment courses in the sphenoidal compartment, the M2 segment courses on the insulae, the M3 segment passes over the deep surface of the opercula, and the M4 segment courses on the cortical surface. At this anterior level, the frontal operculum covers more of the insula than the temporal operculum. B, coronal section at the midportion of the sylvian fissure where the frontal and temporal opercula are of nearly equal height. C, coronal section at a more posterior level where the temporal operculum covers more of the insula than does the frontoparietal operculum. D, coronal section from the posterior end of the sylvian fissure. Only the opercular cleft remains; the insular cleft has disappeared. Ant., anterior; C.A., carotid artery; Fr., frontal; Gyr., gyri; Inf., inferior; Lat., lateral; N., nerve; O., optic; Par., parietal; Perf., perforated; Subst., substance; Sup., superior; Temp., temporal; Vent., ventricle. (From, Gibo H, Carver CC, Rhoton AL Jr, Lenkey C, Mitchell RJ: Microsurgical anatomy of the middle cerebral artery. J Neurosurg 54:151–169, 1981 [14].)



Click here to view the interactive module and related content for this image.

FIGURE 2.12 A-E. Cerebral arteries, superior view. A, the upper part of the left hemisphere has been removed to expose the atrium and

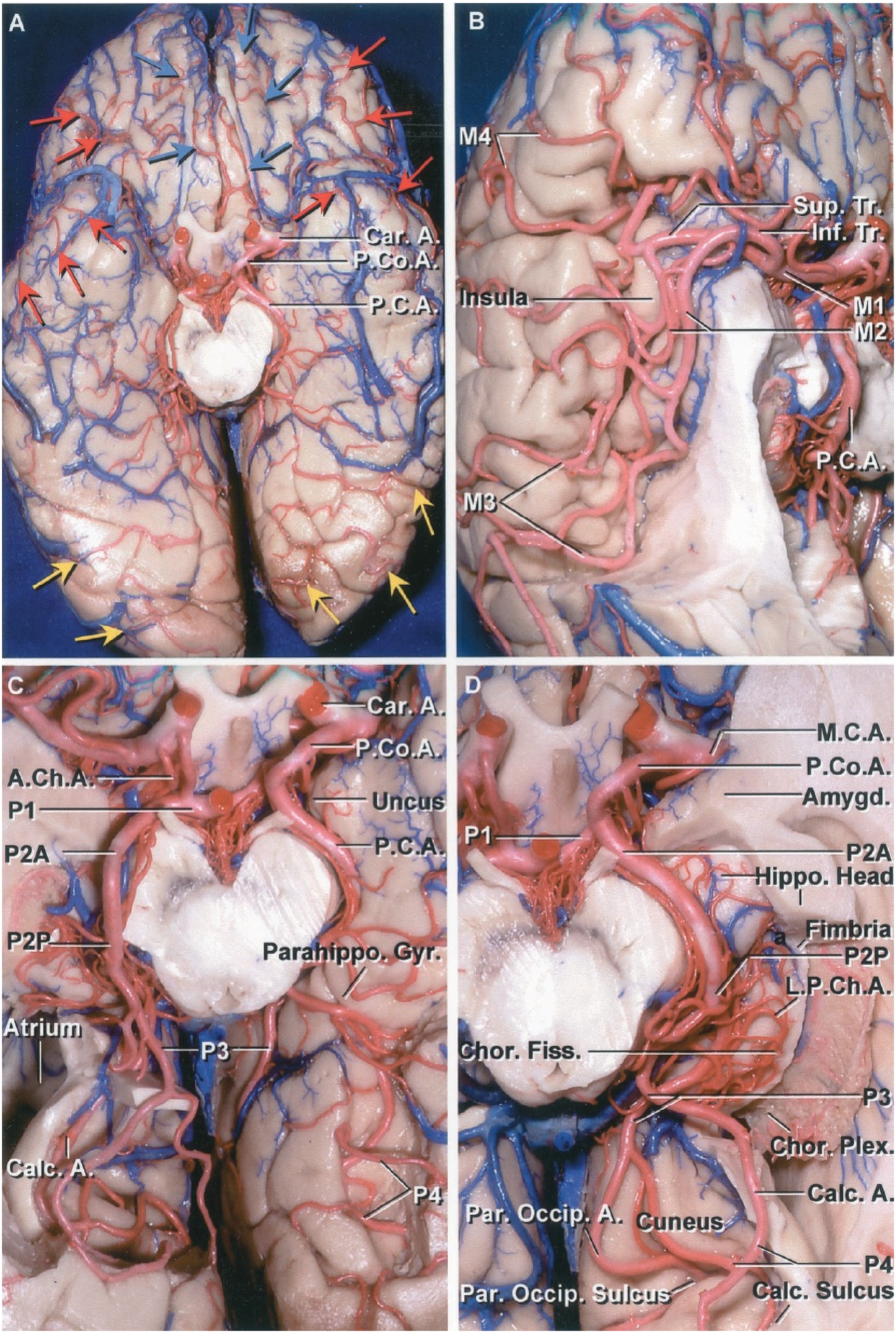
temporal horn. Part of the optic tract and cerebral peduncle has been preserved. The ACA crosses above the chiasm and along the medial surface of the hemisphere. The MCA passes laterally below the anterior perforated substance and turns posteriorly in the depths of the sylvian fissure on the medial side of the opercular lips. The M1 segment courses below the anterior perforated substance and ends at the limen insula, the M2 segment crosses the insular, the M3 crosses the opercular lips, and the M4 branches course on the lateral convexity. B, enlarged view. The initial segment of the optic tract has been preserved. The MCA courses laterally in the area above and anterior to the temporal pole and turns posteriorly in the sylvian fissure. The sylvian point, the site at which the last MCA turns away from the insula, coincides with the point where the most posterior of the transverse temporal gyri intersect the insula. The PCA is hidden below the optic tract and cerebral peduncle. C, the anterior part of the right hemisphere has been removed to show the symmetry of the MCAs. Lenticulostriate arteries are exposed below the lentiform nucleus. The upper part of the left cerebral peduncle and optic tract has been removed to expose the PCA and basal veins in the crural and ambient cisterns. D, enlarged view. The P2 arises at the level of the PComA and passes around the brainstem. The anterior part of the P2, the part that passes through the crural cistern, is designated the P2A, or crural segment, and the posterior part that courses in the ambient cistern is designated the P2P, or ambient segment. The P3 is located in the quadrigeminal cistern and the P4 segment consists of the cortical branches. The calcarine branch courses deeply within the calcarine sulcus, roofed above by the cuneus, which has been removed to exposed the floor of the calcarine sulcus formed by the lingula. The calcarine branch courses adjacent to the calcar avis, which is the prominence in the medial wall of the atrium formed by the deep end of the calcarine sulcus. E, enlarged view. The AChA courses around the anterior and posterior uncal segments and the uncal apex to reach the temporal horn just behind the posterior uncal segment. The PComA courses below and medial to the AChA and joins the P1 at the anterior edge of the crural cistern.



F
Par. Occip. A.
P4
Quad. Cist.
P3
P2P
M3
P2A
P.Co.A.
M2
M1
A2
Car. A.
G
Basal V.
P2
Post. Seg.
Temp. Horn
P1
Apex
CN III
P.Co.A.
Ant. Seg.
A.Ch.A.
A1
M1
A2
H
Limen
M1
Ant. Seg.
M2
Apex
Hippo. Head
M3
Post. Seg.
P2
Trans. Temp. Gyri
M4
Calc. A.
Calc. Sulcus
I
M1
Ant. Seg.
Apex
Uncus
Post. Seg.
P2

Click here to view the interactive module and related content for this image.

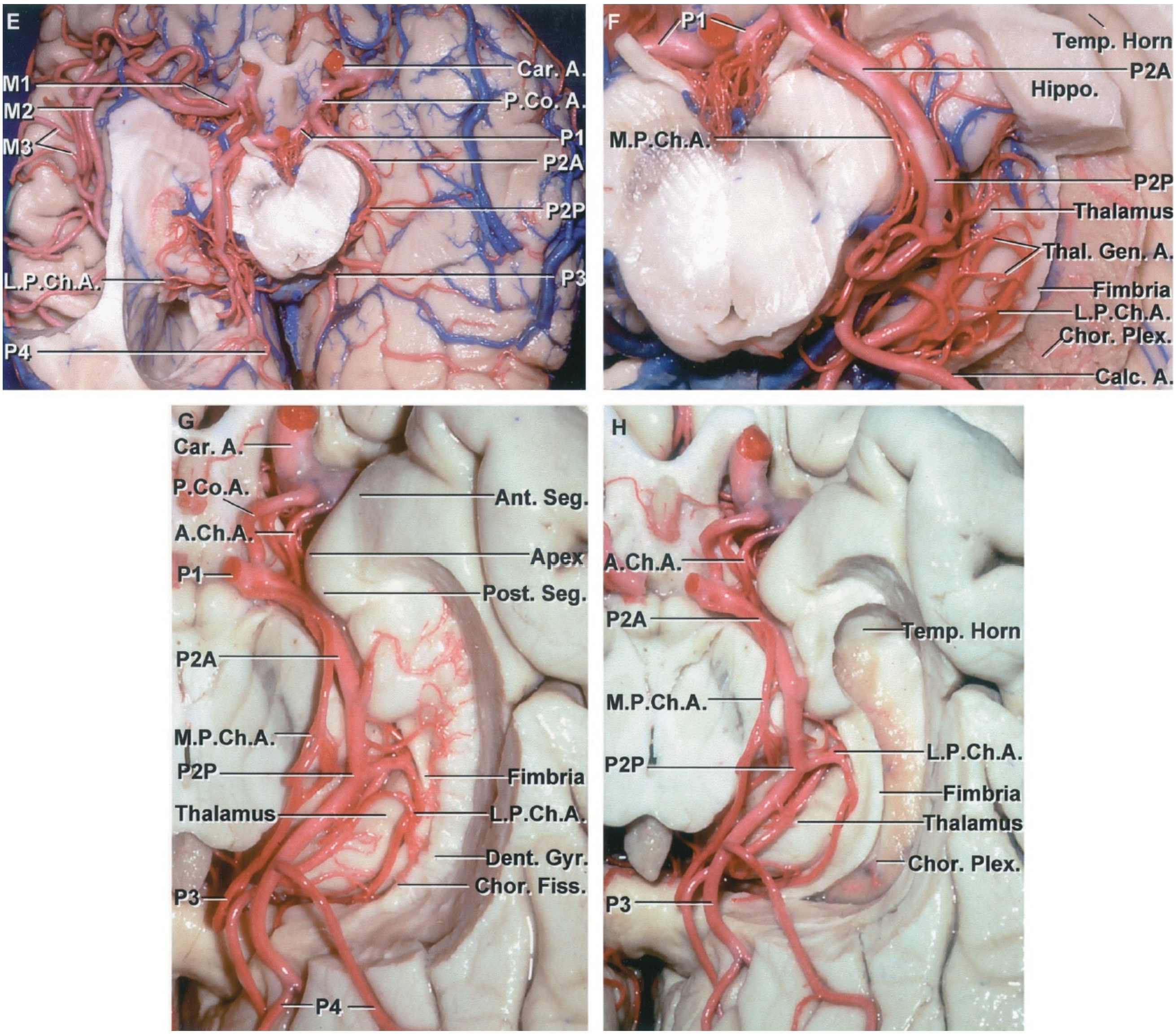
FIGURE 2.12 F-I. F, another specimen in which the anterior portion of the hemisphere has been removed to expose the temporal horn. The M1, M2, and M3 and the P2A, P2P, P3, and P4 have been exposed. The branches of the PCA pass back to the occipital pole. G, enlarged view. The anterior segment of the uncus faces the carotid, middle cerebral, anterior choroidal, and posterior communicating arteries. The posterior segment of the uncus, which forms the lateral margin of the crural cistern, faces the P2A, the basal terminal part of the AChA and the uncal apex is located lateral to the oculomotor nerve. The basal vein courses above the PCA. H, upper surface of the temporal and occipital lobes. The M1 courses along the stem of the sylvian fissure below the anterior perforated substance. The M2 begins at the limen insula and courses over the surface of the insula. The M3 courses over the opercular lips. The M4 is distributed to the cortical surface. The P2 has been preserved. It courses medial to the posterior segment of the uncus and parahippocampal gyrus and through the crural and ambient cisterns. The calcarine branch courses deep in the calcarine sulcus on the medial side of the atrium. I, inferior surface of the temporal lobe. The P2 branches are distributed to the inferior and the lower part of the lateral surfaces of the temporal and occipital lobes. The M1 courses above the anterior uncal segment. A., arteries, artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; Ant., anterior; Calc., calcarine; Car., carotid; Chor., choroid; Cist., cistern; CN, cranial nerve; Gen., geniculate; Gyr., gyrus; Hippo., hippocampal, hippocampus; Lat., lateral; Lent., lentiform; Lent. Str., lenticulostriate; M.C.A., middle cerebral artery; M.P.Ch.A., medial posterior choroidal artery; Nucl., nucleus; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Par. Occip., parieto-occipital; Parahippo., parahippocampal; Ped., peduncle; Plex., plexus; Post., posterior; Quad., quadrigeminal; Seg., segment; Temp., temporal; Tr., tract; Trans., transverse; V., vein; Vent., ventricle.


A
Car. A.
P.Co.A.
P.C.A.
B
M4
Sup. Tr.
Inf. Tr.
Insula
M1
M2
P.C.A.
M3
C
Car. A.
P.Co.A.
A.Ch.A.
P1
Uncus
P2A
P.C.A.
P2P
Parahippo. Gyr.
Atrium
P3
Calc. A.
P4
D
M.C.A.
P.Co.A.
Amygd.
P1
P2A
Hippo. Head
Fimbria
a
P2P
L.P.Ch.A.
Chor. Fiss.
P3
Chor. Plex.
Calc. A.
Par. Occip. A.
Cuneus
P4
Par. Occip. Sulcus
Calc. Sulcus

Click here to view the interactive module and related content for this image.

FIGURE 2.13 A-D. Arteries of the basal surface. A, inferior view of the basal surface of the frontal, temporal, and occipital lobes. The orbital surface of the frontal lobe is supplied by the ACA and MCA. The branches of the ACA overlap from the interhemispheric fissure onto the adjacent part of the orbital surface of the frontal lobe (blue arrows) and the MCA branches overlap onto the lateral part of the orbital surface (red arrows). Most of the lower surface of the temporal and occipital lobes is supplied by the PCA; however, branches of the MCA overlap onto the basal surface of the temporal pole and adjacent part of the temporal lobe (red arrows). Branches of the PCA (yellow arrows) extend around the occipital pole lower hemispheric margin to reach the lateral surface of the temporal and occipital lobe (yellow arrows). B, the temporal lobe has been removed to expose the M1 bifurcating into superior and inferior trunks below the anterior perforated substance and passing across the insula and the frontoparietal operculi. The superior trunk supplies most of the lateral surface of the frontal lobe and the inferior trunk supplies most of the lateral surface of the parietal and temporal lobe. The M1 courses below the anterior perforated substance, the M2 courses on the insula, the M3 passes around the opercular lips, and the M4 is formed by the cortical branches. C, the PCAs arise in the interpeduncular cistern in front of the brainstem and pass through the crural cistern, located between the uncus and cerebral peduncle, and the ambient cistern, located between the midbrain and parahippocampal gyrus, to reach the quadrigeminal cisterns. The P2 segment courses in the crural and ambient cisterns, the P3 in the quadrigeminal cistern, and the P4 is the cortical segment. The P2 is divided into a P2A that courses in the crural cistern and a P2P that courses in the ambient cistern. The floor of the right atrium and the lower lip of the calcarine sulcus have been removed to expose the calcarine branches of the PCA coursing in the depths of the calcarine sulcus adjacent to the medial atrial wall. The PCA branches in the depths of the calcarine sulcus are separated from the medial wall of the atrium by only the thin layer of cortex and white matter that form the

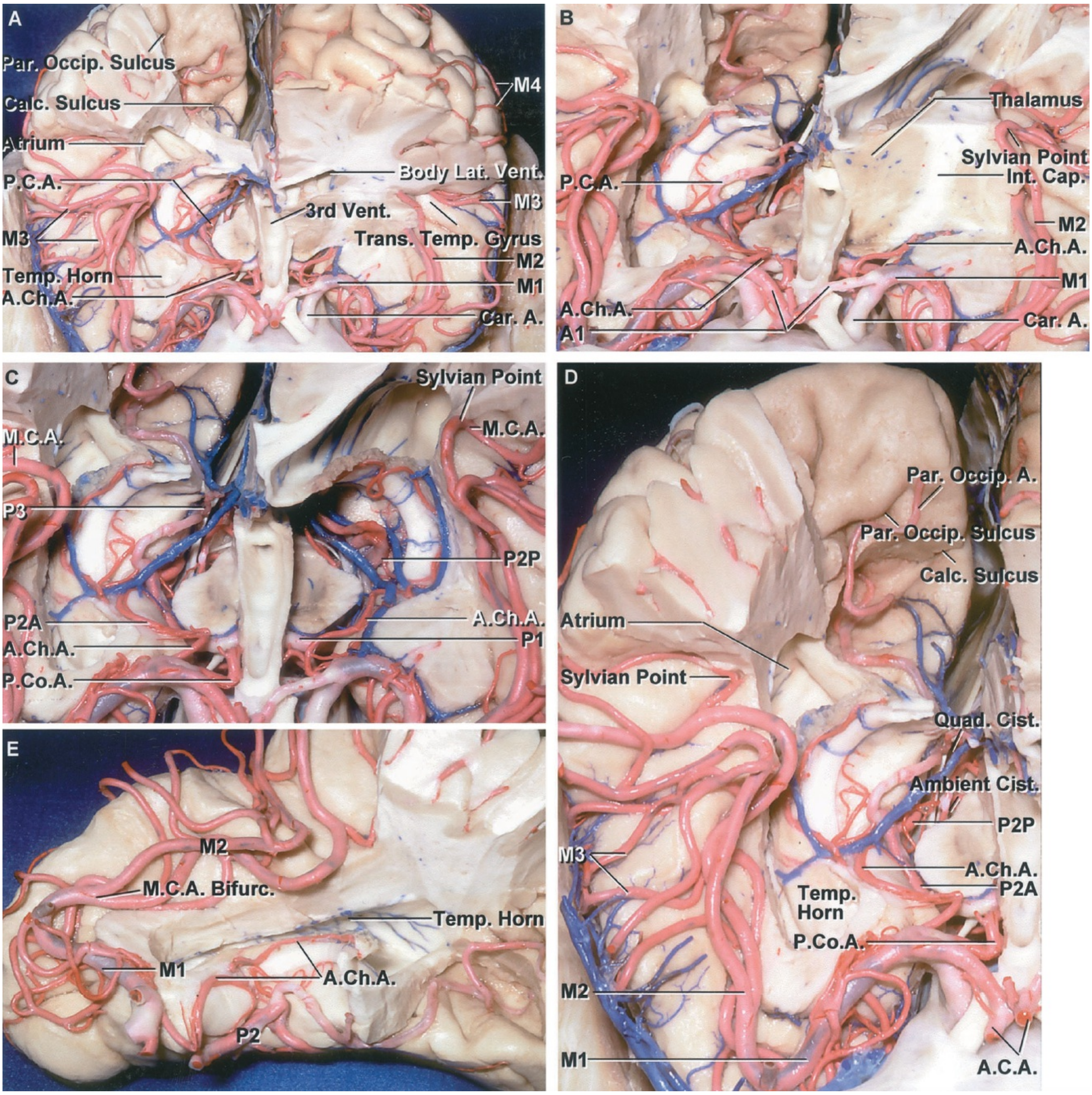
calcar avis, the prominence in the medial atrial wall overlying the deep end of the calcarine sulcus. D, the floor of the left temporal horn, except for some of the head of the hippocampus and the fimbria, has been removed. The head of the hippocampus folds into and constitutes most of the posterior segment of the uncus, which faces the P2A. The amygdala is located in the anterior uncal segment, which faces the carotid and PComAs. The lower lip of the calcarine sulcus, formed by the lingula, has been removed to expose the upper lip, formed by the cuneus, and the calcarine arteries coursing just outside the medial wall of the atrium. The calcarine branch courses deeply into the calcarine sulcus, and the parietooccipital branch ascends in the parieto-occipital sulcus. The fimbria of the fornix has been preserved. The LPChAs arise below the thalamus and pass through the choroidal fissure, located between the thalamus and fimbria, to reach the choroid plexus in the temporal horn and atrium. The thalamogeniculate branches arise from the P2P and enter the roof of the ambient cistern by passing through the lower thalamus in the region of the geniculate bodies.



Click here to view the interactive module and related content for this image.

FIGURE 2.13 E-H. E, inferior surface of both cerebral hemispheres showing the MCA coursing along the sylvian cistern and the PCAs coursing through the crural, ambient, and quadrigeminal cisterns. F, enlarged view of the P2P coursing below the thalamus, which forms the roof of the ambient cistern. The left temporal horn has been opened by removing part of the floor. Some of the head of the hippocampus has been preserved. The P2P gives rise to a complex arborizing group of perforating arteries that enter the lower thalamus, some passing through the geniculate bodies, and constituting the thalamogeniculate arteries. G, inferior view of another cerebral hemisphere. The medial part of the parahippocampal gyrus has been removed to expose the PCA coursing through the crural, ambient, and quadrigeminal cisterns. The AChA

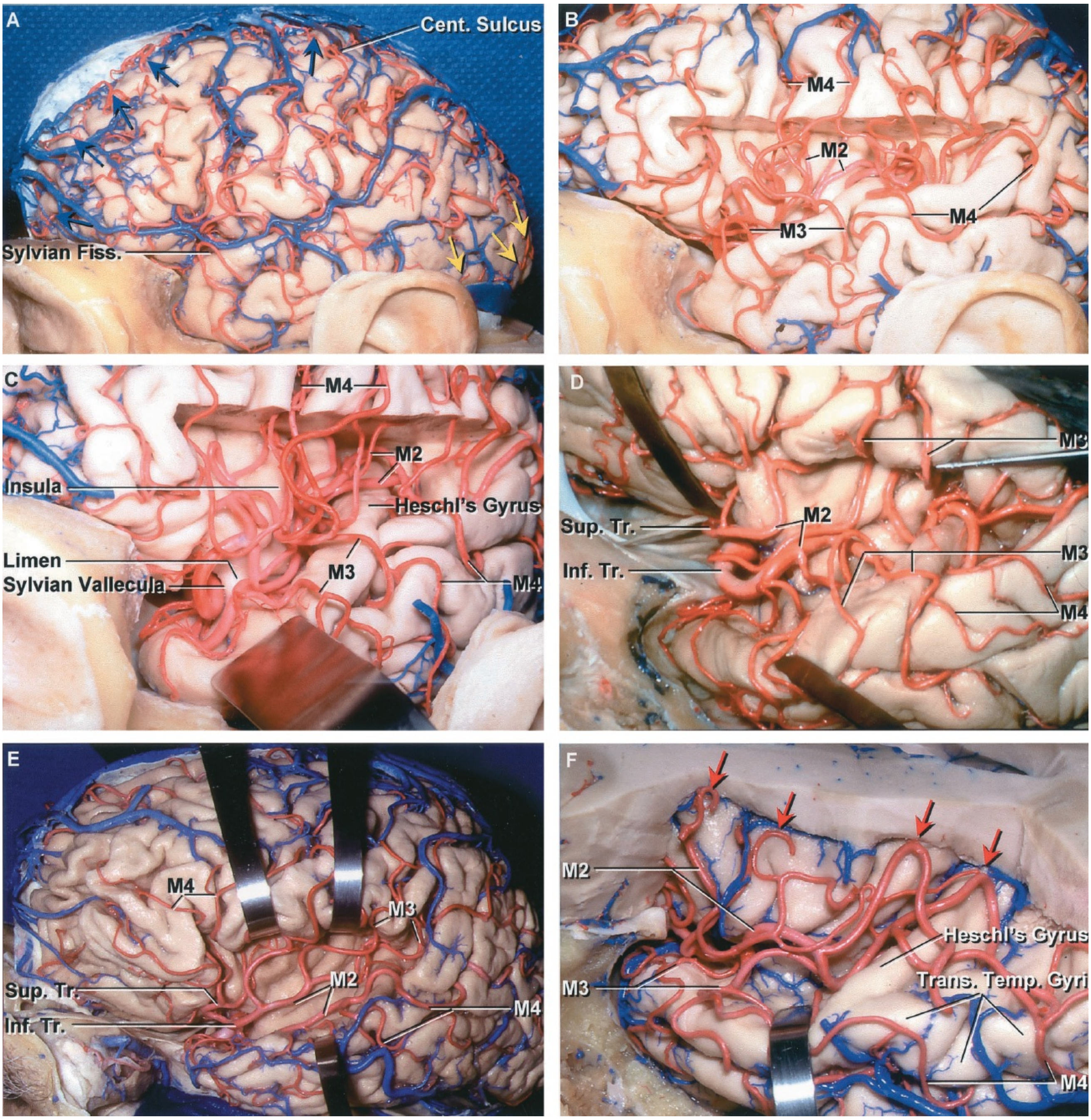
courses around the uncus. The uncus has an anterior segment that faces the carotid, middle cerebral, anterior choroidal, and posterior communicating arteries, and a posterior segment that faces the posterior cerebral and the terminal segment of the AChA. The choroidal fissure is located between fimbria of the fornix and the lower surface of the thalamus and has its lower end just behind the posterior uncal segment. The LPChA pass laterally through the choroidal fissure located between the fimbria and the thalamus. The dentate gyrus is located below the fimbria. A MPChA courses medial to the PCA. H, the dentate gyrus and adjacent part of the parahippocampal gyrus has been removed to expose the choroid plexus in the temporal horn. The LPChAs pass laterally between the fimbria and the lower margin of the thalamus, formed in part by the lateral geniculate body and pulvinar, to reach the choroid plexus in the temporal horn and atrium. A., artery; A.Ch.A., anterior choroidal artery; Amygd., amygdala; Ant., anterior; Calc., calcarine; Car., carotid; Chor., choroid, choroidal; Dent., dentate; Fiss., fissure; Gyr., gyrus; Hippo., hippocampal, hippocampus; Inf., inferior; L.P.Ch.A., lateral posterior choroidal artery; M.C.A., middle cerebral artery; M.P.Ch.A., medial posterior choroidal artery; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Par. Occip., parieto-occipital; Parahippo., parahippocampal; Plex., plexus; Post., posterior; Seg., segment; Sulc., sulcus; Sup., superior; Temp., temporal; Thal. Gen., thalamogeniculate; Tr., trunk.



Click here to view the interactive module and related content for this image.

FIGURE 2.14. Superior views of the cerebral arteries. A, the upper part of the right cerebral hemisphere has been removed to expose the temporal horn, atrium, and the basal cisterns. The part of the left hemisphere anterior to the midportion of the body of the lateral and above the sylvian fissure has been removed. The ICAs ascend on the lateral side of the optic nerves. The MCAs travel laterally in the sylvian fissures. The M1 crosses below the anterior perforated substance. The trunks of the M2 cross the insula and the M3 extends around the opercular lips. The M4 is formed by the cortical branches on the convexity. The PCAs pass

posteriorly in the crural and ambient cisterns to reach the quadrigeminal cistern. The ACA passes above the optic chiasm. The floor of the third ventricle and the calcarine and parieto-occipital sulcus have been exposed. The upper lip of the parieto-occipital sulcus formed by the precuneus has been removed. The lower lip of the parieto-occipital sulcus is formed by the cuneus, which also forms the upper lip of the calcarine sulcus. B, enlarged view. The AChAs enter the choroid plexus in the temporal horn. The sylvian point is located where the most posterior branch of the M2 turns away from the insular surface and toward the lateral convexity. C, the anterior part of the left hemisphere has been removed down to the level of the temporal lobe and the midbrain. The AChAs pass around the upper medial part of the uncus to reach the temporal horn. P2A courses medial to the uncus in the crural cistern, the P2P courses in the ambient cistern, and the P3 courses in the quadrigeminal cistern. D, enlarged view. The M2 crosses the insula just above and lateral to the temporal horn. The artery forming the sylvian point often has its apex directed medially toward the atrium. The parieto-occipital branch of the PCA courses along the parieto-occipital sulcus. The calcarine branch is directed backward in the calcarine sulcus. E, the right temporal lobe has been removed while preserving the M1, M2, and M3. The P2 courses along the medial surface of the temporal lobe. The AChA arises from the carotid artery and takes a somewhat tortuous course to reach the choroid plexus and temporal horn. A., artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; Bifurc., bifurcation; Calc., calcarine; Cap., capsule; Car., carotid; Cist., cistern; Int., internal; Lat., lateral; M.C.A., middle cerebral artery; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Par. Occip., parieto-occipital; Quad., quadrigeminal; Temp., temporal; Trans., transverse; Vent., ventricle.



Click here to view the interactive module and related content for this image.

FIGURE 2.15. The insula and middle cerebral arteries. A, left side. The cortical branches of the MCA, which form the M4, spread out from the sylvian fissure to supply the majority of the lateral convexity. Branches of the ACA (yellow arrows) spread over the superior hemispheric border to reach the lateral hemispheric surface, and branches of the PCA pass around the occipital pole and adjacent art of the temporal lobe to supply the adjacent part of the convexity (red arrows). B, the frontoparietal operculum that covers the upper part of the insula has been removed to

show the M2 crossing the insula, the M3 curving around the opercular lips, and the M4 on the lateral cortical surface. C, enlarged view. The sylvian vallecula is the opening between the lips of the sylvian at the limen insula where the MCA turns posteriorly to form the M2 segment. D, another specimen with the lips of the sylvian fissure retracted. This shows a large dominant inferior trunk that gives rise to multiple branches that supply the majority of the lateral convexity. E, another hemisphere with the lips of the sylvian fissure retracted to expose the branches forming the M2, M3, and M4 crossing the insula and passing around the opercular lips to reach the cortical surface. F, the upper part of the hemisphere and the frontal and parietal operculum have been removed to expose the M2 branches crossing the insula. The posterior M3 branches cross the transverse temporal gyri, the most anterior of which forms Heschl's gyrus, to reach the cortical surface. Cent., central; Fiss., fissure; Inf., inferior; Sup., superior; Temp., temporal; Tr., trunk; Trans., transverse.

Perforating Branches

The perforating branches of the MCA enter the anterior perforated substance and are called the lenticulostriate arteries

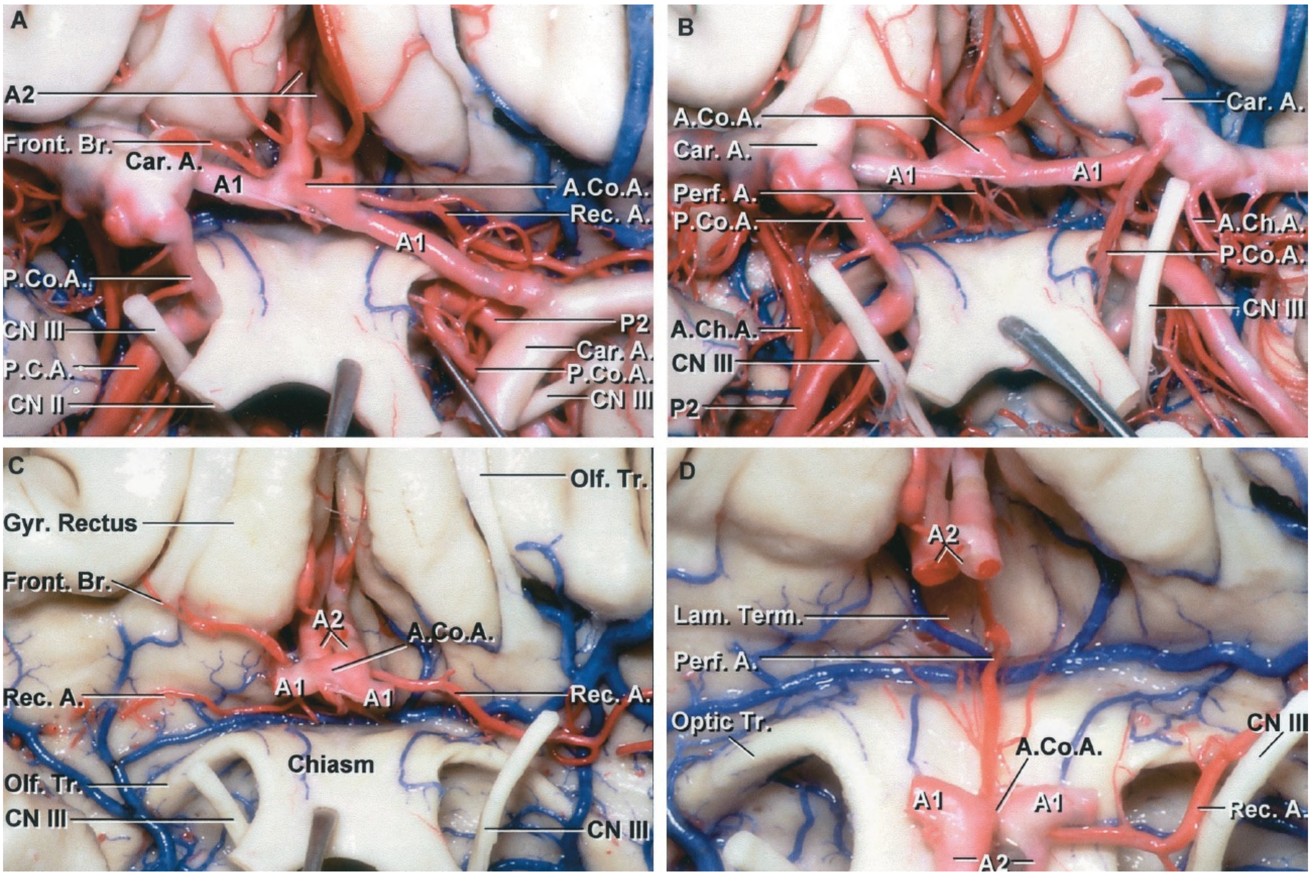
(Fig. 2.16). There is an average of 10 (range, 1–21) lenticulostriate arteries per hemisphere (36). Lenticulostriate branches arise from the prebifurcation part of the M1 in every case and from the postbifurcation part of the M1 segment in half of the hemispheres. Of the total number of lenticulostriate branches, approximately 80% arise from the prebifurcation part of the M1. Most of the remainder arise from the postbifurcation part of the M1, but a few arise from the proximal part of the M2 near the genu. The earlier the bifurcation, the greater the number of postbifurcation branches. No branches to the anterior perforated substance arise from the postbifurcation trunks if the bifurcation is 2.5 cm or more from the origin of the middle cerebral artery.

The lenticulostriate arteries are divided into medial, intermediate, and lateral groups, each of which has a unique origin, composition, morphology, and characteristic distribution in the anterior perforated substance. The medial group is the least constant of the three groups and is present in only half of the hemispheres (36). When present, it consists of one to five branches that arise on the medial prebifurcation part of the M1 segment near the carotid bifurcation or an early branch, and pursue a relatively direct course to enter the anterior perforated substance just lateral to the C4 branches. Most arise from the posterior or superior aspect of the main trunk. Branching before entering the anterior perforated substance is less common than in the intermediate or lateral groups.

The intermediate lenticulostriate arteries form a complex array of branches before entering the anterior perforated substance between the medial and lateral lenticulostriate arteries. They are present in more than 90% of hemispheres. The most distinctive feature of the intermediate group is that it possesses at least one major artery, which furnishes a complex arborizing array of as many as 30 branches to the anterior perforated substance. The fewer perforating branches in this group (average, three) and the division yielding a great number of total branches entering the anterior perforated sub stance is evidence of this distinctive morphology. The intermediate lenticulostriate arteries arise almost exclusively on the M1 or its early branches. Most arise from the posterior, posterosuperior, or superior aspect of the MCA. They arise predominantly from the main or prebifurcation part of the M1 or an early branch.

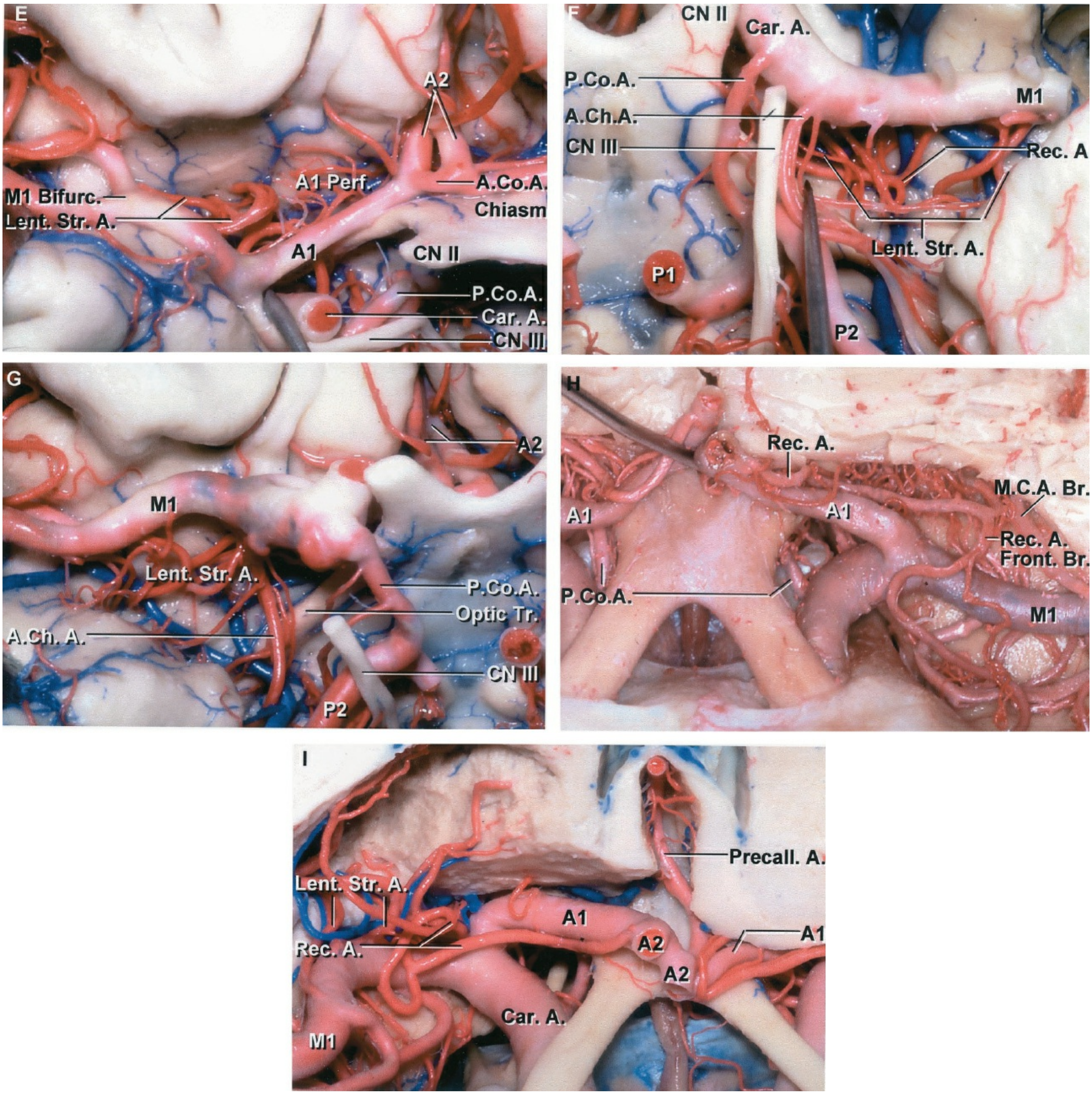
The lateral lenticulostriate arteries are present in almost all hemispheres. They originate predominantly on the lateral part of the M1, pursue an S-shaped course, and enter the posterolateral part of the anterior perforated substance. An average of five lateral lenticulostriate arteries per hemisphere divide to yield as many as 20 branches before they enter the anterior perforated substance. They may also arise from the early branches of the M1 or from the M2. They can arise from the pre- or postbifurcation trunks of the M1. More branches arise from postbifurcation branches if there is an early bifurcation; they could arise from either the superior or inferior trunk distal to the bifurcation, but there is a strong predilection for the inferior trunk. They arise from either the posterior, superior, or posterosuperior aspect of the parent trunks, travel medially with the parent trunks, then loop sharply posteriorly, laterally, and superiorly, and finally, turn posteromedially just before penetrating the anterior perforated substance. The branches with a more medial origin arise at a less acute angle to the parent vessel and pursue a more direct posterior, superior, and medial route to the anterior perforated substance.

The lateral and intermediate groups of lenticulostriate arteries pass through the putamen and arch medially and posteriorly to supply almost the entire anterior-to-posterior length of the upper part of the internal capsule and the body and head of the caudate nucleus. The medial lenticulostriate arteries irrigate the area medial to and below that supplied by the lateral and intermediate lenticulostriate arteries; this area includes the lateral part of the globus pallidus, the superior part of the anterior limb of the internal capsule, and the anterosuperior part of the head of the caudate nucleus. The relationship of the lateral lenticulostriate arteries to the M1 bifurcation is important because the bifurcation is the site of most aneurysms arising from the middle cerebral artery. Nearly 30% of the lateral lenticulostriate arteries originate from the pre- or postbifurcation trunks 2.0 mm or less from the M1 bifurcation; and nearly 70% are positioned 5.0 mm or less from the bifurcation (36). Some branches arise directly on the bifurcation. Of the arteries originating near the bifurcation, there is a nearly even split between an origin on the pre- and postbifurcation trunks. The area of supply and clinical features are reviewed below, under the Anterior Perforating Arteries.



Click here to view the interactive module and related content for this image.

FIGURE 2.16 A-D. Perforating branches of the anterior part of the circle of Willis. A, the A1, A2, and AComA are exposed above the optic chiasm. The left recurrent arteries arise from the ACA at the level of the AComA and travel laterally above the carotid bifurcation and below the anterior perforated substance. A small frontal branch arises at the same level on the right side. The stump of the right carotid artery has been folded upward and the left downward. B, the chiasm has been reflected downward and the ACA gently elevated to expose the perforating branches that arise from the AComA and pass backward to enter the diencephalon through the region of the lamina terminalis. The AChAs pass around the medial aspect of the uncus. C, the A1s have been removed to expose the recurrent arteries passing laterally below the anterior perorated substance. The left recurrent artery is larger than the right. D, the anterior communicating complex has been folded downward to expose the perforating branches that pass upward and enter the brain through the region of the lamina terminalis.



Click here to view the interactive module and related content for this image.

FIGURE 2.16 E-I. E, enlarged anterior view of the right carotid bifurcation. The right M1 divides as a bifurcation before reaching the limen insula. Lenticulostriate arteries arise from the posterosuperior margin of the M1. The A1 also gives rise to perforating branches that enter the anterior perforated substance. F, enlarged view of the lenticulostriate branches arising from the left M1 and entering the anterior perforated substance. The lateral end of the recurrent artery intermingles with the lenticulostriate branches of the M1 segment. The AChA is directed around the medial aspect of the uncus. G, enlarged view

of the left carotid bifurcation. Perforating branches arise from the PComA and ascend to enter the diencephalon medial to the optic tract. Lenticulostriate branches arise from the M1 and enter the anterior perforated substance. H, anterior view of the lenticulostriate branches of M1 and a large recurrent artery in another specimen. The artery sends a small branch to the frontal lobe and might be called an accessory MCA. I, anterior view. Some of the gray matter above the anterior perforated substance has been removed to expose the intraparenchymal course of the recurrent and lenticulostriate arteries. A., arteries, artery; A.Ch.A., anterior choroidal artery; Bifurc., bifurcation; Br., branch; Car., carotid; CN, cranial nerve; Front., frontal; Gyr., gyrus; Lam., lamina; Lent. Str., lenticulostriate; M.C.A., middle cerebral artery; Olf., olfactory; P.C.A., posterior cerebral artery; P.Co.A., posterior communicating artery; Perf., perforating; Precall., precallosal; Rec., recurrent; Term., terminalis; Tr., tract.

Cortical Distribution

The cortical territory supplied by the MCA includes the majority of the lateral surface of the hemisphere, all of the insular and opercular surfaces, the lateral part of the orbital surface of the frontal lobe, the temporal pole, and the lateral part of the inferior surface of the temporal lobe. The MCA territory does not reach the occipital or frontal poles or the upper margin of the hemisphere, but it does extend around the lower margin of the cerebral hemisphere onto the inferior surfaces of the frontal and temporal lobes (Fig. 2.17).

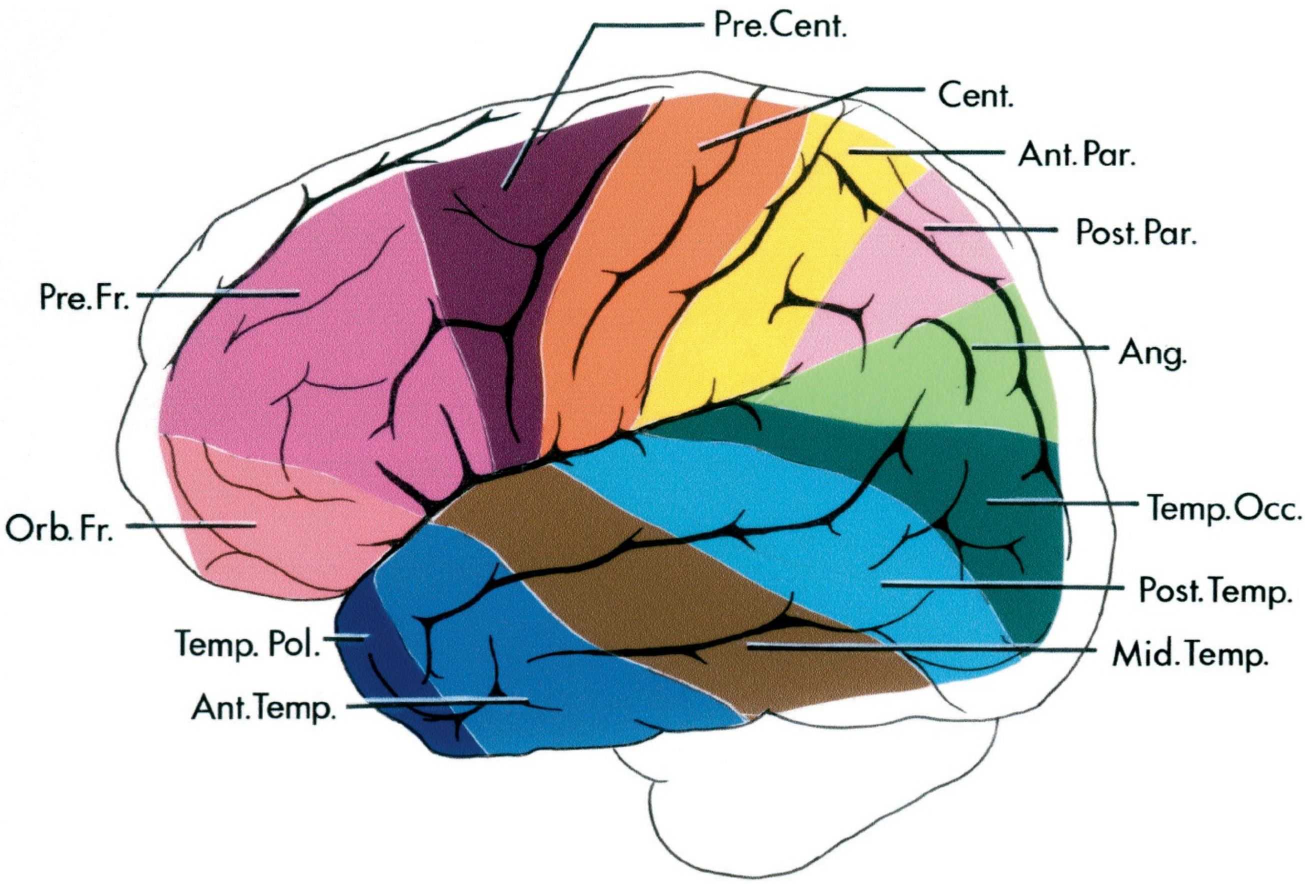
The narrow peripheral strip on the lateral surface of the cerebral hemisphere, supplied by the ACA and PCA rather than the MCA, extends along the entire length of the superior margin of the hemisphere from the frontal to the occipital pole. It is broadest in the superior frontal region and narrowest in the superior parietal area. This strip continues around the occipital pole and onto the posterior part of the lateral surface of the temporal lobe and narrows and disappears anteriorly on the temporal lobe where the branches of the MCA extend around the lower border of the hemisphere onto the inferior surface of the temporal lobe and the orbital surface of the frontal lobe.

The cortical area supplied by the MCA is divided into 12 areas (Fig. 2.17):

1. Orbitofrontal area. The orbital portion of the middle and inferior frontal gyri and the inferior part of the pars orbitalis.
2. Prefrontal area. The superior part of the pars orbitalis, the pars triangularis, the anterior part of the pars opercularis, and most of the middle frontal gyrus.
3. Precentral area. The posterior part of the pars opercularis and the middle frontal gyrus, and the inferior and middle portions of the precentral gyrus.
4. Central area. The superior part of the precentral gyrus and the inferior half of the postcentral gyrus.
5. Anterior parietal area. The superior part of the postcentral gyrus, and frequently, the upper part of the central sulcus, the anterior part of the inferior parietal lobule, and the anteroinferior part of the superior parietal lobule.
6. Posterior parietal area. The posterior part of the superior and inferior parietal lobules, including the supramarginal gyrus.
7. Angular area. The posterior part of the superior temporal gyrus, variable portions of the supramarginal and angular gyri, and the superior parts of the lateral occipital gyri (the artery to this area is considered the terminal branch of the MCA).
8. Temporo-occipital area. The posterior half of the superior temporal gyrus, the posterior extreme of the middle and inferior temporal gyri, and the inferior parts of the lateral occipital gyri.
9. Posterior temporal area. The middle and posterior part of the superior temporal gyrus, the posterior third of the middle temporal gyrus, and the posterior extreme of the inferior temporal gyrus.
10. Middle temporal area. The superior temporal gyrus near the level of the pars triangularis and pars opercularis, the middle part of the middle temporal gyrus, and the middle and posterior part of the

inferior temporal gyrus.

11. Anterior temporal area. The anterior part of the superior, middle, and inferior temporal gyri.
12. Temporopolar area. The anterior pole of the superior, middle, and inferior temporal gyri.



Click here to view the interactive module and related content for this image.

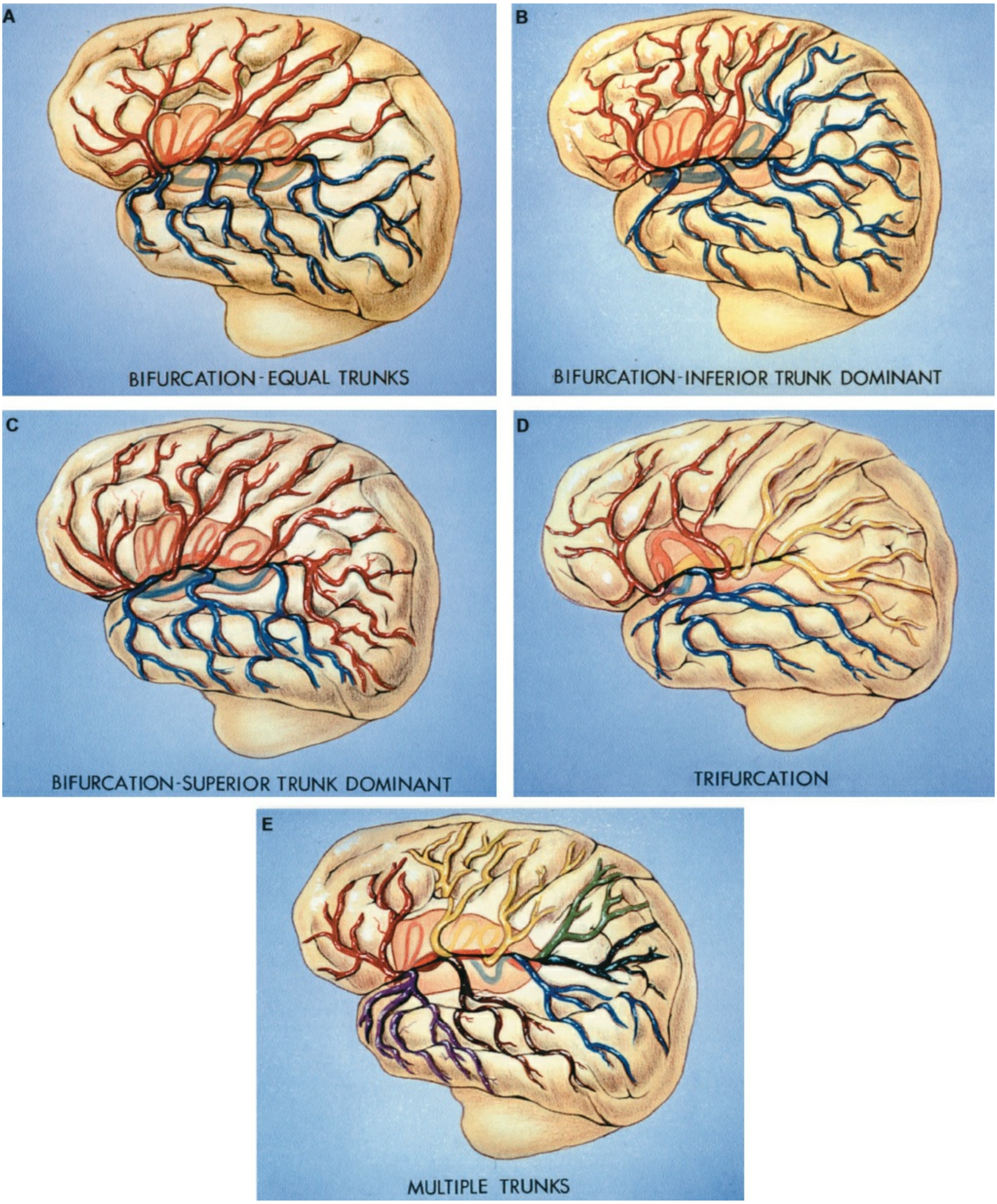
FIGURE 2.17. Classification of the cortical areas used in this study The territory of the middle cerebral artery is divided into 12 areas: orbitofrontal, prefrontal, precentral, central, anterior parietal, posterior parietal, angular, temporo-occipital, posterior temporal, middle temporal, anterior temporal, and temporopolar. Ang., angular; Ant., anterior; Cent., central; Mid., middle; Orb.Fr., orbitofrontal; Par., parietal; Post., posterior; Pre.Cent., precentral; Pre.Fr., prefrontal; Temp., temporal; Temp. Occ., temporo-occipital; Temp. Pol., temporopolar. (From, Gibo H, Carver CC, Rhoton AL Jr, Lenkey C, Mitchell RJ: Microsurgical anatomy of the middle

cerebral artery. J Neurosurg 54:151–169, 1981 [14].)

Branching Pattern

The main trunk of the MCA divides in one of three ways: bifurcation into superior and inferior trunks; trifurcation into superior, middle, and inferior trunks; or division into multiple (four or more) trunks (Figs. 2.18 and 2.19). In our study, 78% of the MCAs divided in a bifurcation, 12% divided in a trifurcation, and 10% divided by giving rise to multiple trunks (14). The distal division of the MCA also generally occurs in a series of bifurcations. The small arteries that arise proximal to the bifurcation or trifurcation and are distributed to the frontal or temporal pole are referred to as early branches.

The MCAs that bifurcate are divided into three groups, designated equal bifurcation, superior trunk dominant, and inferior trunk dominant, based on the diameter and the size of the cortical area of supply of their superior and inferior trunks. The equal bifurcation (18% of hemispheres) yields two trunks with nearly equal diameters and size of cortical area. The inferior trunk supplies the temporal, temporo-occipital, and angular areas, and the superior trunk supplies the frontal and parietal regions. The superior trunk usually supplies the orbitofrontal to the posterior parietal areas, and the inferior trunk usually supplies the angular to the temporopolar areas. The inferior trunk dominant type of bifurcation (32% of hemispheres) yields a larger inferior trunk that supplies the temporal and parietal lobes and a smaller superior trunk that supplies all or part of the frontal lobe. The maximal area perfused by the inferior trunk includes all of the territory between and including the precentral and temporopolar areas. The superior trunk dominant type of bifurcation (28% of hemispheres) yields a larger superior trunk that supplies the frontal and parietal regions and a smaller inferior trunk that supplies only the temporal lobe. The maximal area supplied by the dominant superior trunk includes the orbitofrontal to the temporo-occipital areas.



Click here to view the interactive module and related content for this image.

FIGURE 2.18. Branching patterns of the middle cerebral artery. The main trunk divides in a bifurcation in 78% of hemispheres and in a trifurcation in 12%. In the remaining 10%, the main trunk divides into multiple (four or more) branches. A, bifurcation: equal trunk pattern (18% of

hemispheres). The main trunk divides into superior (red) and inferior (blue) trunks that are of approximately the same diameter and supply cortical areas of similar size. The superior trunk supplies the frontal and parietal areas and the inferior trunk supplies the temporal and temporo-occipital areas. B, bifurcation: inferior trunk dominant (32% of hemispheres). The inferior trunk (blue) has a larger diameter and area of supply than the superior trunk (red). The inferior trunk supplies the temporal, occipital, and parietal areas, and the superior trunk supplies the frontal areas. C, bifurcation: superior trunk dominant (28% of hemispheres). The superior trunk (red) has the largest diameter and area of supply; it supplies the frontal, parietal, temporo-occipital, and posterior temporal areas, and the smaller inferior trunk (blue) supplies the temporopolar through the middle temporal areas. D, trifurcation pattern (12% of hemispheres). The main trunk of the middle cerebral artery divides into three trunks. The superior trunk (red) supplies the frontal areas, the middle trunk (yellow) supplies the areas around the posterior end of the sylvian fissure, and the inferior trunk (blue) supplies the temporal areas. E, multiple trunks (10% of hemispheres). The main trunk gives rise to multiple smaller trunks. Two trunks supply the frontal areas (red and yellow), two supply the parietal areas (light green and dark green), and three supply the temporal and occipital areas (purple, brown, and blue). (From, Gibo H, Carver CC, Rhoton AL Jr, Lenkey C, Mitchell RJ: Microsurgical anatomy of the middle cerebral artery. J Neurosurg 54:151–169, 1981 [14].)

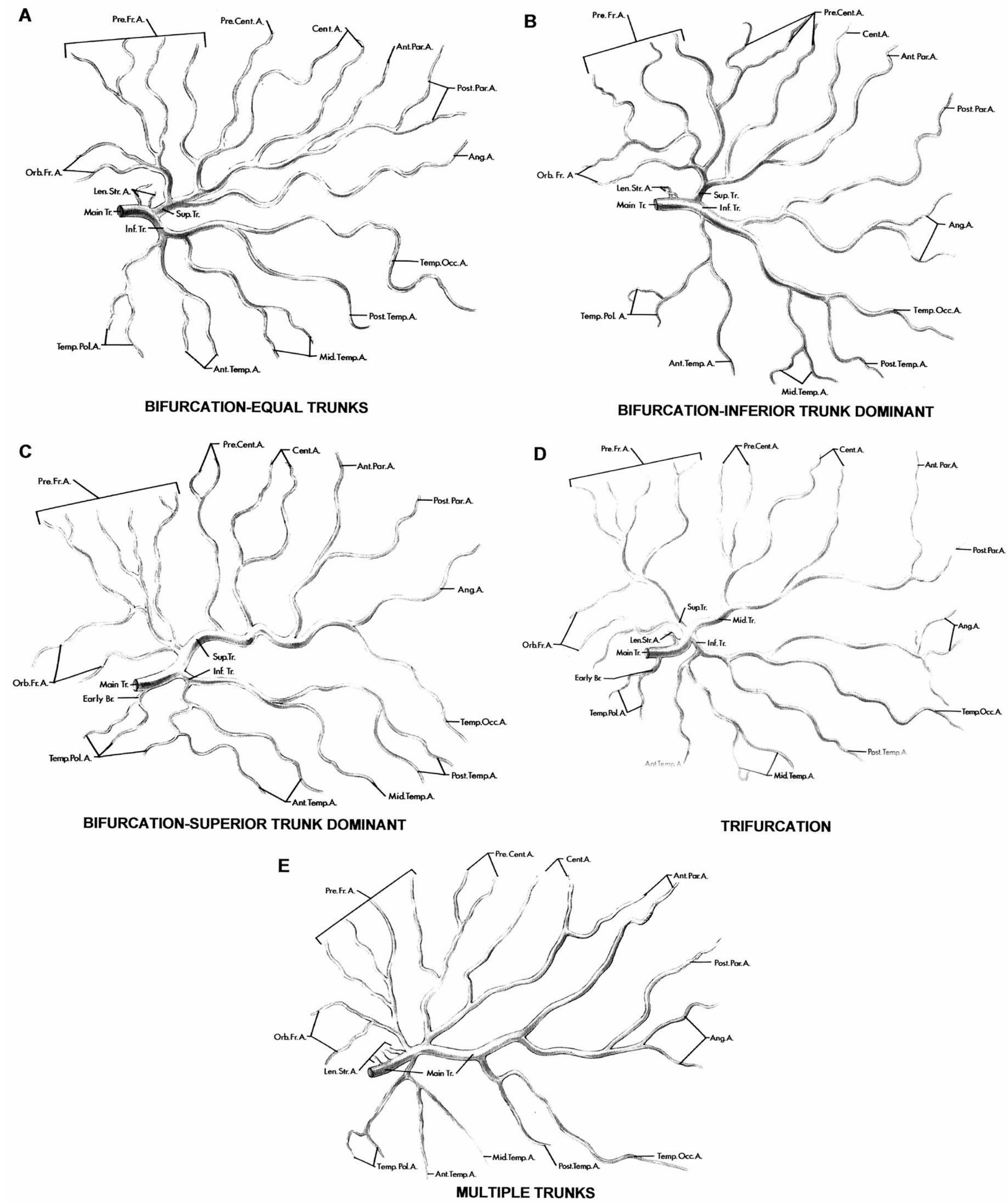


FIGURE 2.19. Branching patterns of the middle cerebral artery. These drawings of MCAs dissected from five cerebral hemispheres show the different branching patterns of the main trunk. The main trunk divides in a bifurcation in 78% of hemispheres, in a trifurcation in 12%, and in a multiple branch pattern (four or more trunks) in 10%. The drawings show the main, superior, middle, and inferior trunks. These trunks give rise to the lenticulostriate, orbitofrontal, prefrontal, precentral, central, anterior parietal, posterior parietal, angular, temporo-occipital, posterior

temporal, middle temporal, anterior temporal, and temporopolar arteries. A, bifurcation: equal trunks (18% of hemispheres). The main trunk divides into superior and inferior trunks that are of approximately the same diameter and supply cortical areas of similar size. The superior trunk gives rise to the orbitofrontal arteries through the angular arteries, and the inferior trunk gives rise to the temporopolar through the temporo-occipital arteries. B, bifurcation: inferior trunk dominant (32% of hemispheres). The inferior trunk has a larger diameter and area of supply than the superior trunk. The superior trunk supplies the orbitofrontal through the anterior parietal areas, and the inferior trunk supplies the posterior parietal through the temporopolar areas. C, bifurcation: superior trunk dominant (28% of hemispheres). The superior trunk has a larger diameter and area of supply than the inferior trunk. It supplies the orbitofrontal through the temporo-occipital areas, and the inferior trunk supplies the temporal areas except for the temporopolar area, which is supplied by an early branch (Early Br.) that arises from the main trunk. D, trifurcation pattern (12% of hemispheres). The main trunk of the MCA divides into three trunks. The superior trunk supplies the orbitofrontal and prefrontal areas, the middle trunk supplies the precentral through the posterior parietal areas, and the inferior trunk supplies the angular through the anterior temporal areas. The temporopolar artery arises from the main trunk as an early branch. E, multiple trunks (10% of hemispheres). The main trunk gives rise to more than three trunks. There are five trunks in the specimen shown. A., arteries, artery; Ang., angular; Ant., anterior; Br., branch; Cent., central; Inf., inferior; Len. Str., lenticulostriate; Mid., middle; Orb.Fr., orbitofrontal; Par., parietal; Post., posterior; Pre. Cent., precentral; Pre. Fr., prefrontal; Sup., superior; Temp., temporal; Temp. Occ., temporo-occipital; Temp. Pol., temporopolar; Tr., trunk. (From, Gibo H, Carver CC, Rhoton AL Jr, Lenkey C, Mitchell RJ: Microsurgical anatomy of the middle cerebral artery. J Neurosurg 54:151–169, 1981 [14].)

Stem Arteries

The stem arteries arise from the trunks and give rise to the individual cortical branches (Fig. 2.20). They arise from the main trunk and the two or more trunks formed by a bifurcation, trifurcation, or division into multiple trunks. There is considerable variation in the number and size of the area supplied by the stem arteries. The most common pattern is made up of 8 stem arteries per hemisphere (range, 6 to 11) (14).

The individual stem arteries give rise to one to five cortical arteries. The most common pattern is for one of the 12 cortical areas to be supplied by a stem artery supplying one or two adjacent areas. The cortical areas most commonly receiving a stem artery serving only that area are the temporo-occipital, angular, and central areas. Stem arteries supplying four or five of the cortical areas are most commonly directed to the area below the sylvian fissure. In our study, we also examined the stem arteries supplying each lobe (14). The frontal lobe is supplied by one to four stem arteries. The most common pattern, a two-stem pattern, had one stem giving rise to the orbitofrontal, prefrontal, and precentral arteries, and the other stem giving rise to the central artery. The parietal lobe and the adjoining part of the occipital lobe are supplied by one to three stem arteries. The most frequent pattern is for each of the three cortical areas to have its own stem. In the most frequent two-stem pattern, one stem gives rise to the anterior and posterior parietal arteries and the other stem gives rise to the angular artery. The temporal lobe, along with the adjoining part of the occipital lobe, is supplied by one to five stem arteries; the most common pattern is to have four stem arteries. This lobe has more stem arteries than the other lobes supplied by the MCA.

Cortical Arteries

The cortical arteries arise from the stem arteries and supply the individual cortical areas. Generally, one, or less commonly, two cortical arteries (range, one to five) pass to each of the 12 cortical areas (Figs. 2.17 and 2.20). The smallest cortical arteries arise at the anterior end of the sylvian fissure and the largest arteries arise at the posterior limits of the fissure. The cortical branches to the frontal, anterior temporal, and anterior parietal areas are smaller than those supplying the posterior parietal, posterior temporal, temporo-occipital, and angular areas. The smallest arteries supply the orbitofrontal and temporopolar areas, and the largest ones supply the temporooccipital and the angular areas. There is an inverse relationship between the size and number of arteries supplying a cortical area. The temporo-occipital area has the smallest number of arteries, but they are the largest in size, and the prefrontal area has the largest number of arteries, but they are smaller.

The temporopolar, temporo-occipital, angular, and anterior, middle, and posterior temporal arteries usually arise from the inferior trunk; the orbitofrontal, prefrontal, precentral, and central arteries usually arise from the superior trunk. The anterior and posterior parietal arteries have an origin evenly divided between the two trunks and usually arise from the dominant trunk.

Early Branches

The cortical arteries arising from the main trunk proximal to the bifurcation or trifurcation are called early branches (Fig. 2.3). The early branches are distributed to the frontal or temporal lobes. Nearly half of MCAs send early branches to the temporal lobe, but less than 10% give early branches to the frontal lobe (14). The temporal branches usually supply the temporopolar and anterior temporal areas. The frontal branches terminate in the orbitofrontal and prefrontal areas. A few MCAs will give rise to early branches to both the frontal and temporal areas.

There is most commonly only one early branch, but a few hemispheres will give rise to two early branches. In our study, the distance between the bifurcation or trifurcation of the MCA and the origin of the early branches to the frontal lobe was 5.5 mm (range, 5.0–6.0 mm) and 11.2 mm (range, 3.5–30.0 mm) for the temporal lobe (14).

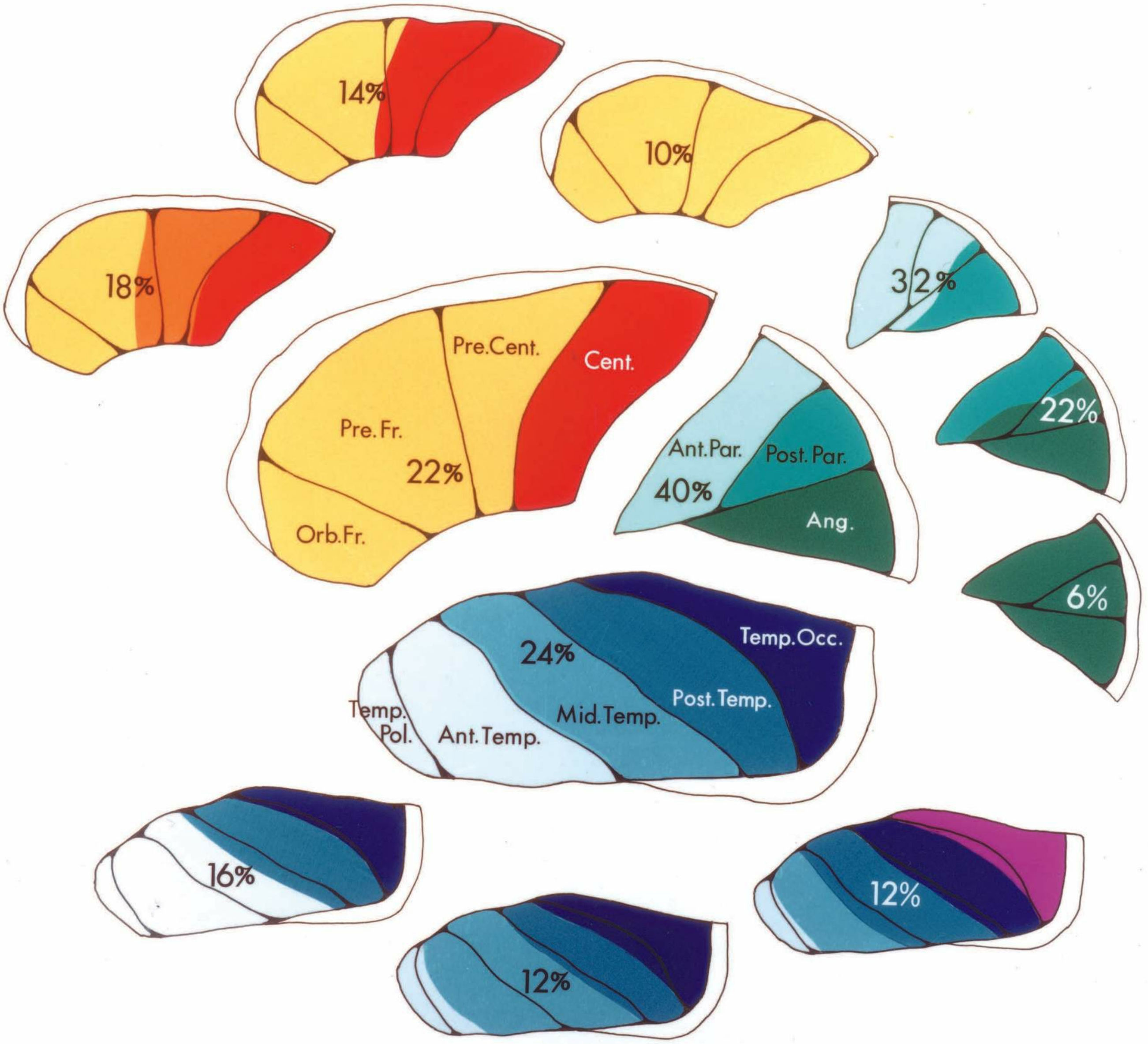


FIGURE 2.20. Stem artery patterns. The stem arteries arise from the trunks and give rise to the cortical arteries. The central illustration shows the lateral surface of a left cerebral hemisphere with a space between the frontal, parietal, and temporal areas. The frontal lobe is formed by the orbitofrontal, prefrontal, precentral, and the central areas; the parietal lobe is composed of the anterior parietal, posterior parietal, and angular areas; the temporal and occipital lobes are formed by the temporopolar, anterior temporal, middle temporal, posterior temporal, and temporooccipital areas. The posterior part of the central area, which is actually part of the parietal lobe, is included with the frontal lobe. The central diagram shows the most common stem pattern, and the peripheral diagrams show the next three most common patterns. Each color or shade of a color shows the area supplied by one stem artery. The percentage of hemispheres having the stem pattern shown is listed on each diagram. The most common frontal lobe pattern involves two stem

arteries: one gives rise to the branches to the orbitofrontal, prefrontal, and precentral areas, and the other supplies the central area. The most common parietal lobe pattern involves three stem arteries, one each for the anterior and posterior parietal and the angular areas. The most common temporal and occipital lobe pattern involves four stem arteries: one stem artery supplies both the temporopolar and the anterior temporal areas, and there is one stem each for the middle temporal, posterior temporal, and temporo occipital areas. The next three most common stem patterns for each lobe are shown on the peripheral diagrams. The four patterns shown for each lobe do not account for 100% of the hemispheres, but show only the four most common patterns for that lobe. Ang., angular; Ant., anterior; Cent., central; Mid., middle; Orb. Fr., orbitofrontal; Par., parietal; Post., posterior; Pre. Cent., precentral; Pre. Fr., prefrontal; Temp., temporal; Temp. Occ., temporo-occipital; Temp. Pol., temporopolar. (From, Gibo H, Carver CC, Rhoton AL Jr, Lenkey C, Mitchell RJ: Microsurgical anatomy of the middle cerebral artery. J Neurosurg 54:151–169, 1981 [14].)

Anomalies

Anomalies of the MCA, consisting of either a duplicate or an accessory MCA, are infrequent and occur less often than anomalies of the other intracranial arteries (14). A duplicated MCA is a second artery that arises from the internal carotid artery and an accessory MCA is one that arises from the anterior cerebral artery. Both the duplicate and accessory MCAs send branches to the cortical areas usually supplied by the MCA. The accessory MCAs usually arise from the anterior cerebral artery near the origin of the anterior communicating artery (AComA). The accessory MCA is differentiated from a recurrent artery of Heubner by the fact that the recurrent artery, although arising from the same part of the anterior cerebral artery as an accessory MCA, enters the anterior perforated substance, but the accessory MCA, although sending branches to the anterior perforated substance, also courses lateral to this area and sends branches to cortical areas normally supplied by the MCA (Fig. 2.16H).

MCA Branches for Extracranial-Intracranial Bypass

Important factors in selecting a cortical artery for a bypass procedure are its diameter and the length of artery available on the cortical surface. The largest cortical artery is the temporo-occipital artery (14). Nearly two-thirds are 1.5 mm or more in diameter, and 90% are 1 mm or more in diameter. The smallest cortical artery is the orbitofrontal artery; approximately one quarter are 1 mm or more in diameter. The central sulcal artery is the largest branch to the frontal lobe, and the angular artery is the largest branch to the parietal lobe. The temporo-occipital and the posterior temporal arteries are the largest branches to the temporal lobe. The minimum length of a cortical artery needed to complete a bypass is 4 mm. The length of each of the cortical arteries on the cortical surface averages 11.8 mm or more. The angular, posterior parietal, and temporo-occipital arteries have the longest segments on the cortical surface, and the orbitofrontal and temporopolar arteries have the shortest cortical segment.

Chater et al. (3) undertook an analysis of the cortical branches of the MCA available in three circular cortical zones with a diameter of 4 cm. These three zones were centered over the convexity of the frontal lobe, the tip of the temporal lobe, and the region of the angular gyrus and were selected to be readily accessible by means of a small craniectomy. An external diameter of 1 mm was postulated to be the minimum required for long-term anastomosis patency. Chater et al. (3) found a cortical artery with a diameter of more than 1.4 mm in the angular zone in 100% of hemispheres. The arteries over the tip of the temporal lobe and the frontal lobe were considerably smaller. In the temporal zone, an artery with a diameter of more than 1.0 mm was present in 70% of hemispheres, and in the frontal zone, an arterial diameter of more than 1.0 mm was present in only 52%. These authors also noted that the vessels in the region of the angular gyrus had the advantage of being located so as to be accessible for anastomosis not only with the superficial temporal artery, but also with the occipital artery. They recommended that the craniotomy for exposing the cortical branches of the MCA be 4 cm in diameter, and that it be centered 6 cm above the external auditory canal.

Discussion

Occlusion of the individual cortical branches of the MCA, depending on the area supplied, may cause the following deficits: motor weakness caused by involvement of the corticospinal tract in the central gyrus; sucking and grasping reflex caused by involvement of the premotor area; motor aphasia resulting from involvement of the posteroinferior surface of the frontal cortex of the dominant hemisphere; changes in mentation and personality caused by involvement of the prefrontal area; visual field defects caused by a disturbance of the geniculocalcarine tract in the temporal, parietal, and occipital lobes; impairment of discriminative sensations and neglect of space and body parts resulting from involvement of the parietal lobes; finger agnosia, right-left disorientation, acalculia, and agraphia (Gerstmann's syndrome) caused by involvement of the functional area between the parietal and occipital lobes of the dominant hemisphere; or a receptive aphasia caused by disturbance of the dominant temporoparietal area.

Reports of specific clinical syndromes associated with occlusion of the individual cortical branches are rare. Occlusions of the individual cortical arteries are difficult to identify on angiograms, but, when detectable, they frequently correlate well with the neurological deficit (42). Embolism is a more frequent cause of occlusion of the MCA than thrombosis. In series of angiographically and autopsy-proven occlusions of the branches and trunks of the MCA, the ratio of embolic to thrombotic occlusions is approximately 13:1 to 16:1 (10).

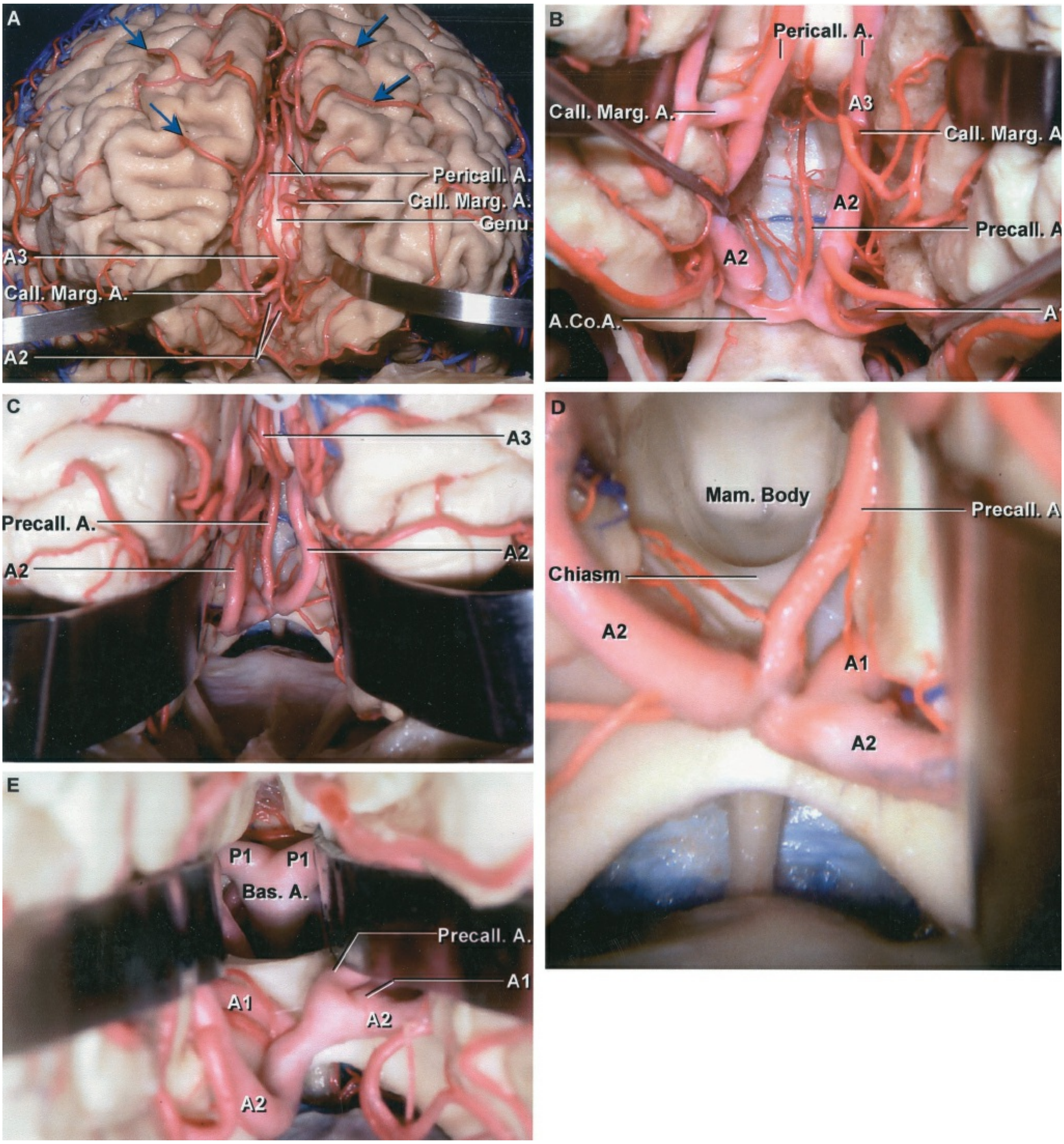
Fisher (10) described the syndromes of obstructing the superior and inferior trunk of the MCA as follows: obstruction of the superior trunk causes a sensory-motor hemiplegia without receptive aphasia in the dominant hemisphere; obstruction of the inferior division causes a receptive aphasia in the absence of hemiplegia in the dominant side. Fisher's syndromes would apply if the trunks were nearly equal in size, with the superior trunk supplying the frontal and parietal regions and the inferior trunk supplying the temporal and occipital lobes. However, we found marked variation in the size of the superior and inferior trunks and the area that they supply. In a few hemispheres, the inferior trunk supplied the temporal and parietal lobes and extended forward onto the precentral motor area, and, in another group of hemispheres, a large superior trunk supplied the frontal and parietal lobes and extended onto the speech centers on the posterior part of the temporal lobe.

The site of an MCA anastomosis for an MCA branch, trunk, or stem occlusion should be selected only after a careful review of the angiogram. If an early branch to the temporal lobe were used as a recipient vessel for a bypass operation, in cases of MCA stenosis or occlusion near the bifurcation, the new flow would frequently be channeled into the MCA proximal to the occlusion and none would have been delivered into the hypoperfused area distal to the occlusion. Some early branches, although arising proximal to the carotid bifurcation, may reach as far distally as the posterior temporal area. If one trunk of the MCA is stenotic or obstructed, an anastomosis to the other trunk will deliver blood to the proximal MCA and distally into the normal rather than into the ischemic area. Most surgeons use the angular, temporo-occipital, or posterior temporal branch of the MCA for a bypass, the three largest branches in this study (30).

Anterior Cerebral Artery

The ACA, the smaller of the two terminal branches of the internal carotid artery, arises at the medial end of the sylvian fissure, lateral to the optic chiasm and below the anterior perforated substance (Figs. 2.1 and 2.3). It courses anteromedially above the optic nerve or chiasm and below the medial olfactory striate to enter the interhemispheric fissure. Near its entrance into the fissure, it is joined to the opposite ACA by the AComA, and ascends in front of the lamina terminalis to pass into the longitudinal fissure between the cerebral hemispheres.

The arteries from each side are typically not side by side as they enter the interhemispheric fissure and ascend in front of the lamina terminalis (Figs. 2.1 and 2.21). Rather, one distal ACA lies in the concavity of the other. Above the lamina terminalis, the arteries make a smooth curve around the genu of the corpus callosum and then pass backward above the corpus callosum in the pericallosal cistern. In their midcourse, one or both ACAs frequently turns away from the corpus callosum only to dip sharply back toward it. After giving rise to the cortical branches, the ACA continues around the splenium of the corpus callosum as a fine vessel, often tortuous, and terminates in the choroid plexus in the roof of the third ventricle. The posterior extent of the ACA depends on the extent of supply of the PCA and its splenial branches. The ACA often has four convex curves as viewed laterally: the convexity is posterosuperior between its origin and the AComA, anteroventral as it turns into the interhemispheric fissure, posterosuperior at the junction of the rostrum and genu of the corpus callosum, and anterior as it courses around the genu of the corpus callosum (Fig. 2.22). Branches of the distal ACA are exposed in surgical approaches to the sellar and chiasmatic regions, third and lateral ventricles, falx and parasagittal areas, and even in approaches to the medial parieto-occipital and pineal regions.



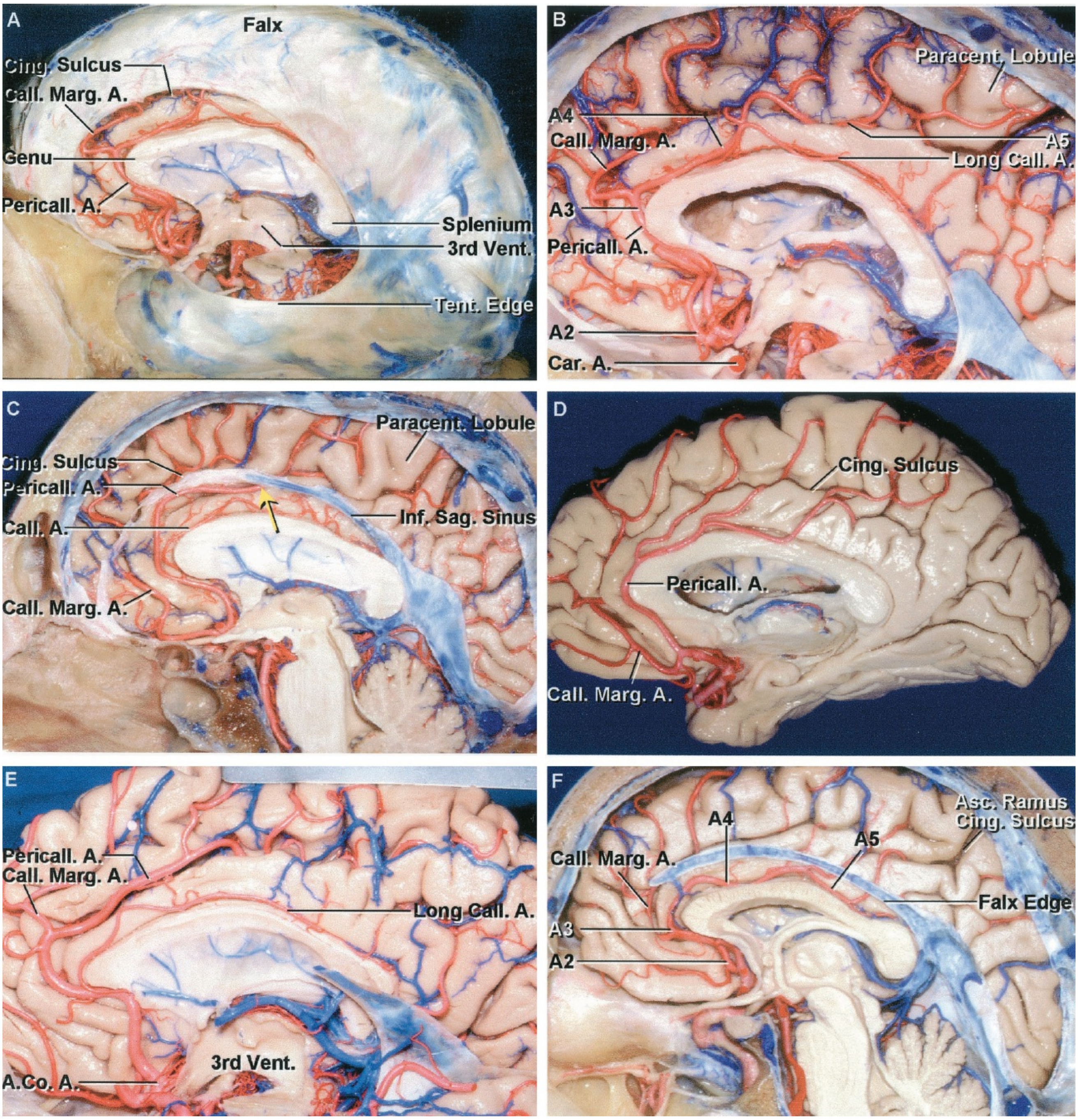
Click here to view the interactive module and related content for this image.

FIGURE 2.21. Anterior cerebral artery. A, the lips of the anterior part of the interhemispheric fissure have been retracted to expose the branches of the pericallosal and callosomarginal arteries coursing around the genu of the corpus callosum. The callosomarginal artery arises anterior to the genu of the corpus callosum. The cortical branches (yellow arrow) pass around the superior margin to reach the lateral cortical surface. The A2 courses below the corpus callosum, the A3 courses around the callosal

genu, and the A4 and A5 course above the corpus callosum. B, enlarged view. A precallosal artery arises from the AComA adjacent to the left ACA and passes upward in front of the lamina terminalis and rostrum of the corpus callosum, sending branches to the diencephalon and corpus callosum along its course. C, another specimen. The lips of the interhemispheric fissure have been retracted to expose a large precallosal artery that ascends around the genu to reach the upper callosal surface. D, the large precallosal artery has been retracted to the left and the lamina terminalis opened to expose the mamillary bodies in the floor of the third ventricle. E, the floor of the third ventricle has been opened to expose the apex of the basilar artery and origin of the P1s in the interpeduncular cistern at the posterior margin of the circle of Willis. A., artery; A.Co.A., anterior communicating artery; Bas., basilar; Call. Marg., callosomarginal; Mam., mamillary; Pericall., pericallosal; Precall., precallosal.

Segments

The ACA is divided at the AComA into two parts, proximal (precommunicating) and distal (post-communicating) (Fig. 2.22). The proximal part, extending from the origin to the AComA, constitutes the A1 segment. The distal part is formed by the A2 (infracallosal), A3 (precallosal), A4 (supracallosal), and A5 (posterocallosal) segments. The relationships of the four distal segments are reviewed below, under Distal Part.



Click here to view the interactive module and related content for this image.

FIGURE 2.22. Variations in the origin of the callosomarginal artery from the pericallosal artery. The pericallosal artery is defined as arising at the AComA and the callosomarginal is defined as the branch arising from the pericallosal to course along the cingulate sulcus and supply two or more cortical areas. The callosomarginal artery can arise from the pericallosal artery just distal to the AComA or at any site along the course of the pericallosal artery. A and B show the most common variation in which the callosomarginal artery arises as the pericallosal artery courses around

the genu of the corpus callosum. A, the callosomarginal artery arises anterior to the genu of the corpus callosum. The distal part of the ACA, the part beginning at the AComA, is divided into four segments: The A2 extends from the AComA to the lower margin of the corpus callosum; the A3 courses around the anterior part of the corpus callosum; the A4 and A5 course above the anterior and posterior half of the corpus callosum, respectively. The anterior part of the falx cerebri is more widely separated from the corpus callosum than the posterior part. The inner edge of the anterior part of the falx is widely separated from the anterior part of the corpus callosum, but the space between the falx and callosal surface narrows as it proceeds posteriorly so that the posterior falx tightly hugs the splenium. The wide opening anteriorly between the falx and the corpus callosum permits the anterior part of the hemisphere and the more forward branches of the ACA to exhibit greater shift anteriorly than posteriorly. B, the falx has been removed. The distal ACA branches extend around the margins of the hemisphere to reach the orbital surface of the frontal lobe and the anterior two-thirds of the lateral convexity. The distal part of the pericallosal artery ascends to course along the cingulate sulcus to reach the paracentral lobule. C, the callosomarginal artery arises just distal to the AComA in the cistern of the lamina terminalis and ascends along the cingulate sulcus. The narrow band of the inner edge of the falx that contains the inferior sagittal sinus has been preserved to show the relationship of the branches of the pericallosal artery. The yellow arrow shows the site at which the ACA would show a sharp angulation when shifted to the opposite side by a mass lesion. A callosal artery arises just below the genu of the corpus callosum and crosses the upper callosal surface toward the splenium. D, the pericallosal artery arises in the subcallosal area several millimeters distal to the AComA and sends branches across the superior margin of the hemisphere to supply the adjacent part of the lateral convexity. E, the pericallosal artery turns anteriorly at the level of the lower margin of the genu of the corpus callosum and courses along the cingulate sulcus, where it gives rise to the callosomarginal artery. The pericallosal artery gives rise to a long callosal artery that courses posteriorly to reach the splenium. F, the callosomarginal artery arises at the level of the lower

margin of the callosal genu. The distal segments (A2 to A5) are shown. The ascending ramus of the cingulate sulcus marks the posterior border of the paracentral lobule formed by the central and precentral sulci overlapping onto the medical surface. A., artery; A.Co.A., anterior communicating artery; Asc., ascending; Call., callosal; Call. Marg., callosomarginal; Car., carotid; Cing., cingulate; Inf., inferior; Sag., sagittal; Paracent., paracentral; Pericall., pericallosal; Tent., tentorial; Vent., ventricle.

A1 Segment and the Anterior Communicating Arteries

The A1 courses above the optic chiasm or nerves to join the AComA. The junction of the AComA with the right and left A1 is usually above the chiasm (70% of brains) rather than above the optic nerves (30%) (Figs. 2.23 and 2.24) (26). Of those passing above the optic nerves, most journey above the nerve near the chiasm rather than distally. The shorter A1s are stretched tightly over the chiasm; the longer ones travel anteriorly over the optic nerves. The arteries with a more forward course are often tortuous and elongated, with some resting on the tuberculum sellae or planum sphenoidale. The A1 varies in length from 7.2 to 18.0 mm (average, 12.7 mm) (26). The length of the AComA is usually between 2 and 3 mm, but may vary from 0.3 to 7.0 mm (26). The longer AComAs are commonly curved, kinked, or tortuous.

A normal ACA-AComA complex is one in which an AComA connects A1s of nearly equal size, and both A1s and the AComA are of sufficient size to allow circulation between the two carotid arteries and through the anterior circle of Willis. The AComA diameter averages approximately 1 mm less than the average diameter of the A1. The AComA diameters are the same or larger than their smaller A1 in only 25% of the brains (26). Ten percent of the brains have an A1 of 1.5 mm or less in diameter and only 2% have an A1 with a diameter of 1.0 mm or less. The diameter of the AComA was 1.5 mm or smaller in 44% of brains and 1.0 mm or smaller in 16%.

The A1 is the favorite site on the circle of Willis for hypoplasia. A1 hypoplasia has a high rate of association with aneurysms; it is found with

85% of AComA aneurysms (Figs. 2.23 and 2.24) (38). It is the only anatomic variant that correlates with the location of cerebral aneurysm. The importance of this variant in aneurysm formation is reviewed in more detail in Chapter 3.

There is a direct correlation between the difference in size of the right and left A1s and the size of the AComA. As the difference in diameter between the A1s increases, so does the size of the AComA. Thus, a large AComA is often associated with a significant difference in diameter between the right and left A1. This is understandable from a functional point of view because, with a small or hypoplastic A1, more collateral circulation flows across the AComA to make up the deficit. A

difference in diameter of 0.5 mm or more between the right and left A1 is found in half of the brains and a difference of 1 mm or more in 12%. The average AComA diameter is 1.2 mm in the group of brains in which the difference in diameter between the right and left A1s is 0.5 mm or less and 2.5 mm if the difference is more than 0.5 mm. This correlation between the size of the A1s permits a rough estimate of the size of the AComA, even though the artery is not visualized, because it is the most difficult part of the circle of Willis to define on cerebral angiography.

Another difficulty in angiographically defining the AComA is that it is frequently not oriented in a strictly transverse plane. The length of the AComA is oriented in an oblique or straight anterior-posterior plane if one ACA passes between the hemispheres behind the other ACA. The ACAs are side by side as they pass between the cerebral hemispheres in approximately one in five hemispheres, and the left is anterior to the right more often than the right is anterior to the left. These variations may explain why angiography in the oblique position is often needed to define the AComA. The AComA usually has a round appearance, but it may seem flat because of a broad connection with both ACAs, or even triangular with a large base on one ACA and a threadlike connection on the other.

One AComA was present in 60%, two in 30%, and three in 10% of the brains we examined (Fig. 2.24) (26). Double AComAs can take a variety of forms; one is simply a hole in the middle of a broad or triangular artery separating arteries. The double or triple arteries can be approximately the same size or can vary markedly in diameter. A common pattern is for one to be large and the others relatively small. It is rare to find no connection between the two sides, but in some cases, the connection may be tiny—as small as 0.2 mm in diameter. An infrequent finding is duplication of a portion of the A1. Another infrequent anomaly consists of a third or median ACA arising from the AComA. The median artery courses upward and backward above the corpus callosum. It frequently divides opposite the paracentral lobule and gives branches to the paracentral lobules of both sides. In such cases, the ACAs proper are usually small and supply the anteromedial surfaces of the hemispheres.

Recurrent Artery

The recurrent branch of the ACA, first described by Heubner in 1874, is unique among arteries in that it doubles back on its parent ACA and passes above the carotid bifurcation and MCA into the medial part of the sylvian fissure before entering the anterior perforated substance (Figs. 2.16, 2.23, and 2.24) (18). It pursues a long, redundant path to the anterior perforated substance, sometimes looping forward on the gyrus rectus and inferior surface of the frontal lobe. In its journey to the anterior perforated substance, it is often closely applied to the superior or posterior aspect of the A1. It may seem, falsely, to be issuing from the A1 until further dissection clarifies its site of origin at the level of the AComA. The recurrent arteries arising proximally on the A1 follow a more direct path to the anterior perforated substance than those arising distally.

The recurrent branch is the largest artery arising from the A1 or the proximal 0.5 mm of the A2 in the majority of hemispheres (26). It may infrequently be absent on one side or arise as several branches. In our study, there was a single recurrent artery in 28% of the hemispheres, two in 48%, and three or four in 24% (26). If there were two or more recurrent arteries, both or at least one arose at the level of the junction of the A1 and A2 (36). Rarely does more than a single recurrent artery arise from the A1. If there are two recurrent arteries and one arises on the A1, the second usually arises at the junction of the A1 and A2. A large basal perforating artery may infrequently arise from the A1 between the AComA and the recurrent artery. The recurrent artery diameter is usually less than half that of the A1, but it may infrequently be as large as or exceed the A1 diameter if the A1 is hypoplastic.

The recurrent branch usually arises from the distal A1 or from the proximal part of the ACA segment just distal to the AComA, referred to as the A2; however, it may emerge at any point along the A1. It most commonly originates from the A2. In our study, it originated from the A2 in 78%, from the A1 in 14%, and at the A1–A2 junction at the level of the AComA in 8% (26). In 52%, it arose within 2 mm of the AComA, in 80% within 3 mm, and in 95% within 4 mm. The recurrent arteries arising near the AComA usually arise from the lateral side of the junction of the A1 and A2 at a right angle to the parent vessel. They may originate either in common with or give rise to the frontopolar artery.

Most recurrent arteries course anterior to the A1 and are seen on elevating the frontal lobe before visualizing the A1, but they may also course superior to the A1, between it and the anterior perforated substance, or may loop posterior to A1. It courses above the internal carotid bifurcation and the proximal middle cerebral artery in its lateral course.

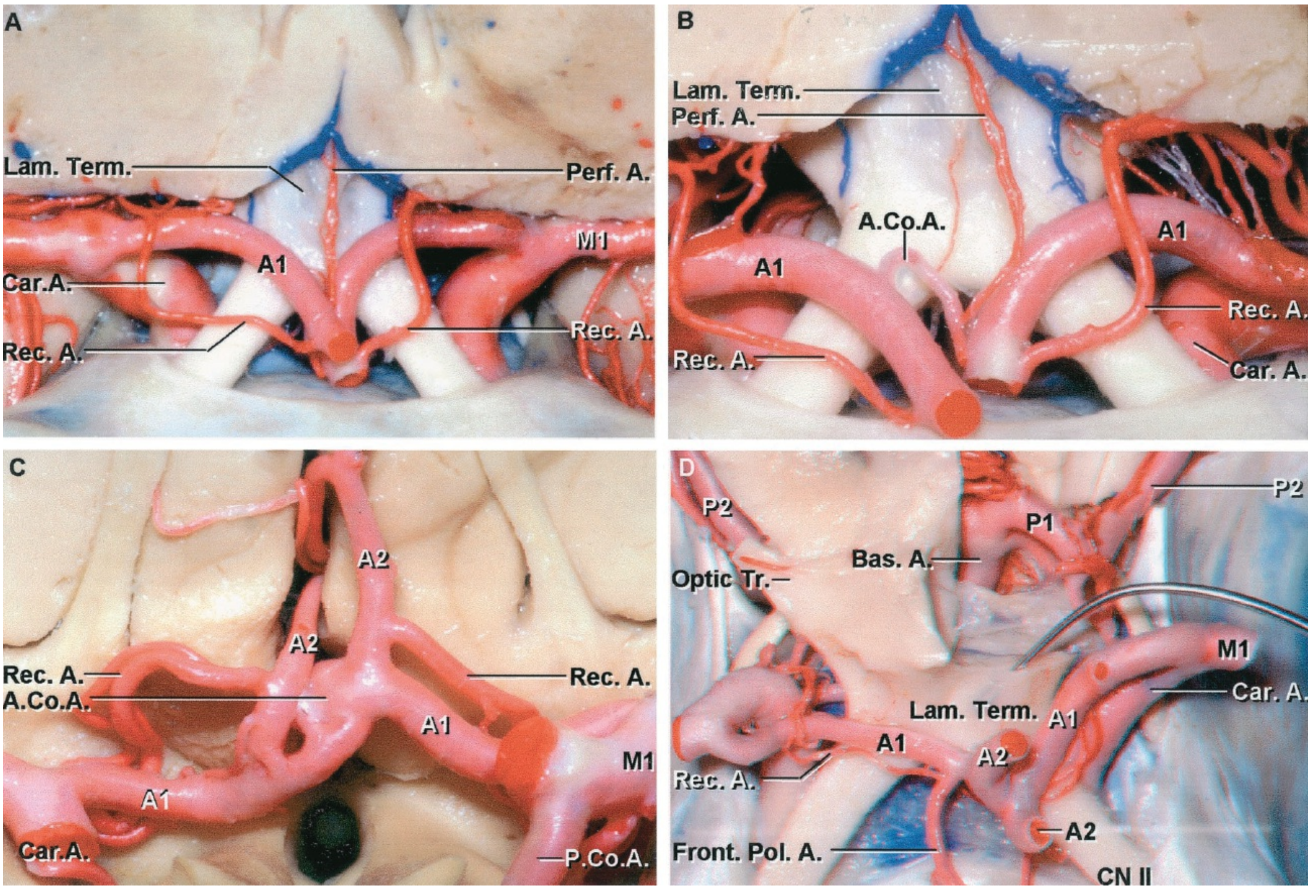
The recurrent artery may enter the anterior perforated substance as a single stem or divide into many branches (average, four). Of the total branches, approximately 40% terminate in the anterior perforated substance medial to the origin of the ACA, and 40% terminate lateral to the ACA origin. The remaining branches pass to the inferior surface of the frontal lobe adjacent the anterior perforated substance. The recurrent artery supplies the anterior part of the caudate nucleus, anterior third of the putamen, anterior part of the outer segment of the globus pallidus, anteroinferior portion of the anterior limb of the internal capsule, and the uncinate fasciculus, and, less commonly, the anterior hypothalamus. The hypothalamic supply is less than from the A1. In the treatment of anterior communicating aneurysms, great care must be taken to avoid unnecessary manipulation or occlusion of Heubner’s artery. Occlusion may cause hemiparesis with facial and brachial predominance because of compromise of that branch supplying the anterior limb of the internal capsule, and aphasia if the artery is on the dominant side.

Basal Perforating Branches

The A1 and A2 and the AComA give rise to numerous basal perforating arteries (Figs. 2.16 and 2.24). An average of 8 basal perforators (range, 2–15), exclusive of Heubner's artery, arise from each A1 (26, 27). The lateral half of A1 is a richer source of branches than the medial half. The A1 branches terminate, in descending order of frequency, in the anterior perforated substance, the dorsal surface of the optic chiasm or the suprachiasmatic portion of the hypothalamus, the optic tract, dorsal surface of the optic nerve, and the sylvian fissure between the cerebral hemispheres and the lower surface of the frontal lobe. The striking difference in the termination of A1 branches as compared with those from the recurrent artery is the lack of recurrent artery branches to the upper surface of the optic nerves and chiasm and the anterior hypothalamus and the greater number of recurrent branches entering the sylvian fissure. Approximately 40% of both A1 and recurrent artery branches terminate in the anterior perforated substance medial to the A1 origin, but almost no Heubner's branches enter the area around the optic chiasm and tract, although 40% of those from A1 terminated there. Approximately 40% of the recurrent artery branches enter the anterior perforated substance lateral to the carotid bifurcation.

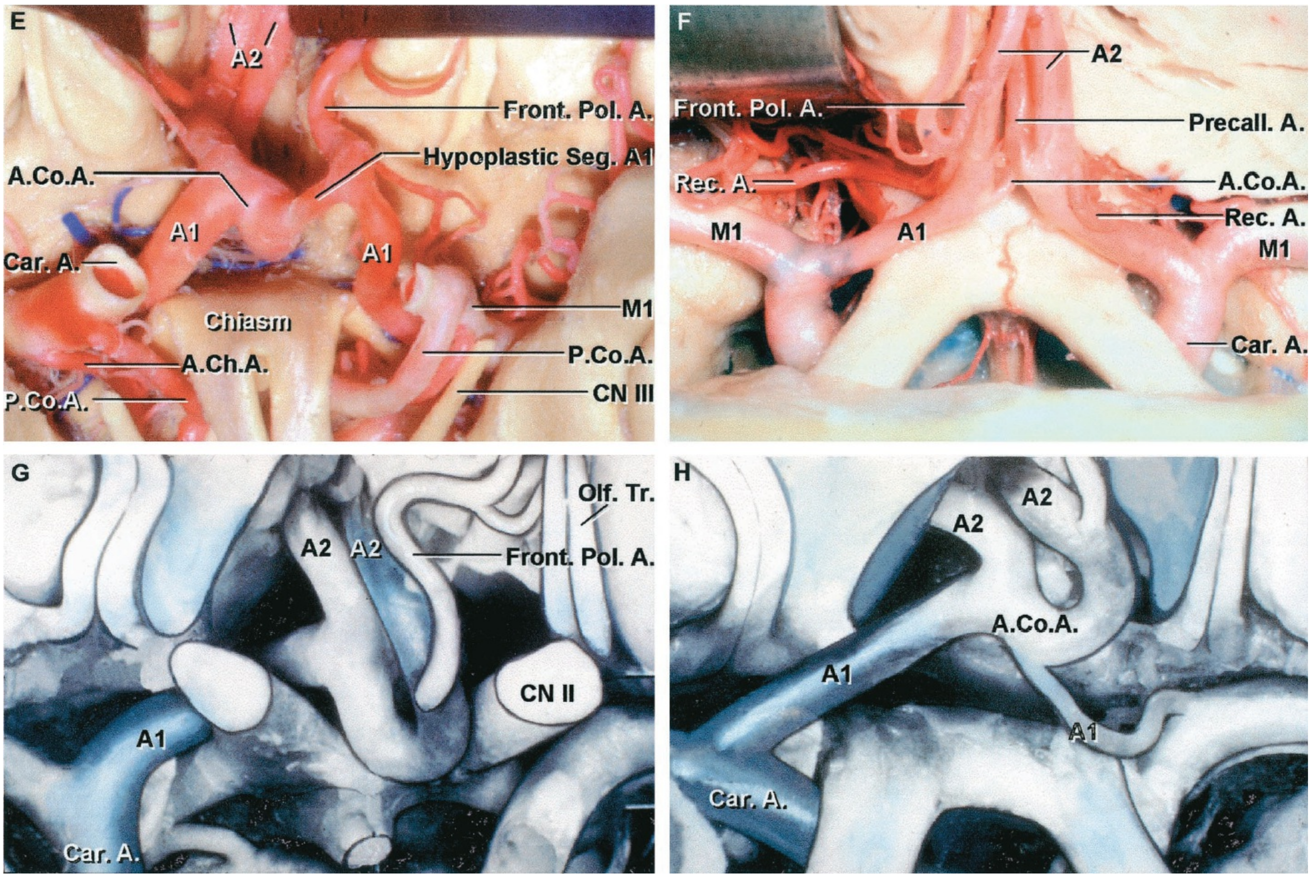
The A1, excluding the recurrent artery and the A2, most consistently supplies the chiasm and anterior third ventricle and hypothalamic area, but only inconsistently supplies the caudate and globus pallidus. Heubner's artery, by contrast, provides a rich supply to the caudate and adjacent internal capsule, but much less to the hypothalamus than the A1. Involvement of the hypothalamic branches that arise mainly from A1, without implication of the recurrent artery, may result in emotional changes, personality disorders, and intellectual deficits, including anxiety and fear, weak spells, and symptoms referable to disordered mentation, such as dizziness, agitation, and hypokinesis without paralysis or alterations of the conscious or waking state (6, 26). The frequent inclusion of recurrent artery ischemia when the A1 branches are involved adds a hemiparesis with brachial predominance to the deficit. This contrasts with the crural weakness of distal ACA occlusion.

The AComA also frequently gives rise to perforating arteries that terminate in the superior surface of the optic chiasm and above the chiasm in the anterior hypothalamus (Figs. 2.16, 2.23, and 2.24). The AComA is frequently the site of origin of one or two, but as many as four branches that terminate, in descending order of frequency, in the suprachiasmatic area, dorsal surface of the optic chiasm, anterior perforated substance, and frontal lobe, and perfuse the fornix, corpus callosum, septal region, and anterior cingulum (6, 8). Most arise from the superior or posterior surfaces of the AComA. The A2, to be discussed below, is also the site of origin of perforating branches terminating in the inferior frontal area, anterior perforated substance, dorsal optic chiasm, and the suprachiasmatic area.



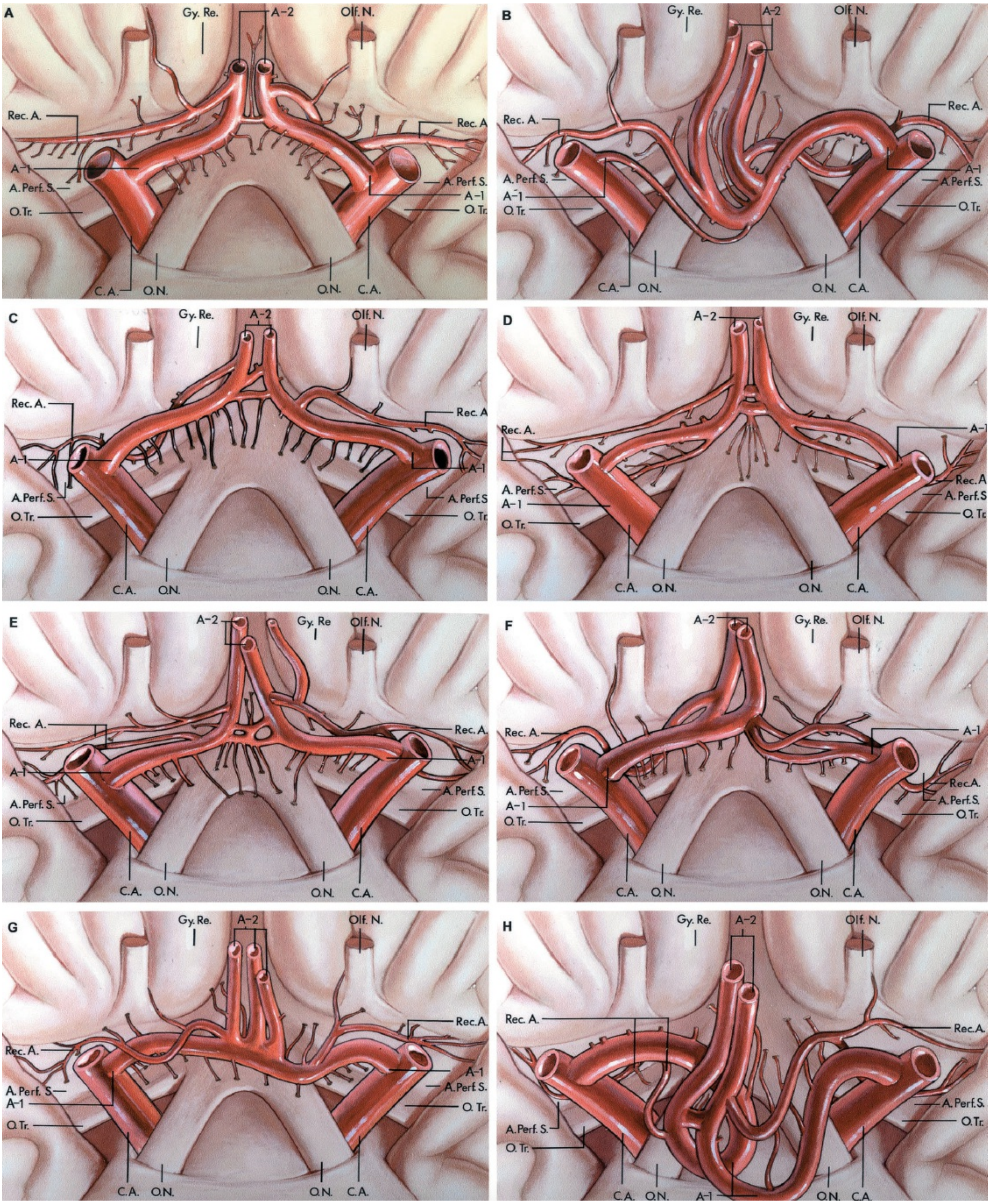
Click here to view the interactive module and related content for this image.

FIGURE 2.23 A-D. Variations in the anterior part of the circle of Willis. A, anterior view of A1s of nearly equal size. The AComA is hypoplastic and is hidden between the ACAs. Recurrent arteries arise from the A2s at the same level on both sides. B, the A2s have been separated to expose the AComA, which is the site of a perforating branch that enters the brain through the region of the lamina terminalis. C, the A1s are of equal size and give rise to A2s of approximately the same size. The AComA is broad and somewhat dimpled and is expanding behind the right A2 in what may be the beginning of an aneurysm. Both recurrent arteries arise from the proximal A2. D, the left A1 is larger than the right A1. The right recurrent artery arises from a frontopolar artery and passes laterally toward the carotid bifurcation. The AComA is of approximately the same diameter as the left A1 and is the predominant source of flow to both A2s. The floor of the third ventricle has been opened to expose the basilar apex and the P1s.



Click here to view the interactive module and related content for this image.

FIGURE 2.23 E-H. E, the left A1 gives rise to a frontopolar branch. The segment of the A1 between the origin of the frontopolar branch and the AComA is hypoplastic. The right A1 is dominant and provides the majority of the flow to both A2s. F, anterior view. The left A1 is larger than the right. The AComA is short and small. A precallosal artery arises from the left A1-A2 junction near the AComA. The right recurrent artery arises from the frontopolar artery and passes laterally above the carotid bifurcation. The left recurrent artery arises at the level of the AComA. G and H, most common anatomic variant associated with an AComA aneurysm. G, the right A1 is dominant and gives rise to both A2s. The left A1 is hidden behind the optic nerve. The left A2 loops downward between the optic nerves. H, the anterior communicating complex has been elevated to show the hypoplastic left A1. A., artery; A.Ch.A., anterior choroidal artery; Bas., basilar; Car., carotid; CN, cranial nerve; Front. Pol., frontopolar; Lam., lamina; Olf., olfactory; P.Co.A., posterior communicating artery; Perf., perforating; Precall., precallosal; Rec., recurrent; Seg., segment; Term., terminalis; Tr., tract.



Click here to view the interactive module and related content for this image.

FIGURE 2.24. Anterior views of A1 and proximal A2 segments of the ACA, AComA, and recurrent arteries. Gyrus rectus, olfactory tract, and frontal lobe above; optic nerves and chiasm below. Arterioles to optic nerves, chiasm, and tracts, and lamina terminalis arise from the ACA and

AComA. A, A1 segments of equal size and small communicating artery pass above the optic chiasm. Recurrent arteries arise from the lateral side of A2. Recurrent arteries pass anterosuperior to A1. B, both A2 segments arise from large left A1. The right A1 is small. A1 segments pass above the optic nerves. Recurrent arteries arise from A2 segments. Right recurrent artery is longer than the A1 segment. The left recurrent artery passes superior to the A1. Branches of the AComA supply the lamina terminalis above the optic chiasm. C, A1 segments are connected by a double communicating artery. The right recurrent artery arises from the A2 and courses above the A1. The left recurrent artery arises from and passes above the A1. Multiple arterioles pass to the optic chiasm and tract. D, A1 segments are connected by a double communicating artery. Two recurrent arteries arise on the right; one arises proximal and one distal to the communicating artery. The left recurrent artery arises from the posterior aspect of the A1. A spray of arterioles passes from the communicating artery to the optic chiasm. E, a multichanneled AComA gives rise to multiple arterioles to the optic nerves and chiasm and lamina terminalis. A double

recurrent artery is on the right. The left recurrent artery gives rise to a large branch that passes below the gyrus rectus to the frontal tip. F, the left A1 segment is split into a double channel. Both A2 segments arise predominantly from the right A1. The left recurrent artery arises from one of the two A1 segments on the left. The right recurrent artery arises from the A2. G, triple A2 segments arise from the communicating artery area. The left recurrent artery arises from the A1 segment; right from the junction of the A1 and A2 segments. H, tortuous A1 segments loop forward to the area of the tuberculum sellae. The left recurrent artery arises from the A2 segment and the right recurrent artery arises from the A1 segment. A., anterior, artery; C.A., carotid artery; Gy., gyrus; N., nerve; O., optic; Olf., olfactory; Perf., perforated; Re., rectus; Rec., recurrent; S., substance; Tr., tract. (From, Perlmutter D, Rhoton AL Jr: Microsurgical anatomy of the anterior cerebral-anterior communicating-recurrent artery complex. J Neurosurg 45:259–272, 1976 [26].)

Distal Part

The distal or postcommunicating part of the ACA begins at the AComA and extends around the corpus callosum to its termination (Figs. 2.22 and 2.25). The distal ACA is divided into four segments (A2 through A5). The A2 (infracallosal) segment begins at the AComA, passes anterior to the lamina terminalis, and terminates at the junction of the rostrum and genu of the corpus callosum. The A3 (precallosal) segment extends around the genu of the corpus callosum and terminates where the artery turns sharply posterior above the genu. The A4 (supracallosal) and A5 (postcallosal) segments are located above the corpus callosum and are separated into an anterior (A4) and posterior (A5) portion by a point bisected in the lateral view close behind the coronal suture. The A2 and A3 segments, together, and A4 and A5 have been referred to as the ascending and horizontal segments, respectively (27). In our discussion, the distal ACA is synonymous with the precallosal artery.

The Pericallosal Artery

The pericallosal artery is the portion of the ACA distal to the AComA around and on or near the corpus callosum (Figs. 2.22, 2.25, and 2.26). Some authors reserve that term for the artery formed by the bifurcation near the genu of the corpus callosum into the pericallosal and callosomarginal arteries (27). We refer to the segment distal to the AComA as the pericallosal artery because both the AComA and pericallosal artery are consistently present, but the callosomarginal artery is inconsistent; it is quite variable with regard to its site of origin and is absent in nearly 20% of hemispheres (27). If one assumes the pericallosal artery begins at the callosomarginal origin, the variability of origin of the callosomarginal artery could place the origin of the pericallosal artery at any point from near the AComA to the genu of the corpus callosum, and, in addition, if the callosomarginal artery is absent, some arbitrary point must be selected as the origin of the pericallosal artery. Thus, the term pericallosal artery refers to the portion of the ACA beginning at the AComA, which includes the A2 to A5 segments.

The Callosomarginal Artery

The callosomarginal artery, the largest branch of the pericallosal artery, is defined as the artery that courses in or near the cingulate sulcus and gives rise to two or more major cortical branches (Figs. 2.22, 2.25, and 2.26) (27). The callosomarginal artery is present in 80% of hemispheres. The callosomarginal artery cannot be defined in terms of a given group of vessels that arises from it because any of the usual branches of the callosomarginal artery may arise directly from the pericallosal artery. It follows a course roughly parallel to that of the pericallosal artery, coursing above the cingulate gyrus in or near the cingulate sulcus. Its origin varies from just distal to the AComA to the level of the genu of the corpus callosum. Its most frequent origin is from the A3, but it may also arise from the A2 or A4. Its branches ascend on the medial surface of the hemisphere and continue on to the lateral convexity for approximately 2 cm. Portions of the premotor, motor, and sensory areas are included in its area of perfusion.

The size of the pericallosal artery distal to the callosomarginal origin varies inversely with the size of the callosomarginal artery. Immediately past the origin of the callosomarginal artery, the pericallosal and callosomarginal arteries are equal in diameter in only 20% of hemispheres; the pericallosal is larger in 50%; and the callosomarginal is larger in 30% (27). The callosomarginal artery should not be mistaken for the pericallosal artery in lateral angiography, because the mistaken wider curvature may be falsely interpreted as representing hydrocephalus.

The anterior portion of the falx cerebri is consistently narrower than its posterior part, with the free margin of its anterior portion lying well above the genu of the corpus callosum, whereas the free margin of its posterior portion is more closely applied to the splenium (Fig. 2.22). The entire course of the pericallosal artery, except for the posterior portion, is below the free margin of the falx cerebri and is free to shift across the midline. The callosomarginal artery, on the other hand, has only the most anterior portion below the free margin of the falx; the remainder lies above the free edge, and its displacement across the midline is limited by the rigidity of the falx (Fig. 2.22, A–C).

Distal ACA Branches

The distal ACA gives origin to two types of branches: 1) basal perforating branches to basal structures including the optic chiasm, suprachiasmatic area, lamina terminalis, and anterior hypothalamus, structures located below the rostrum of the corpus callosum; and 2) cerebral branches divided into cortical branches to the cortex and adjacent white matter and subcortical branches to the deep white and gray matter and the corpus callosum.

Basal Perforating Branches

The A2 segment typically gives rise to 4 or 5 (range, 0–10) basal perforating branches that supply the anterior hypothalamus, septum pellucidum, medial portion of the anterior commissure, pillars of the fornix, and anteroinferior part of the striatum (Figs. 2.16, 2.23, and 2.24) (26, 27, 39). They commonly take a direct course from the A2 segment to the anterior diencephalon. In a few cases, the perforating branches may arise from a larger artery, referred to as the precallosal artery, that originates from A2 and passes upward between the A2 segment and the lamina terminalis toward the genu of the corpus callosum (Figs. 2.21 and 2.23). The recurrent artery may also arise from the A2, as described above.

Cortical Branches

The cortical branches supply the cortex and adjacent white matter of the medial surface from the frontal pole to the parietal lobe where they intermingle with branches of the PCA (Figs. 2.25–2.27). On the basal surface, the ACA supplies the medial part of the orbital gyri, the gyrus rectus, and the olfactory bulb and tract. On the lateral surface, the ACA supplies the area of the superior frontal gyrus and the superior parts of the precentral, central, and postcentral gyri. The band of lateral cortex supplied by the ACA is wider anteriorly, often extending beyond the superior frontal sulcus, and narrows progressively posteriorly. The distal ACA on one side sends branches to the contralateral hemisphere in nearly two-thirds of brains.

Eight cortical branches are typically encountered (Figs. 2.26 and 2.27). They are orbitofrontal, frontopolar, internal frontal, paracentral, and the parietal arteries; the internal frontal group is divided into the anterior, middle, and posterior frontal arteries, and the parietal group is divided into superior and inferior parietal arteries. The smallest cortical branch is the orbitofrontal artery, and the largest is the posterior internal frontal artery. The frontopolar and orbitofrontal arteries are present in nearly all hemispheres; the least frequent branch is the inferior parietal artery, present in approximately two-thirds of hemispheres. The most frequent ACA segment of origin of the cortical branches is as follows: orbitofrontal and frontopolar arteries, A2; the anterior and middle internal frontal and callosomarginal arteries, A3; the paracentral artery, A4; and the superior and inferior parietal arteries, A5. The posterior internal frontal artery arises with approximately equal frequency from A3, A4, and the callosomarginal artery. All of the cortical branches arise from the pericallosal artery more frequently than they do from the callosomarginal. Of the major cortical branches, one of the internal frontal arteries or the paracentral artery arises most frequently from the callosomarginal. The cortical branch that arises most frequently from the callosomarginal artery is the middle internal frontal artery. Of the callosomarginal arteries present in our study, 50% gave rise to two major cortical branches, 32% gave rise to three, 16% gave rise to four, and, in one hemisphere (2%), five of the eight major cortical branches arose from the callosomarginal artery (27).

1. Orbitofrontal Artery

This artery, the first cortical branch of the distal ACA, is present in nearly all hemispheres. It commonly arises from the A2, but may also arise as a common trunk with the frontopolar artery. It may uncommonly arise from the A1 segment just proximal to the AComA. From its origin, it passes down and forward toward the floor of the anterior cranial fossa to reach the level of the planum sphenoidale. It supplies the gyrus rectus, olfactory bulb, and tract, and the medial part of the orbital surface of the frontal lobe.

2. Frontopolar Artery

The next cortical branch, the frontopolar artery, arises from the A2 segment of the pericallosal artery in 90% of hemispheres and from the callosomarginal artery in 10%. From its origin, it passes anteriorly along the medial surface of the hemisphere toward the frontal pole. It crosses the subfrontal sulcus and supplies portions of the medial and lateral surfaces of the frontal pole.

3. Internal Frontal Arteries

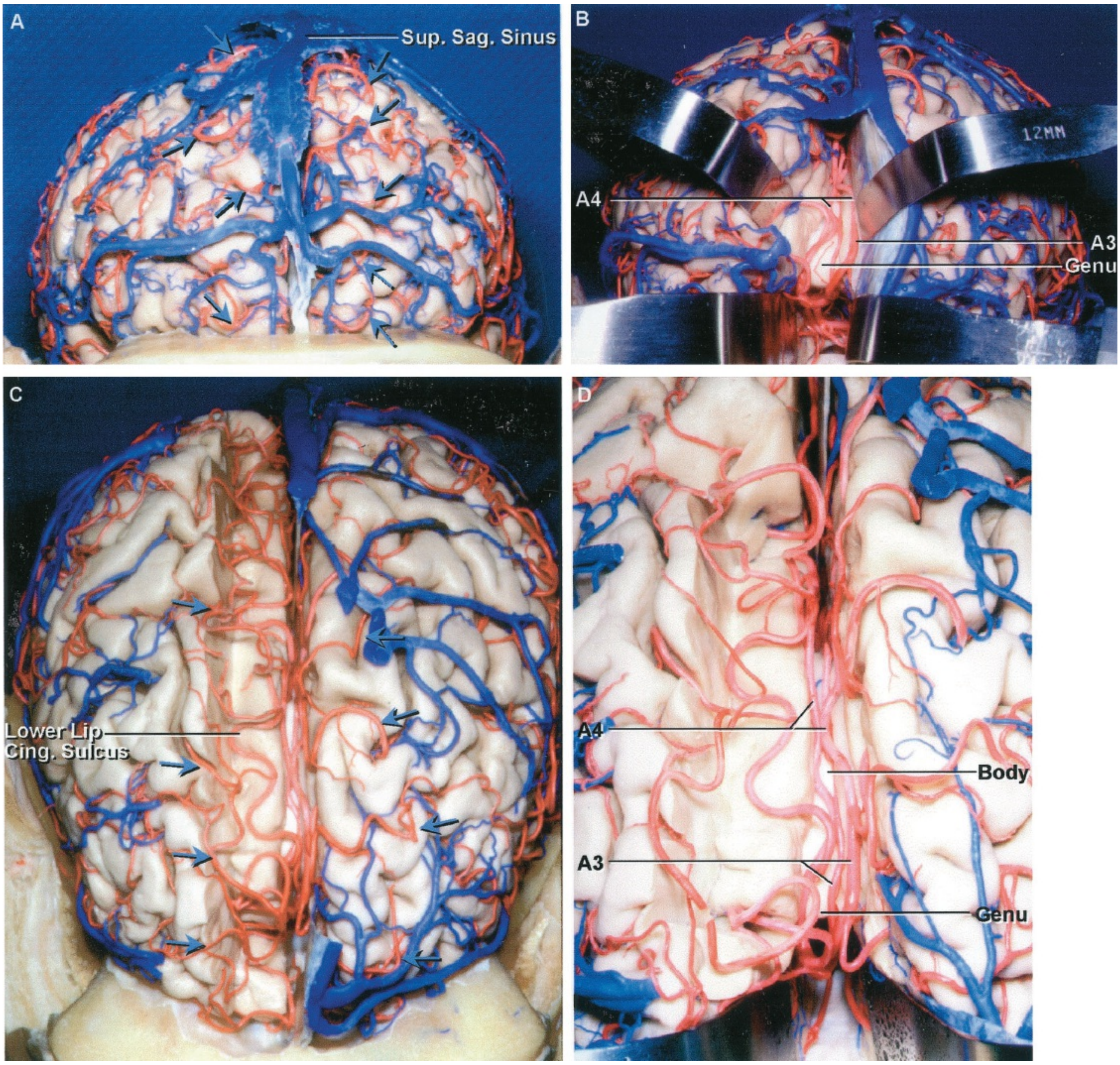
The internal frontal arteries supply the medial and lateral surfaces of the superior frontal gyrus as far posteriorly as the paracentral lobule (6). They most commonly arise from the A3 segment of the pericallosal artery or from the callosomarginal artery. Combinations of origins in which one or two internal frontal arteries have separate origins from the pericallosal artery, but the remaining artery or arteries arise from the callosomarginal, are common. The anterior internal frontal artery usually arises as a separate branch of the A2 or A3, but may also arise from the callosomarginal artery; it supplies the anterior portion of the superior frontal gyrus. The origin, whether from the pericallosal or callosomarginal artery, is most often at or inferior to the level of the genu of the corpus callosum. The middle internal frontal artery arises with nearly equal frequency from the pericallosal and the callosomarginal arteries and courses posteriorly in the cingulate sulcus a short distance before turning vertically to cross over the superior cortical margin im the middle portion of the superior frontal gyrus. It supplies the middle portion of the medial and lateral surfaces of the superior frontal gyrus. It is the cortical branch that arises most frequently from the callosomarginal artery. The posterior internal frontal artery arises with nearly equal frequency from the A3 and A4 and the callosomarginal artery and courses upward to the cingulate sulcus, then backward for a short distance before turning superiorly to terminate in the uppermost limit of the precentral fissure. It supplies the posterior third of the superior frontal gyrus and part of the cingulate gyrus. Its branches frequently reach the anterior portion of the paracentral lobule.

4. Paracentral Artery

This branch usually arises from the A4 or the callosomarginal artery approximately midway between the genu and splenium or the corpus callosum. It usually courses anterior to the marginal limb of the cingulate sulcus or in the paracentral sulcus before turning vertically to the superior portion of the paracentral lobule, where it supplies a portion of the premotor, motor, and somatic sensory areas. It may represent the terminal portion of the ACA.

5. Parietal Arteries

The parietal arteries, named the superior and inferior parietal arteries, supply the ACA distribution posterior to the paracentral lobule. The superior parietal artery arises from the A4 or A5 and from the callosomarginal artery and supplies the superior portion of the precuneus. It usually originates anterior to the splenium of the corpus callosum and courses in the marginal limb of the cingulate sulcus. If it courses posterior to the marginal limb, it often sends a branch to it. It is frequently the last cortical branch of the ACA. The inferior parietal artery most commonly arises from the A5 just before the latter courses around the splenium of the corpus callosum and supplies the posteroinferior part of the precuneus and adjacent portions of the cuneus. It is the least frequent cortical branch of the ACA (64% of hemispheres). An origin from the callosomarginal artery is uncommon.



Click here to view the interactive module and related content for this image.

FIGURE 2.25. Anterior cerebral artery. A, anterior view of the cerebral hemispheres. The branches of the ACA cross the superior and anterior margins of the hemisphere to supply the adjacent part of the lateral convexity (arrows). These ACA branches exiting the interhemispheric fissure course deep to the venous lacunae and the cortical veins entering the superior sagittal sinus. B, the falx and right frontal lobe have been retracted to expose the A3s passing around the genu of the corpus callosum deep in the interhemispheric fissure. The A4s course above the anterior part of the callosal body. C, the cortical strip above the right cingulate sulcus has been removed, while preserving the ACA branches

looping deep within the sulci on the medial surface of the hemisphere. These branches often course within a sulci along the superior margin to reach the lateral surface. D, enlarged view of the branches of the ACA coursing deep within the cingulate sulcus. Some branches course deep within sulci along the superior margin of the hemisphere rather than looping over the upper edge of the superior margin to reach the lateral surface. Cing., cingulate; Sag., sagittal; Sup., superior.

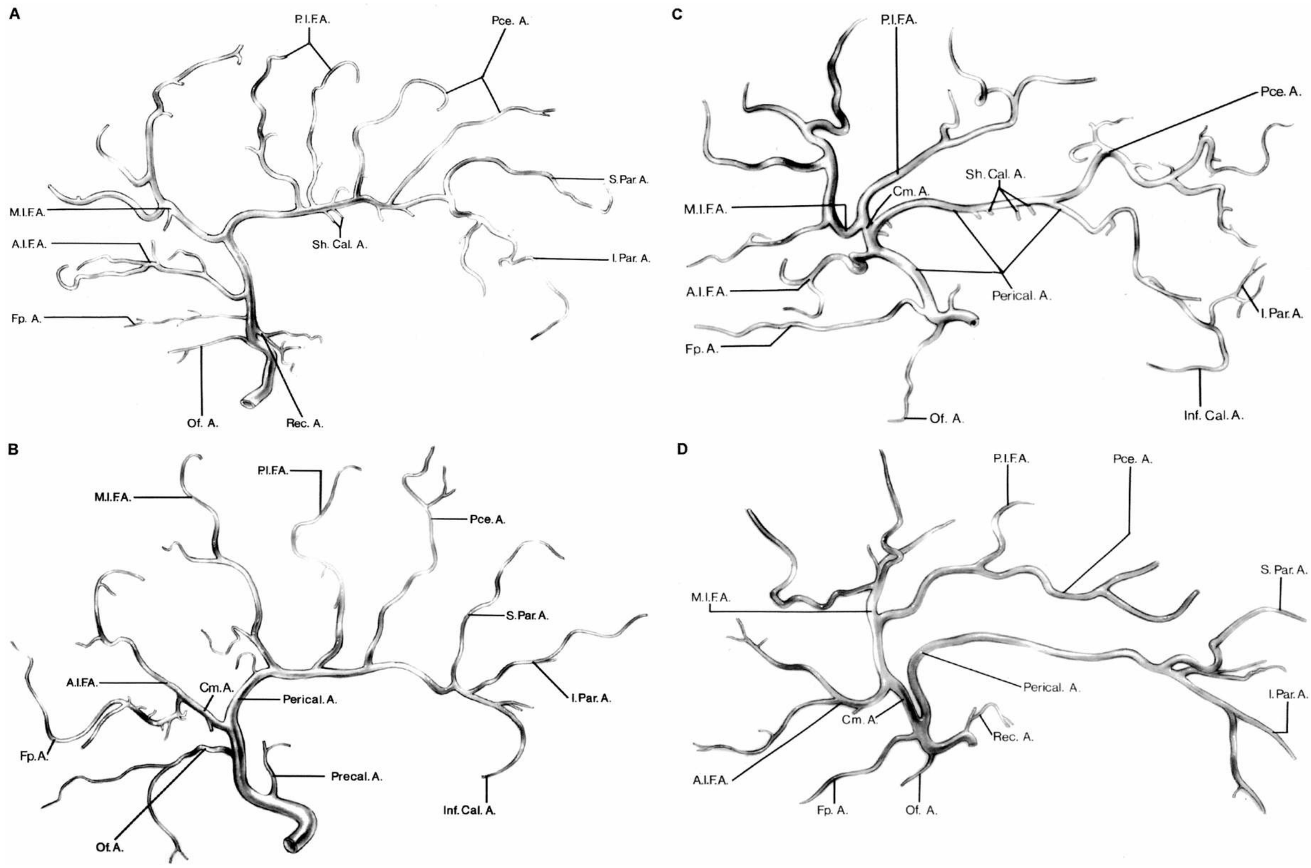
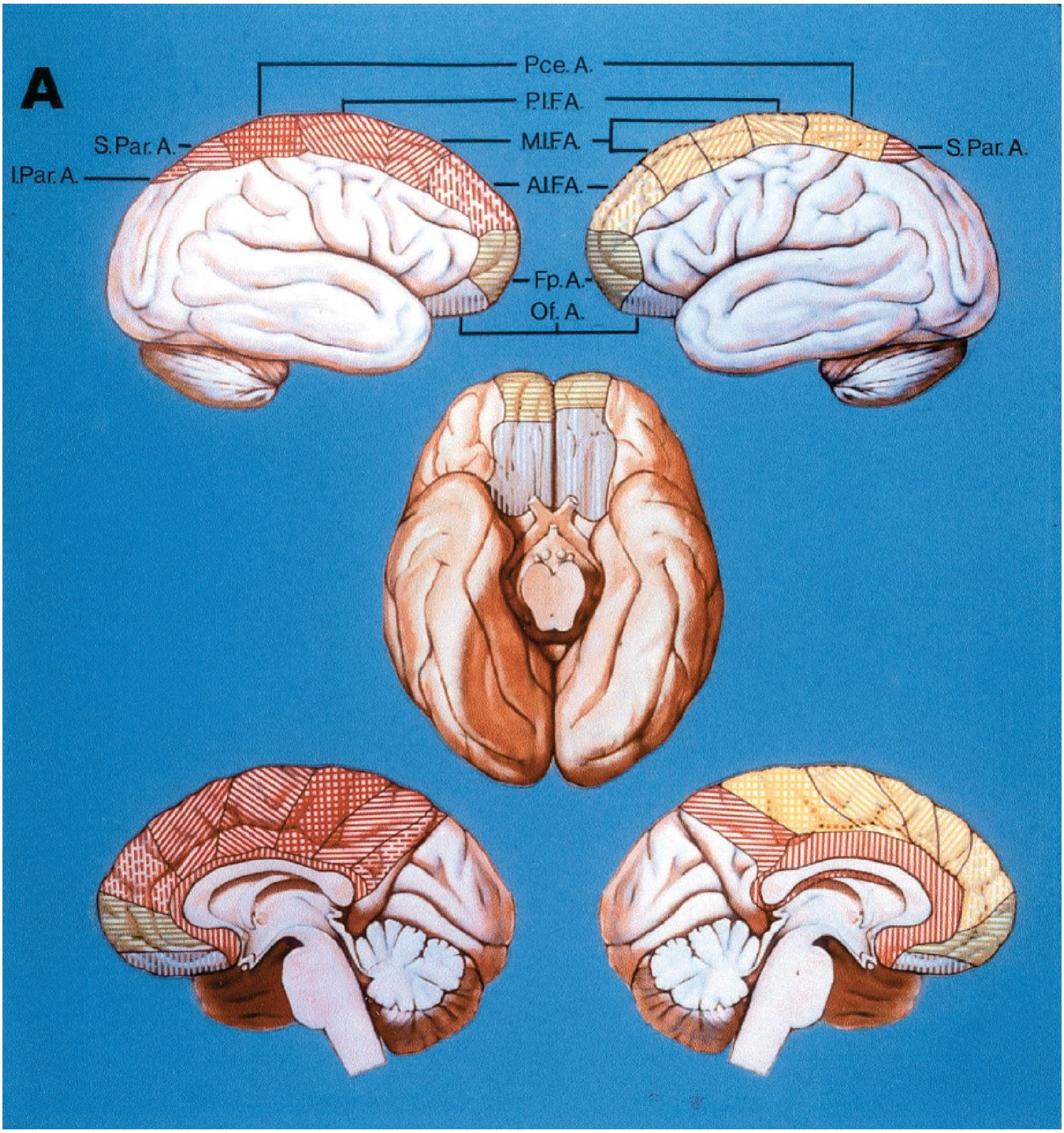


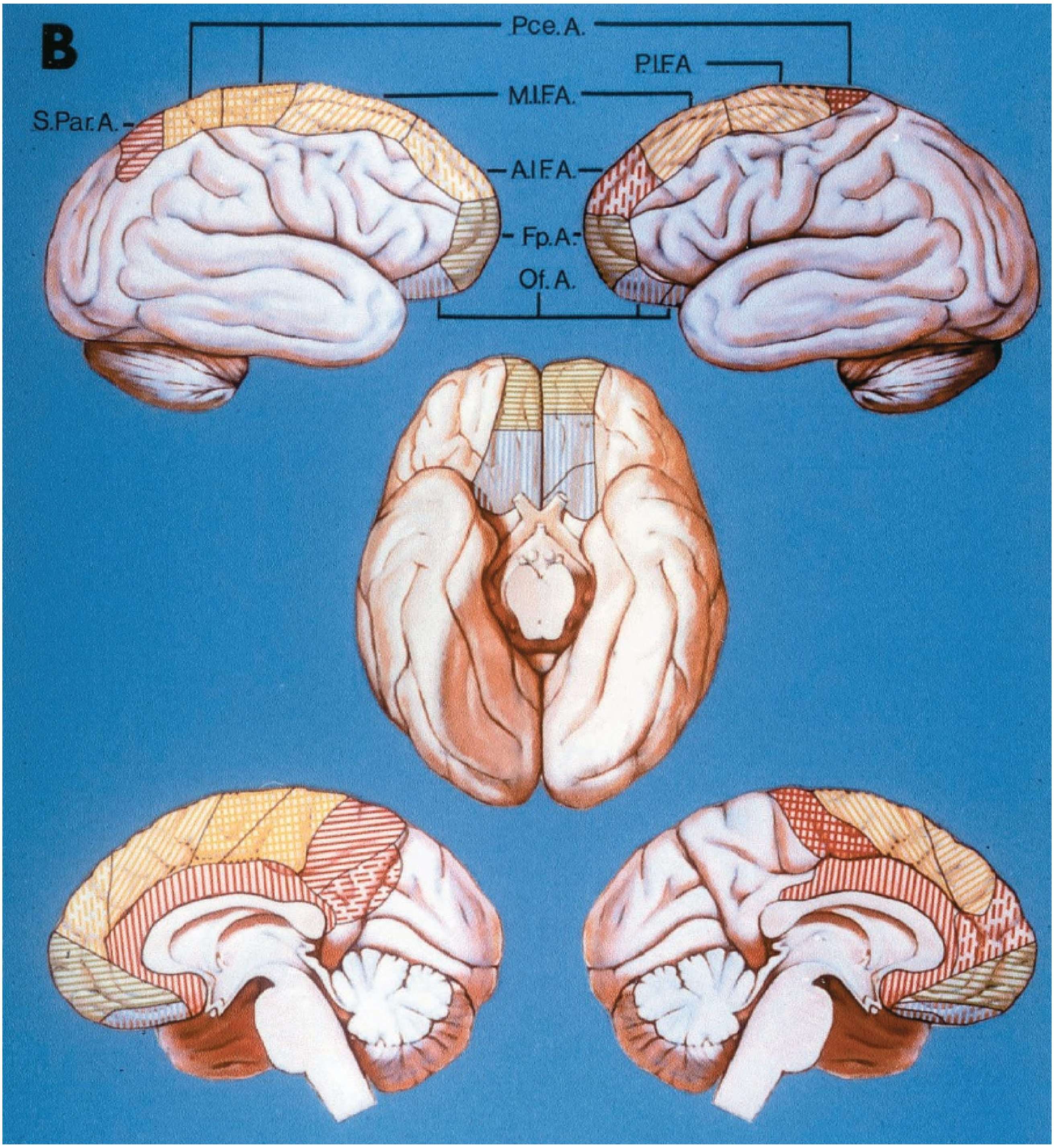
FIGURE 2.26. Drawings of anterior cerebral arteries dissected from the cerebral hemispheres. The pericallosal, callosomarginal, orbitofrontal, frontopolar, anterior, middle and posterior internal frontal, paracentral, superior and inferior parietal, short callosal, inferior callosal, recurrent, and precallosal arteries are seen. A, there is no communicating artery and all the individual cortical branches of the ACA arise directly from the pericallosal artery. There are two posterior internal frontal and paracentral arteries. Short callosal branches arise from the pericallosal artery. B, the callosomarginal artery gives origin to two cortical branches: the frontopolar and anterior internal frontal arteries. The other cortical branches arise from the pericallosal artery. Precallosal and inferior callosal arteries are present. C, the callosomarginal artery gives origin to the middle internal frontal and posterior internal frontal arteries. Short

and inferior callosal arteries are present. D, four cortical branches arise from the callosomarginal artery. A., artery; A.I.F.A., anterior internal frontal artery; Cal., callosal; Cm., callosomarginal; Fp., frontopolar; I., inferior; Inf., inferior; M.I.F.A., middle internal frontal artery; Of., orbitofrontal; Par., parietal; Pce., paracentral; Perical., pericallosal; P.I.F.A., posterior internal frontal artery; Precal., precallosal; Rec., recurrent; S., superior; Sh., short. (From, Perlmutter D, Rhoton AL Jr: Microsurgical anatomy of the distal anterior cerebral artery. J Neurosurg 49:204–228, 1978 [27].)



Click here to view the interactive module and related content for this image.

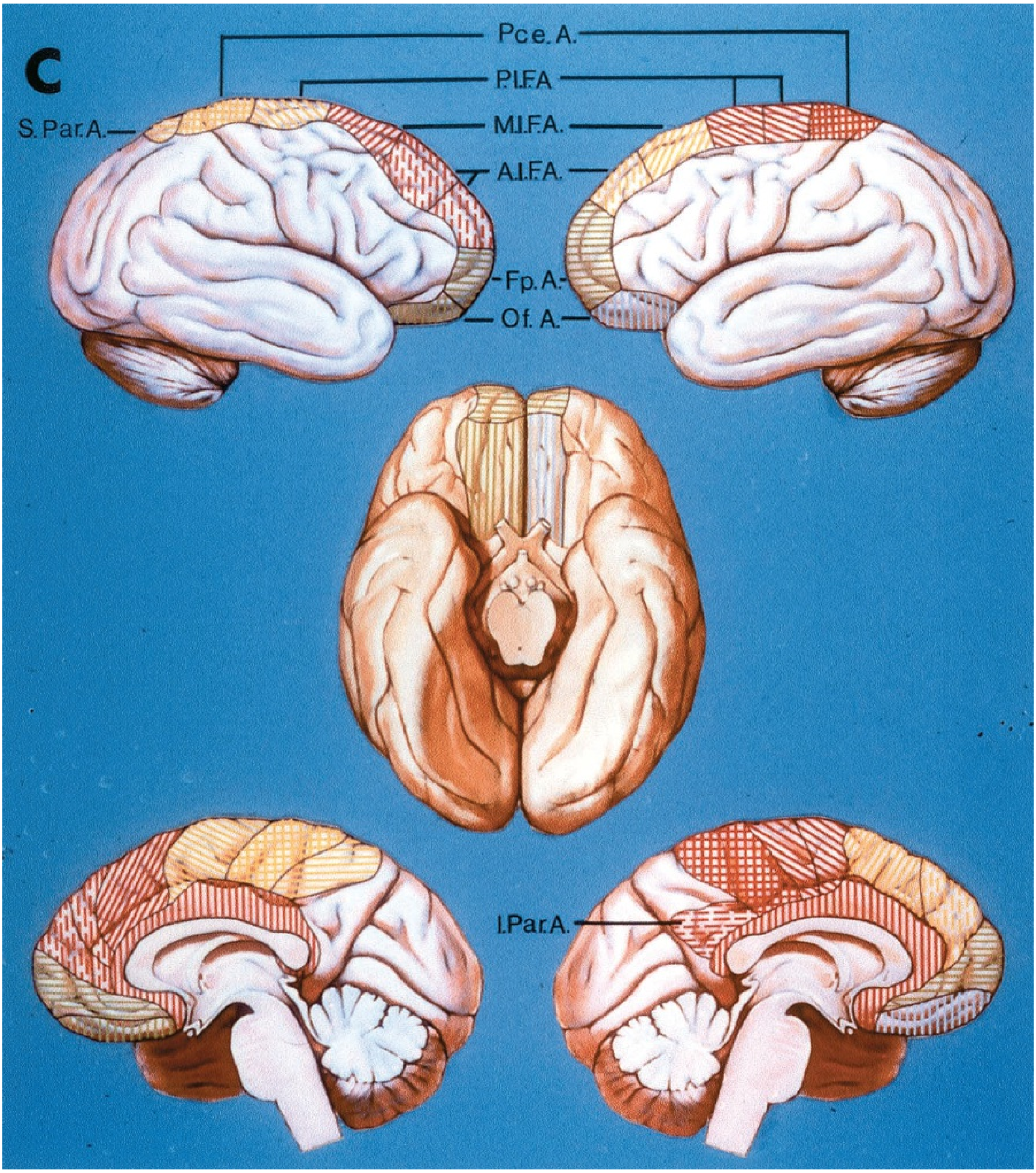
FIGURE 2.27. A, area of supply of the distal anterior cerebral artery and its individual branches. The areas shown in blue, green, and red are supplied by branches arising directly from the pericallosal artery. Areas in yellow arise from branches of the callosomarginal artery. The orbitofrontal and frontopolar arteries are shown in green and blue, respectively. The anterior internal frontal artery shows as vertical broken lines, the middle internal frontal artery as oblique lines passing upward to right; the posterior internal frontal artery as oblique lines passing downward to right; the paracentral artery as cross-hatched; the superior parietal artery as horizontal lines; the inferior parietal artery as horizontal broken lines; and the pericallosal area supplied by short or terminal branches of the pericallosal artery as vertical lines. A, right cerebral hemisphere (upper and lower left, and left half of basal view). All cortical branches of the ACA arise directly from pericallosal artery and are shown in blue, green, and red. The callosomarginal artery is absent in 18% of hemispheres. Left hemisphere (upper and lower right, and right half of basal view) shows four of the major cortical branches arising from the callosomarginal artery (yellow area). The anterior internal frontal through the paracentral arteries arise from the callosomarginal artery. The maximum number of cortical branches that arise from the callosomarginal artery is five. The terminal branch of the pericallosal artery passes around the splenium of the corpus callosum toward the foramen of Monro. The inferior parietal artery is absent.



Click here to view the interactive module and related content for this image.

FIGURE 2.27. B, the right hemisphere (upper and lower left, and left half of basal view) shows an unusually large area of supply of the ACA, extending beyond the parieto-occipital fissure to the cuneus. The posterior internal frontal artery is absent. The callosomarginal artery gives rise to the anterior and middle posterior frontal and the paracentral arteries (yellow area). The black line subdivides the cross-hatched area of the paracentral artery to show the two separate branches arising from

the pericallosal artery to supply the area of the paracentral artery. The left hemisphere (upper and lower right, and right half of basal view) shows an unusually small area of supply of the ACA. The branches reach only the paracentral area. The callosomarginal artery gives origin to two cortical branches: the middle and posterior internal frontal arteries (yellow area). The superior and inferior parietal arteries are absent. The black line divides the orbitofrontal area (blue lines) to show that it was supplied by two separate branches of the pericallosal artery.



Click here to view the interactive module and related content for this image.

FIGURE 2.27. C, the right hemisphere (upper and lower left, and left half of basal view) shows the orbitofrontal and frontopolar arteries arising from a common trunk (both shown in green), a relatively posterior area of supply of three branches arising from the callosomarginal artery (yellow area), and absence of the inferior parietal artery. The left hemisphere (upper and lower right, and right half of basal view) illustrates two cortical branches arising from the callosomarginal area (yellow) and absence of the superior and presence of the inferior parietal artery. The black line subdivides the area of posterior internal frontal artery to show that two separate branches arise from the pericallosal artery to supply this area. A., artery; A.I.F.A., anterior internal frontal artery; Fp., frontopolar; I., inferior; M.I.F.A., middle internal frontal artery; Of., orbitofrontal; Par., parietal; Pce., paracentral; P.I.F.A., posterior internal frontal artery; S., superior. (From, Perlmutter D, Rhoton AL Jr: Microsurgical anatomy of the distal anterior cerebral artery. J Neurosurg 49:204–228, 1978 [27].)

Convexity Branches

There are large areas of the lateral cortical distribution of the ACA where there is a good chance of finding a vessel of sufficient diameter for a bypass anastomosis with a frontal branch of the superficial temporal artery. The area offering the best chance of finding an adequate ACA branch on the lateral surface was determined by drawing a circumferential line on the outer circumference of the hemisphere beginning at the sylvian fissure and continuing around the frontal pole and over the superior hemispheric margin toward the occipital pole. The minimum diameter needed for an anastomosis is usually considered to be 0.8 mm (27). An identical line was drawn 2 cm inside the circumferential line. The largest percentage of ACA branches crossing these lines was located on the anterior portion of the hemisphere between the 5-cm and 15-cm points on the circumferential line.

Callosal Branches

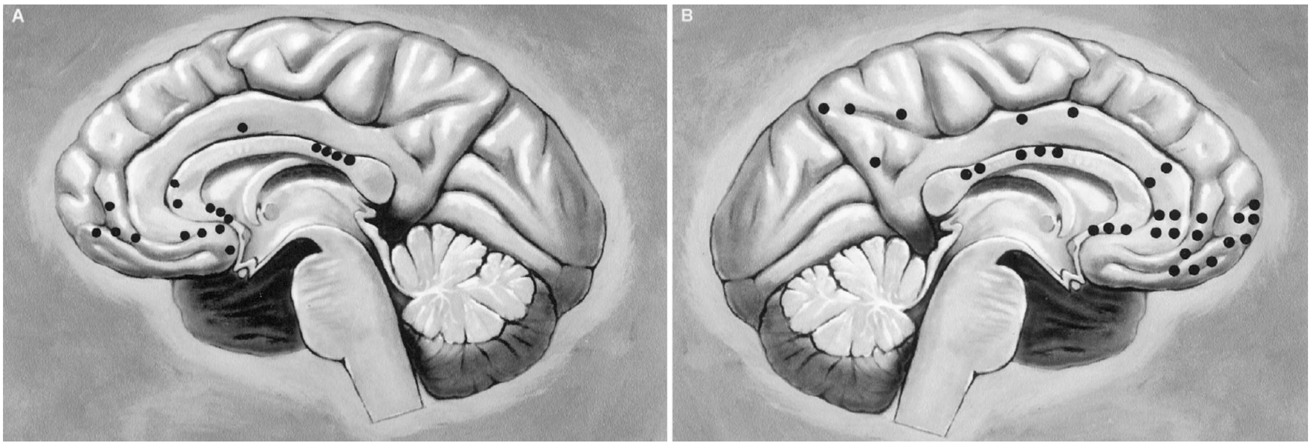
The ACA is the principal artery supplying the corpus callosum. The pericallosal artery sends branches into the rostrum, genu, body, and splenium and often passes inferiorly around the splenium. The terminal pericallosal branches are joined posteriorly by the splenial branches of the PCA. The corpus callosum is most commonly supplied by perforating branches, called short callosal arteries because they arise from the pericallosal artery and penetrate directly into the corpus callosum. As many as 20 short callosal branches (average, 7) may be found in one hemisphere (27). These branches not only supply the corpus callosum, but continue through it to supply the septum pellucidum, the anterior pillars of the fornix, and part of the anterior commissure.

In a few cases, well-formed longer branches, referred to as long callosal arteries, arise from the pericallosal artery and course parallel to the pericallosal artery, between it and the surface of the corpus callosum, to give origin to callosal perforating branches (Fig. 2.22). In addition to sending branches to the corpus callosum, they may supply adjacent cortex as well as the septal nuclei, septum pellucidum, and upper portions of the column of the fornix (27). The pericallosal artery frequently continues around the splenium of the corpus callosum, distal to the origin of the last cortical branch, and passes forward on the lower callosal surface, reaching the foramen of Monro in a few cases.

The precallosal artery, an infrequently occurring A2 or AComA branch, passes upward like a long callosal artery between the pericallosal artery and the lamina terminalis, sending branches into the anterior diencephalon and giving off multiple small branches to the rostrum and inferior part of the genu of the corpus callosum.

Anomalies

Anomalies of the distal ACA, including triplication of the postcommunical segment, failure of pairing of the distal ACA, and bihemispheric branches, are found in approximately 15% of brains (2). A bihemispheric branch is one that divides distal to the AComA and provides the major supply to the medial surface of both hemispheres. In the presence of such an anomaly, occlusion of one ACA distal to the AComA may produce bilateral cerebral injury similar to that produced by blocking both ACAs. The distal ACA on one side sends branches to the contralateral hemisphere in nearly two-thirds of brains (Fig. 2.28). However, most supply only a small area on the medial surface of the contralateral hemisphere. An infrequent anomaly is one in which the ACA distal to the A1 segment is unpaired and a single distal ACA divides to supply both hemispheres (26).



Click here to view the interactive module and related content for this image.

FIGURE 2.28. Medial surface of cerebral hemispheres. A, right hemisphere; B, left hemisphere. Black dots indicate points where a branch from the opposite anterior cerebral artery arrives to supply the hemisphere shown. Based on the right and left hemispheres from 25 brains (from, Perlmutter D, Rhoton AL Jr: Microsurgical anatomy of the distal anterior cerebral artery. J Neurosurg 49:204–228, 1978 [27]).

Anterior Perforating Arteries

The anterior perforating arteries are the group of arteries that enter the brain through the anterior perforated substance (Figs. 2.29–2.31). The interrelationships between the anterior perforated arteries from the different sources and the vital tracts and nuclei they supply in the central part of the cerebrum make them deserving of special attention. These arteries have an intimate relationship to aneurysms of the internal carotid and the middle and anterior cerebral arteries, and to tumors arising deep under the brain (Fig. 2.32) (31, 35, 36).

The anterior perforated substance is a rhomboid-shaped area buried deep in the sylvian fissure, bounded anteriorly by the lateral and medial olfactory striae, posteriorly by the optic tract and the temporal lobe, laterally by the limen insulae; medially, it extends above the optic chiasm to the interhemispheric fissure (Fig. 2.29). The arteries passing below and sending branches into the anterior perforated substance are the ICA, MCA, and ACA, and the AChA. The perforating arteries from each parent artery enter a specific mediolateral and anteroposterior territory of the anterior perforated substance. The site of penetration in the mediolateral direction is described in relation to a line passing posteriorly along the olfactory tract. This line, dividing the anterior perforated substance into medial and lateral territories, crosses the anterior perforated substance near its greatest anterior-posterior dimension and transects the optic tract as it passes around the cerebral peduncle. The medial territory extends above the optic chiasm to the interhemispheric fissure, and the lateral territory extends into the sylvian fissure to the limen insulae. The site of penetration of each group of arteries is also relatively constant in an anterior-posterior direction, based on subdivision of the anterior perforated substance into anterior, middle, and posterior zones extending across the full width of the anterior perforated substance, from the interhemispheric fissure to the limen insulae (Figs. 2.29–2.31).

Choroidal Segment of the C4

The C4 branches entering the anterior perforated substance arise from the choroidal segment (Fig. 2.30, A and B). The choroidal segment sends branches to the anterior perforated substance in nearly 100% of hemispheres (36). These branches tend to originate closer to the bifurcation than to the origin of the AChA. The branches arising at the bifurcation tend to be stouter than those arising below the bifurcation. Typically, these C4 branches follow a posterosuperior route to the posterior portion of the anterior perforated substance, near the optic tract. Approximately half of the branches penetrate the medial territory of the anterior perforated substance and half penetrate the lateral territory.

Most enter the posterior or middle zones and very few enter the anterior zone.

Anterior Choroidal Artery

The AChA sends branches to the anterior perforated substance in 90% of hemispheres (13, 33, 36) (Fig. 2.30, C–F). The majority of the branches pursue a posterior, superior, and medial course, or a direct posterior and superior course to the anterior perforated substance. The branches arising at the origin of the AChA are somewhat stouter than those arising distally. These branches enter the posteromedial portion of the anterior perforated substance close to the optic tract and the line along the olfactory tract separating the medial and lateral territories. Approximately two-thirds of these branches enter the medial and one-third enter the lateral territory of the anterior perforated substance. Most enter the posterior zone or adjacent part of the middle zone of the anterior perforated substance.

Middle Cerebral Artery

The branches to the anterior perforated substance, called the lenticulostriate arteries, arise from the M1 and M2 and occasionally from the early branches (Fig. 2.30, G–J). They arise from the prebifurcation part of the M1 in every case and from the postbifurcation part of the M1 segment in half of the hemispheres. The lenticulostriate arteries are divided into medial, intermediate, and lateral groups. The medial group, present in half of the hemispheres, pursues a relatively direct course to enter the anterior perforated substance just lateral to the C4 branches. Ninety percent of the medial lenticulostriate arteries enter the lateral territory of the anterior perforated substance, whereas only 10% enter the medial territory (36). The predominant pattern is for them to enter the middle and posterior zones of the anterior perforated substance. In the hemispheres in which the medial group of lenticulostriate arteries are absent, their territory in the anterior perforated substance is occupied by branches from the C4 and the ACA, AChA, and the intermediate lenticulostriate arteries.

The intermediate lenticulostriate arteries entering the anterior perforated substance between the medial and lateral lenticulostriate arteries are present in more than 90% of hemispheres. They enjoy a generous area of distribution in the lateral territory of the anterior perforated substance. Nearly 90% enter the middle or posterior zones of the anterior perforated substance between the territory of the medial and lateral lenticulostriate arteries, lateral to the branches from the C4, and posterior to the branches of the recurrent artery.

The lateral lenticulostriate arteries, present in almost all hemispheres, originate predominantly on the lateral part of the M1, but may also arise from the early branches of the M1 or from the M2. They pursue an S-shaped course to enter the posterolateral part of the anterior perforated substance. All of the lateral lenticulostriate arteries enter the lateral territory of the anterior perforated substance near the limen insulae, and nearly all enter the posterior zone of the lateral part of the anterior perforated substance.

Anterior Cerebral Artery

The branches of the anterior cerebral artery to the anterior perforated substance arise from two sources. First, the A1 gives rise to branches that pass directly to the anterior perforated substance. Second, the A1 and proximal part of the A2 give rise to the recurrent artery that sends branches to a broad extent of the anterior perforated substance (Fig. 2.30, M–P). Nearly all A1s send branches to the anterior perforated substance. Nearly 90% arise from the proximal half of the A1 and pursue a direct posterior and superior course to the anterior perforated substance. The ones with a more medial origin journey laterally to reach the anterior perforated substance. Most enter the medial territory of the anterior perforated substance near the optic chiasm and tract, and the remainder enter the lateral territory. Most enter the middle and posterior zones of the anterior perforated substance, predominantly posterior to the branches from the recurrent artery, anteromedial to those from the internal carotid and anterior choroidal arteries, and medial to those from the middle cerebral artery.

The recurrent artery is the largest and longest of the branches directed to the anterior perforated substance. It is present, sending branches to the anterior perforated substance, in all hemispheres. The recurrent branches enter the full mediolateral extent of the anterior perforated substance, yet have a limited representation in the anterior-posterior dimension. The territory penetrated by recurrent branches extends into the narrow part of the medial territory above the optic chiasm and into the lateral territory as far as the inner margin of the limen insulae. Their anteroposterior distribution is limited in contrast to their rich mediolateral representation, in that they are confined predominantly to the anterior half of the anterior perforated substance. The branches from recurrent arteries with a more lateral origin from the A1 have a greater tendency to enter the middle and posterior zones than those arising at the junction of the A1 and A2. By virtue of its long mediolateral extent, the recurrent artery borders on the territory of all the other groups entering the anterior perforated substance.

Discussion

In summary, the ICA and AChA branches enter the posterior half of the central portion of the anterior perforated substance. The MCA enters the middle and posterior portions of the lateral half of the anterior perforated substance. The A1 gives rise to branches that enter the medial half of the anterior perforated substance above the optic nerve and chiasm. The recurrent artery sends branches into the anterior two-thirds of the full mediolateral extent of the anterior perforated substance. There are minimal anastomoses and limited overlap between the different groups at the level of the anterior perforated substance, making it most important that each of these groups be protected in operative approaches to the area. There is a reciprocal relationship between the intraparenchymal and anterior perforated substance territories of the ICA, AChA, ACA, and MCA such that the size of one artery's territory increases or decreases the other artery's territory in a reciprocal manner.

The deep cerebral structures located directly above the anterior perforated substance are the frontal horn and the anterior part of the caudate nucleus, putamen, and internal capsule (23). The anterior perforating arteries pass through the parts of the caudate nucleus, putamen, and internal capsule directly above the anterior perforated substance, and spread posteriorly to supply larger parts of these structures and the adjacent areas of the globus pallidus and thalamus (Fig. 2.32) (39, pp 30–33). The C4 branches penetrating the anterior perforated substance perfuse the genu of the internal capsule and the adjacent part of the globus pallidus, posterior limb of the internal capsule, and thalamus. The branches of the AChA entering the anterior perforated substance supply the medial two segments of the globus pallidus, the inferior part of the posterior limb of the internal capsule, and the anterior and ventrolateral nuclei of the thalamus. The lateral and intermediate groups of lenticulostriate arteries pass through the putamen and arch medially and posteriorly to supply almost the entire anterior-to-posterior length of the upper part of the internal capsule and the body and head of the caudate nucleus. The medial lenticulostriate arteries irrigate the area medial to and below that supplied by the lateral and intermediate lenticulostriate arteries; this area includes the lateral part of the globus pallidus, the superior part of the anterior limb of the internal capsule, and the anterosuperior part of the head of the caudate nucleus.

The A1 branches supply the area below the anteromedial part to the territory supplied by the lenticulostriate arteries. This region includes the area around the optic chiasm, the anterior commissure, the anterior hypothalamus, the genu of the internal capsule, and the anterior part of the globus pallidus. Its area of supply may less commonly extend to the contiguous part of the posterior limb of the internal capsule and to the anterior part of the thalamus (26). The recurrent artery supplies the most anterior and inferior parts of the head of the caudate nucleus and putamen, and the adjacent part of the anterior limb of the internal capsule (26).

The arteries entering the anterior perforated substance are intrinsically related to and commonly exposed in operations for aneurysms of the internal carotid, anterior communicating, and middle cerebral arteries. These relationships are reviewed in Chapter 3. The intradural exposure of the C4 and all of the arteries sending branches to the anterior perforated substance can be achieved using a small frontotemporal flap centered at the pterion. All of these aneurysms related to the anterior perforating arteries can be exposed by this approach along the ipsilateral sphenoid ridge, with opening of the sylvian fissure. Selected striatal arteriovenous malformations involving the arteries entering the anterior perforated substance have been treated by incision of the anterior perforated substance and occlusion of the feeding arteries without producing a deficit (Fig. 2.16I) (41). Operative treatment of these arteriovenous malformations is usually considered only if the lesion is located directly above the anterior perforated substance in the area anterior to the genu of the internal capsule, unless the genu and posterior limb of the internal capsule have already been damaged.

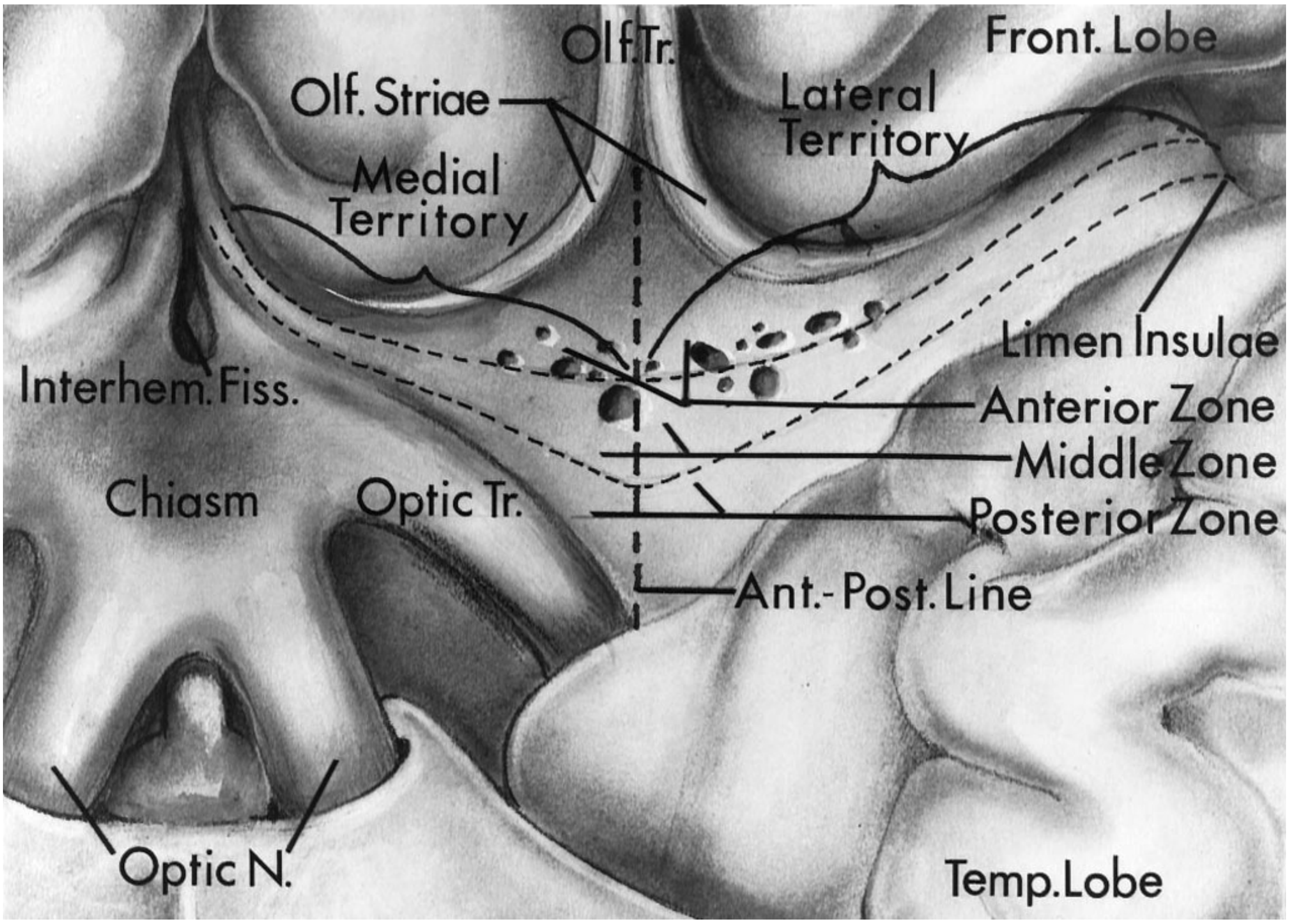
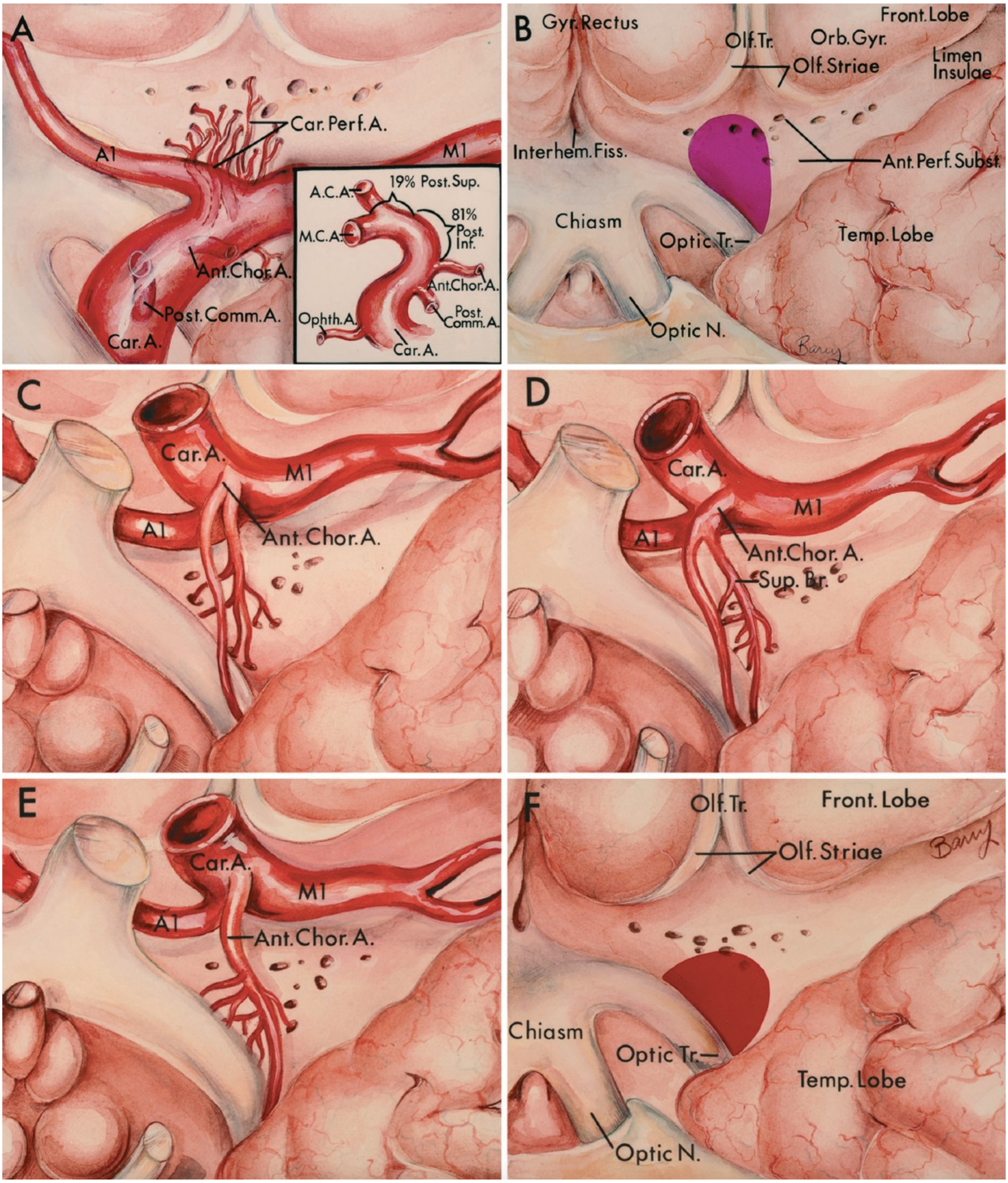


FIGURE 2.29. Territories and zones within the anterior perforated substance. The anterior perforated substance lies between the frontal and temporal lobes. It is bounded anteriorly by the medial and lateral olfactory striae, and posteriorly by the temporal lobe and optic tract. The anterior perforated substance is divided into medial and lateral territories

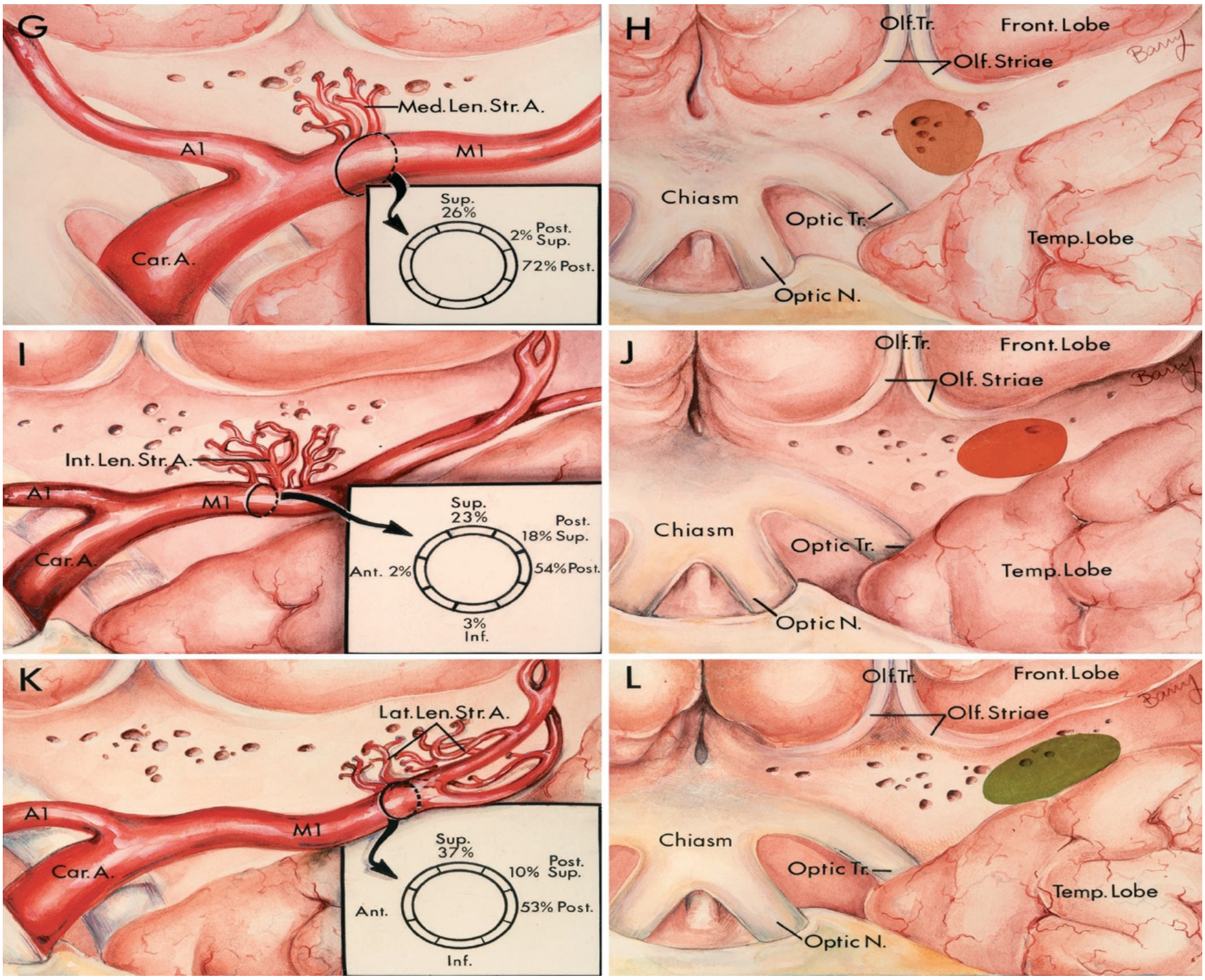
by a line drawn posteriorly along the olfactory tract. The medial territory extends above the optic nerve and chiasm to the interhemispheric fissure, and the lateral territory extends laterally in the sylvian fissure to the limen insulae. The anterior perforated substance is also divided into three transverse strips, the anterior, middle, and posterior zones, which extend from the interhemispheric fissure to the limen insulae, and correspond roughly to the anterior, middle, and posterior thirds of the anterior perforated substance. The point at which each artery penetrates these territories and zones is recorded. The medial and lateral olfactory striae are continuous anteriorly with the olfactory tract. Ant., anterior; Interhem., interhemispheric; Fiss., fissure; Front., frontal; N., nerve; Olf., olfactory; Post., posterior; Temp., temporal; Tr., tract. (From, Rosner SS, Rhoton AL Jr, Ono M, Barry M: Microsurgical anatomy of the anterior perforating arteries. J Neurosurg 61:468–485, 1984 [36].)



[Click here](#) to view the interactive module and related content for this image.

FIGURE 2.30 A–F. A, arteries entering the anterior perforated substance. The internal carotid, anterior and middle cerebral, anterior choroidal, and recurrent arteries send branches to the anterior perforated substance. The carotid branches arise distal to the origin of the anterior choroidal artery, well above the origin of the ophthalmic and posterior

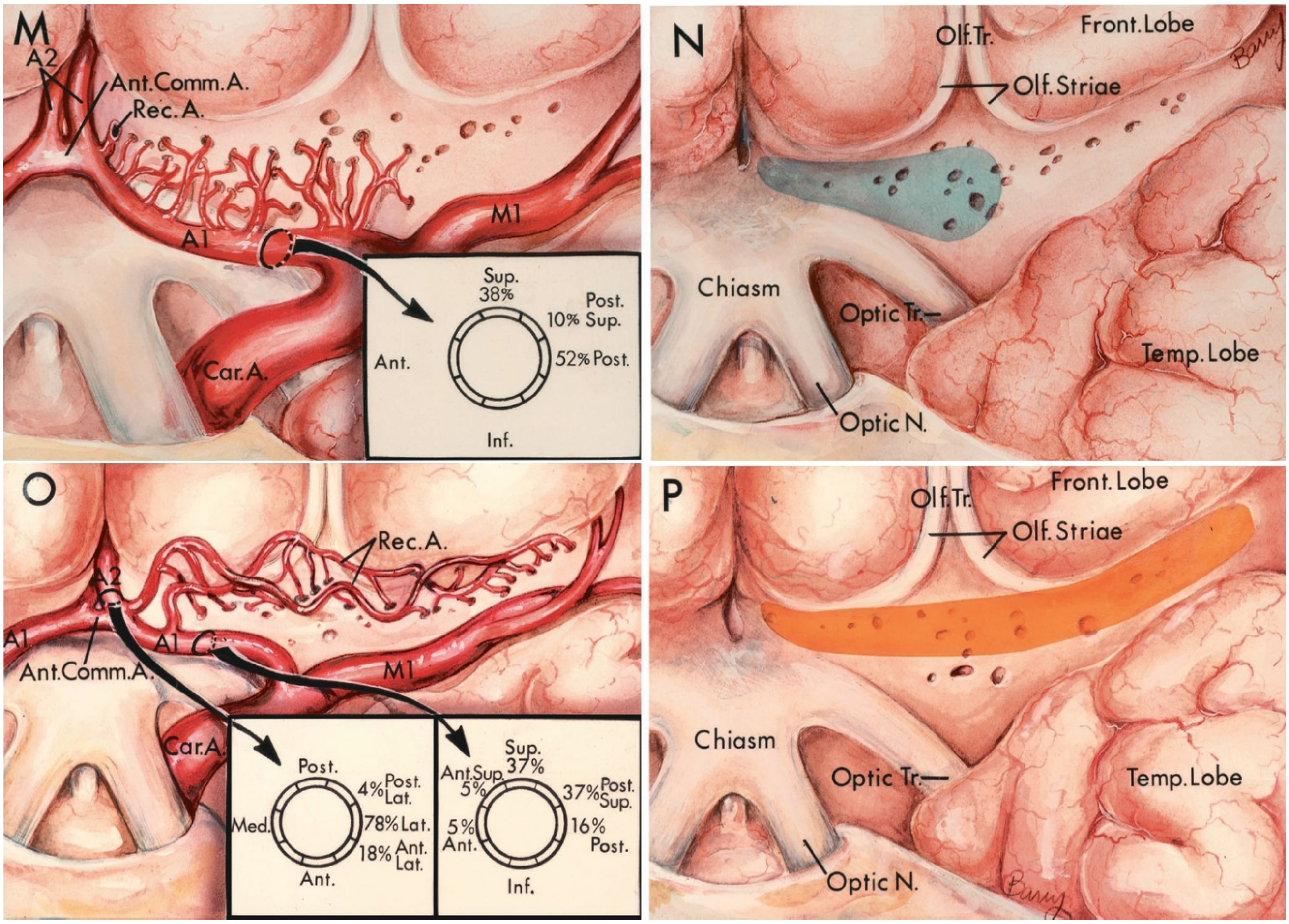
communicating arteries. The middle cerebral branches arise from the M1 and M2 segments. The anterior cerebral branches, including the recurrent arteries, arise from the A1 and A2 segments. The anterior perforated substance extends medially above the optic chiasm to the interhemispheric fissure, laterally to the limen insulae, anteriorly to the olfactory striae, and posteriorly to the optic tract and temporal lobe. The olfactory tract courses along the inferior surface of the frontal lobe at the junction of the gyrus rectus and the orbital gyri. A and B, internal carotid artery. A, the branches from the internal carotid artery to the anterior perforated substance arise from the posterior wall above the anterior choroidal artery, and course upward behind the carotid bifurcation. Inset: lateral view of the carotid artery. Eighty-one percent of the branches to the anterior perforated substance arise from the posterior wall below the bifurcation and 18% arise from the posterosuperior surface of the wall, at or near the level of the bifurcation. B, internal carotid zone and territory in the anterior perforated substance. Most of the branches of the internal carotid artery enter the posterior and middle zones of the medial territory of the anterior perforated substance. C–F, anterior choroidal artery. Inferior views showing three patterns of origin (C–E). C, a branch to the anterior perforated substance arises in common with the origin of the anterior choroidal artery. D, the superior branch of the anterior choroidal artery gives rise to branches to the anterior perforated substance. E, the main trunk of the anterior choroidal artery gives off branches to the anterior perforated substance along its course to the choroid plexus in the temporal horn. F, the anterior choroidal branches enter the posterior and middle zones near the junction of the medial and lateral territories of the anterior perforated substance.



Click here to view the interactive module and related content for this image.

FIGURE 2.30 G–L, lenticulostriate branches of the middle cerebral artery. The lenticulostriate branches are divided into medial, intermediate, and lateral groups. G and H, medial lenticulostriate arteries. G, the medial lenticulostriate arteries arise from the proximal part of the M1 segment. Inset: these arteries arise predominantly from the posterior and superior wall of the artery. H, they enter the middle and posterior zones of the medial part of the lateral territory of the anterior perforated substance. I and J, intermediate lenticulostriate arteries. I, these arteries arise from the M1 segment and, because of a complex branching, form a candelabra appearance as they approach the anterior perforated substance. Inset: they arise predominantly from the posterior, superior, and posterosuperior aspects of the wall. J, the arteries enter predominantly the middle and posterior zones of the central part of the lateral territory

of the anterior perforated substance. K and L, lateral lenticulostriate arteries. K, these arteries arise in closer proximity to the bifurcation of the middle cerebral artery, from the M1 and M2 segments, and have an S-shaped course. First, they pass posterior, medial, and superior, then turn laterally, and finally complete an S-curve by turning medially just before entering the anterior perforated substance. Approximately half arise proximal and half arise distal to the bifurcation of the middle cerebral artery. Inset: site of origin. These arteries arise from the posterior, superior, or posterosuperior aspect of the parent trunk. L, the lateral lenticulostriate arteries enter predominantly the middle and posterior zones of the lateral territory of the anterior perforated substance.



Click here to view the interactive module and related content for this image.

FIGURE 2.30 M-P. M and N, perforating branches of the A1 segment of the anterior cerebral artery. M, the A1 branches arise below the medial part of the anterior perforated substance and pass superior. The lateral half of the A1 segment is a richer site of perforating branches than the medial half. Inset: the branches arise from the posterior, superior, or posterosuperior surface of the A1 segment. N, the A1 branches enter the narrow band of anterior perforated substance extending above the optic chiasm. They enter predominantly the posterior and middle zone of the medial territory of the anterior perforated substance. O and P, recurrent artery. O, as many as four recurrent arteries may arise from the anterior cerebral artery, either proximal to or near the level of the AComA. They pass laterally above the carotid bifurcation and give branches to the full mediolateral extent of the anterior perforated substance. They may wander forward on the posterior part of the orbital surface of the frontal lobe. Inset (lower right): Site of origin of the recurrent arteries. Left inset: Recurrent artery origins near the junction of the A1 and A2 segments. The cross section of the artery at this level is oriented in a transverse plane. These branches arise predominantly from the lateral side of the vessel. Right inset: Site of origin of recurrent arteries arising from the A1 segments. The cross section of the artery at this level has an orientation in the sagittal plane. The branches arise predominantly from the superior or posterosuperior surface. P, the branches of the recurrent artery enter predominantly the anterior half of the anterior perforated substance along its full mediolateral extent, from the interhemispheric fissure to the limen insulae. A., arteries, artery; A.C.A., anterior cerebral artery; Ant., anterior; Car., carotid; Chor., choroidal; Comm., communicating; Fiss., fissure; Front., frontal; Gyr., gyrus; Inf., inferior; Int., intermediate; Interhem., interhemispheric; Lat., lateral; Len. Str., lenticulostriate; M.C.A., middle cerebral artery; Med., medial; N., nerve; Olf., olfactory; Ophth., ophthalmic; Orb., orbital; Perf., perforated, perforating; Post., posterior; Subst., substance; Sup., superior; Tr., tract, trunk; Temp., temporal. (From, Rosner SS, Rhoton AL Jr, Ono M, Barry M: Microsurgical anatomy of the anterior perforating arteries. J Neurosurg 61:468–485, 1984 [36].)

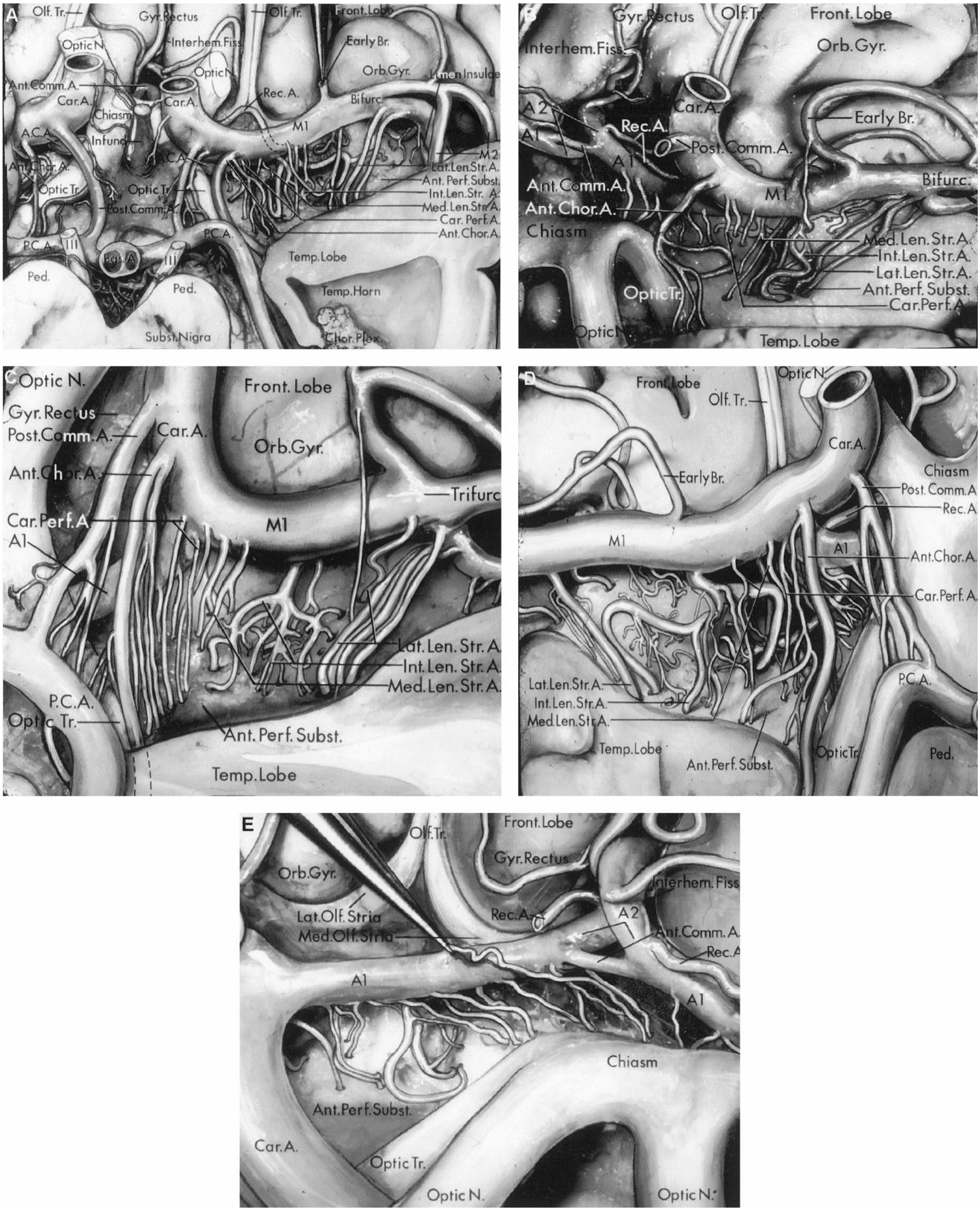
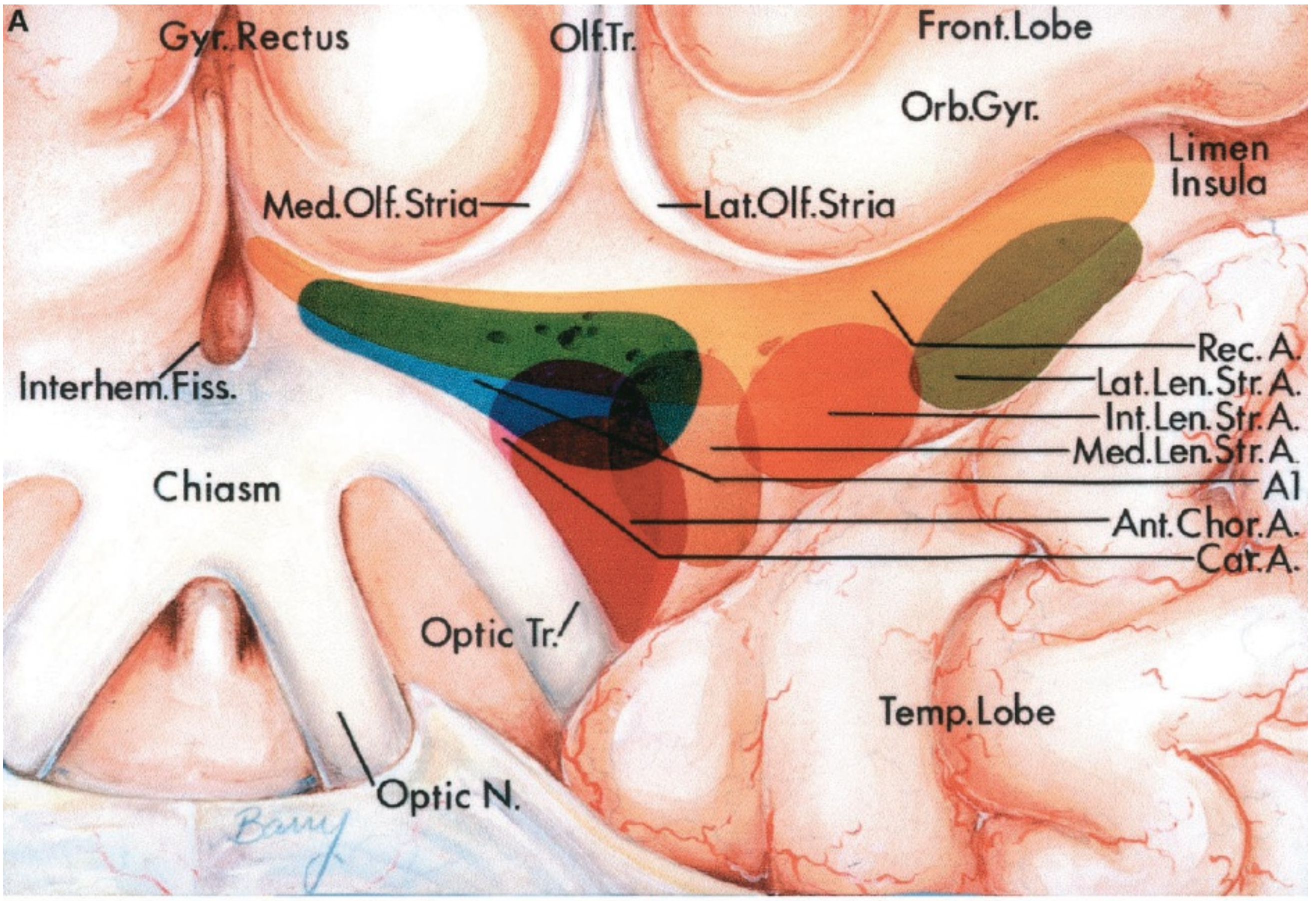
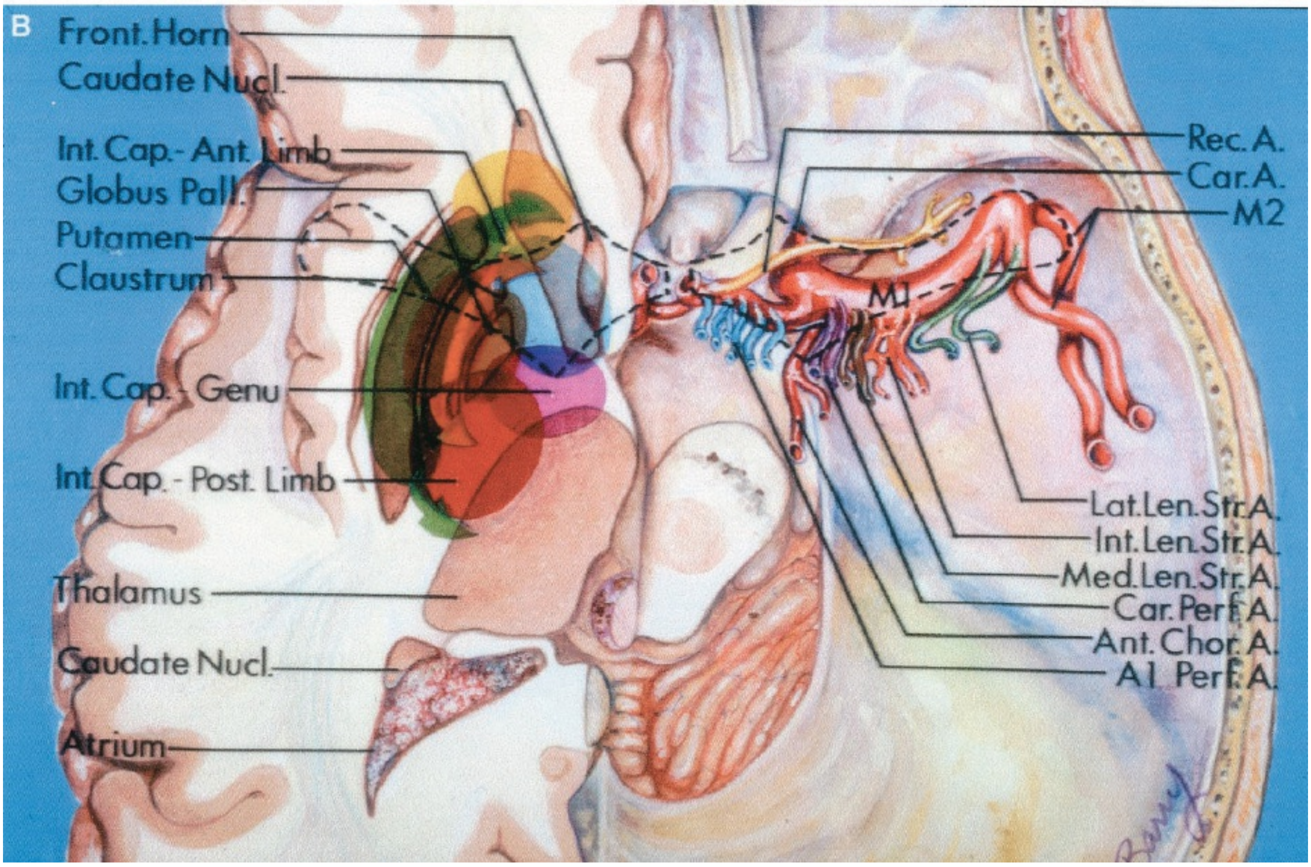


FIGURE 2.31. Arteries entering the anterior perforated substance. A, inferior view. The anterior perforated substance on the left side extends anteriorly to the medial and lateral olfactory striae, posteriorly to the optic tract and temporal lobe, laterally to the limen insulae, and medially above the optic chiasm, to the interhemispheric fissure. The anterior part of the temporal lobe has been removed to expose the temporal horn. The internal carotid, anterior choroidal, and anterior and middle cerebral

arteries (M1 and M2) give rise to branches to the anterior perforated substance. The PComA does not give branches to the anterior perforated substance. The middle cerebral branches, called the lenticulostriate arteries, are divided into medial, intermediate, and lateral lenticulostriate groups. The lateral lenticulostriate arteries arise laterally near the bifurcation of the M1 segment. The anterior choroidal and carotid branches enter the posterior part of the anterior perforated substance near the optic tract. The branches from the anterior cerebral artery enter the narrow strip of the anterior perforated substance above the optic chiasm. The recurrent artery arises from the anterior cerebral artery, near the level of the AComA, and passes laterally above the carotid bifurcation to enter the anterior perforated substance anterior to the branches from the other sources. The M1 segment gives rise to an early branch. B, another specimen. The optic nerve and chiasm have been reflected inferiorly. The branches from the left A1 segment enter the narrow medial sector of the anterior perforated substance extending above the optic chiasm to the interhemispheric fissure. A perforating artery arises from an early branch of the M1. Some of the lateral lenticulostriate arteries arise near the M1 bifurcation. The intermediate lenticulostriate arteries have a candelabra appearance. The anterior choroidal artery sends branches to the posterior half of the anterior perforated substance. Two recurrent arteries arise near the anterior communicating artery. C, another specimen. The anterior choroidal branches to the anterior perforated substance arise near the origin of the anterior choroidal artery. The lateral lenticulostriate arteries arise near the M1 trifurcation and have a roughly S shaped course. The intermediate lenticulostriate arteries have a candelabra appearance. The medial lenticulostriate arteries pass near the perforating branches arising from the carotid artery and the medial half of the A1 segment. D, inferior view, right side. The intermediate lenticulostriate arteries have a candelabra appearance. The A1 branches enter the anterior perforated substance medial to those from the internal carotid, anterior choroidal, and middle cerebral arteries. The recurrent artery arises above the optic chiasm, passes laterally above the carotid bifurcation, and gives rise to branches that enter the anterior perforated substance in front of those from other sources. E, perforating branches of the anterior cerebral artery, anterior view. The recurrent artery arises above the optic chiasm near the level of the AComA. The A1 segment arises from the carotid artery and its perforating branches to enter the medial half of the anterior perforated substance in the narrow sector extending above the optic chiasm. A., arteries, artery; A.C.A., anterior cerebral artery; Ant., anterior; Bifurc., bifurcation; Car., carotid; Chor., choroid, choroidal; Comm., communicating; Br., branch; Fiss., fissure; Front., frontal; Gyr., gyrus; I.C.A., internal cerebral artery; Infund., infundibulum; Int., intermediate; Interhem., interhemispheric; Lat., lateral; Len. Str., lenticulostriate; Med., medial; N., nerve; Olf., olfactory; Orb., orbital; P.C.A., posterior cerebral artery; Ped., peduncle; Perf., perforated, perforating; Plex., plexus; Post., posterior; Rec., recurrent; Subst., substance, substantia; Temp., temporal; Tr., tract; Trifurc., trifurcation. (From, Rosner SS, Rhoton AL Jr, Ono M, Barry M: Microsurgical anatomy of the anterior perforating arteries. J Neurosurg 61:468–485, 1984 [36].)

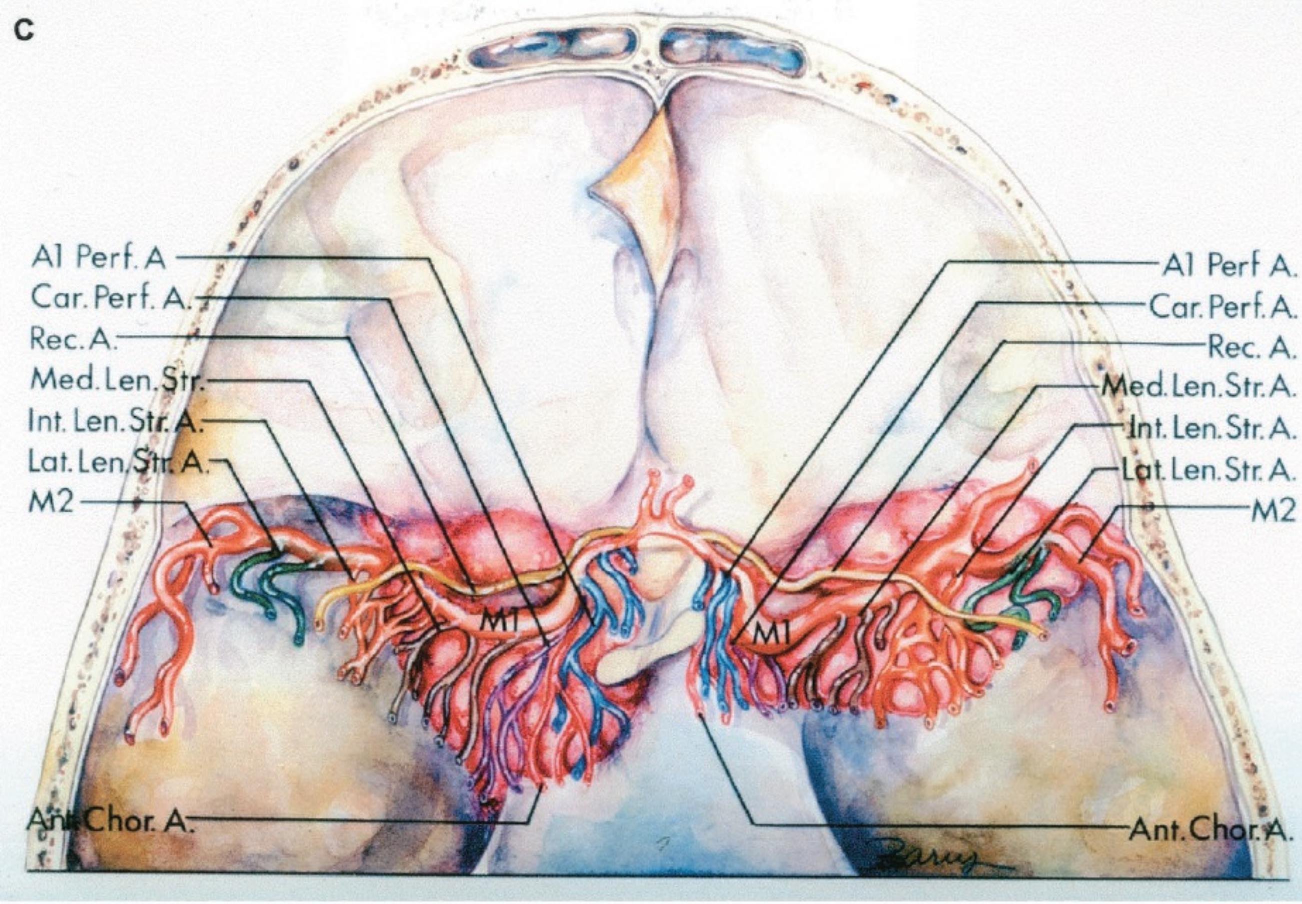


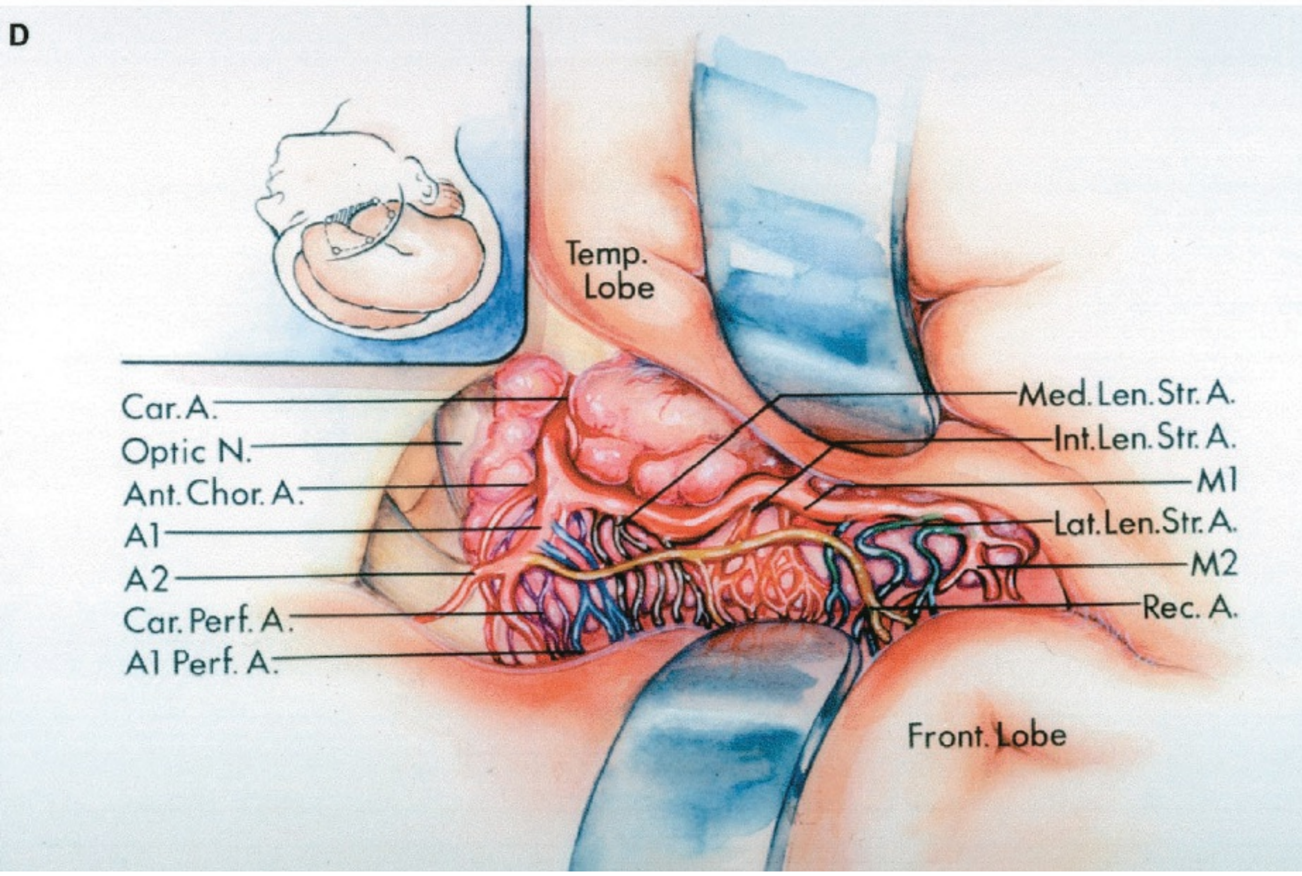


Click here to view the interactive module and related content for this image.

FIGURE 2.32 A-B. A, site of entry of branches of the internal carotid,

anterior choroidal, and anterior and middle cerebral arteries into the anterior perforated substance. The anterior perforated substance is located between the frontal and temporal lobes and is bordered anteriorly by the medial and lateral olfactory striae, laterally by the limen insulae, posteriorly by the optic tract and temporal lobe, and medially extends above the optic nerve and chiasm to the interhemispheric fissure. The A1 segment of the anterior cerebral artery gives rise to branches (blue) that enter the medial half of the anterior perforated substance above the optic nerve and chiasm. The internal carotid (purple) and anterior choroidal arteries (red) give rise to branches that enter the posterior part of the central portion of the anterior perforated substance. The middle cerebral artery gives rise to the medial (brown), intermediate (orange), and lateral lenticulostriate arteries (green) that enter the middle and posterior portions of the lateral half of the anterior perforated substance. The recurrent artery (yellow) sends branches into the anterior half of the full mediolateral extent of the anterior perforated substance. The olfactory tract divides the frontal lobe between the gyrus rectus and the orbital gyri. B, relationship of anterior perforating arteries to the deep cerebral structures. Superior view with all of the right cerebral hemisphere and the superior part of the left cerebral hemisphere removed. The site of the anterior perforated substance is shown on both sides by dotted lines. The deep neural structures above the anterior perforated substance are shown on the left side. The transverse section of the left cerebrum extends through the caudate nucleus, thalamus, globus pallidus, putamen, the anterior limb, genu, and posterior limb of the internal capsule, and the frontal horn and atrium of the lateral ventricle. The right side shows the site of origin of the perforating branches to the anterior perforated substance. The branches to the anterior perforated substance pass through the deep structures directly above the anterior perforated substance and spread posteriorly to supply larger parts of the caudate nucleus, putamen, internal capsule, and the adjacent parts of the globus pallidus and thalamus. The C4 branches (purple) perfuse the genu of the internal capsule, and the adjacent part of the globus pallidus, posterior limb of the internal capsule, and thalamus. The anterior choroidal branches (red) supply the medial two segments of the globus pallidus, the inferior part of the posterior limb of the internal capsule, and the anterior and ventrolateral nuclei of the thalamus. The lateral (green) and intermediate groups (orange) of lenticulostriate arteries pass through the putamen and the adjacent part of the globus pallidus and arch medially and posteriorly (arrows) to supply almost the entire anterior-to-posterior length of the upper part of the internal capsule and the body and head of the caudate nucleus. The medial lenticulostriate arteries (brown) irrigate the lateral part of the globus pallidus, the superior part of the anterior limb of the internal capsule, and the anterosuperior part of the head of the caudate nucleus. The A1 branches (blue) supply the genu of the internal capsule and the anterior part of the globus pallidus, and may extend to the adjacent part of the posterior limb of the internal capsule and, less commonly, to the thalamus. The recurrent artery (yellow) supplies the most anterior and inferior part of the head of the caudate nucleus and putamen, and the adjacent part of the anterior limb of the internal capsule.





Click here to view the interactive module and related content for this image.

FIGURE 2.32 C–D, relationship of the anterior perforating arteries to

tumors along the sphenoid ridge. C, superior view. The anterior perforating arteries are stretched across the upper surface of a sphenoid ridge meningioma. D, pterional exposure. The incision is shown in the inset. The frontal and temporal lobes have been retracted to expose the carotid artery, which is encased by tumor. The anterior perforating arteries are stretched across the upper surface of the tumor. It is best to debulk a tumor of this type before separating the tumor capsule from the perforating arteries by using careful

microtechnique. A., arteries, artery; Ant., anterior; Cap., capsule; Car., carotid; Chor., choroidal; Fiss., fissure; Front., frontal; Gyr., gyrus; Int., intermediate, internal; Interhem., interhemispheric; Lat., lateral; Lent. Str., lenticulostriate; Med., medial; N., nerve; Nucl., nucleus; Olf., olfactory; Orb., orbital; Pall., pallidus; Perf., perforating; Post., posterior; Rec., recurrent; Temp., temporal; Tr., tract. (From, Rosner SS, Rhoton AL Jr, Ono M, Barry M: Microsurgical anatomy of the anterior perforating arteries. J Neurosurg 61:468–485, 1984 [36].)

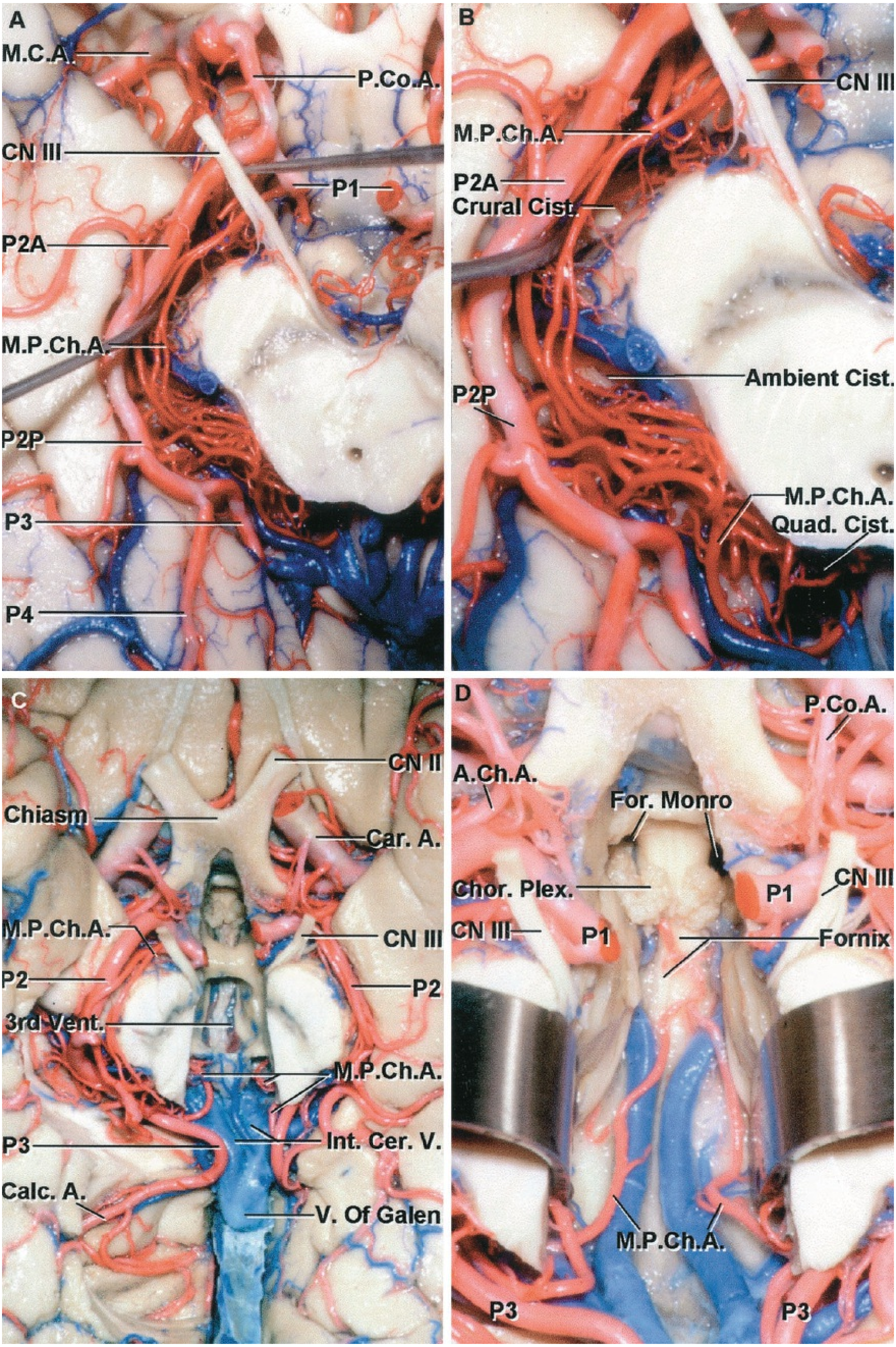
The Posterior Part of the Circle of Willis

The posterior part of the circle of Willis is formed by the proximal PCA and PComA and, together, in varying degrees, they provide the flow to the distal PCA (Figs. 2.8, 2.33, and 2.34). The posterior circle is one of the most difficult sites to approach surgically because of its location in the midline below the third ventricle, the complex series of perforating vessels surrounding and arising from it, and its intimate relationship to the extraocular nerves and upper brainstem. Its branches are exposed in surgical approaches to the basilar apex, tentorial notch, lateral and third ventricles, inferior temporal and medial parieto-occipital areas, and the pineal region— all relatively inaccessible areas.

A normal posterior circle, in which the proximal PCAs have a diameter larger than their PComAs and are not hypoplastic, is present in approximately half of the brains (Figs. 2.8 and 2.34). The other half harbor anomalies of the posterior circle, including either a hypoplastic PComA or a fetal configuration in which the proximal PCA is small and the PComA provides the major supply to the PCA and is larger than the P1 (24).

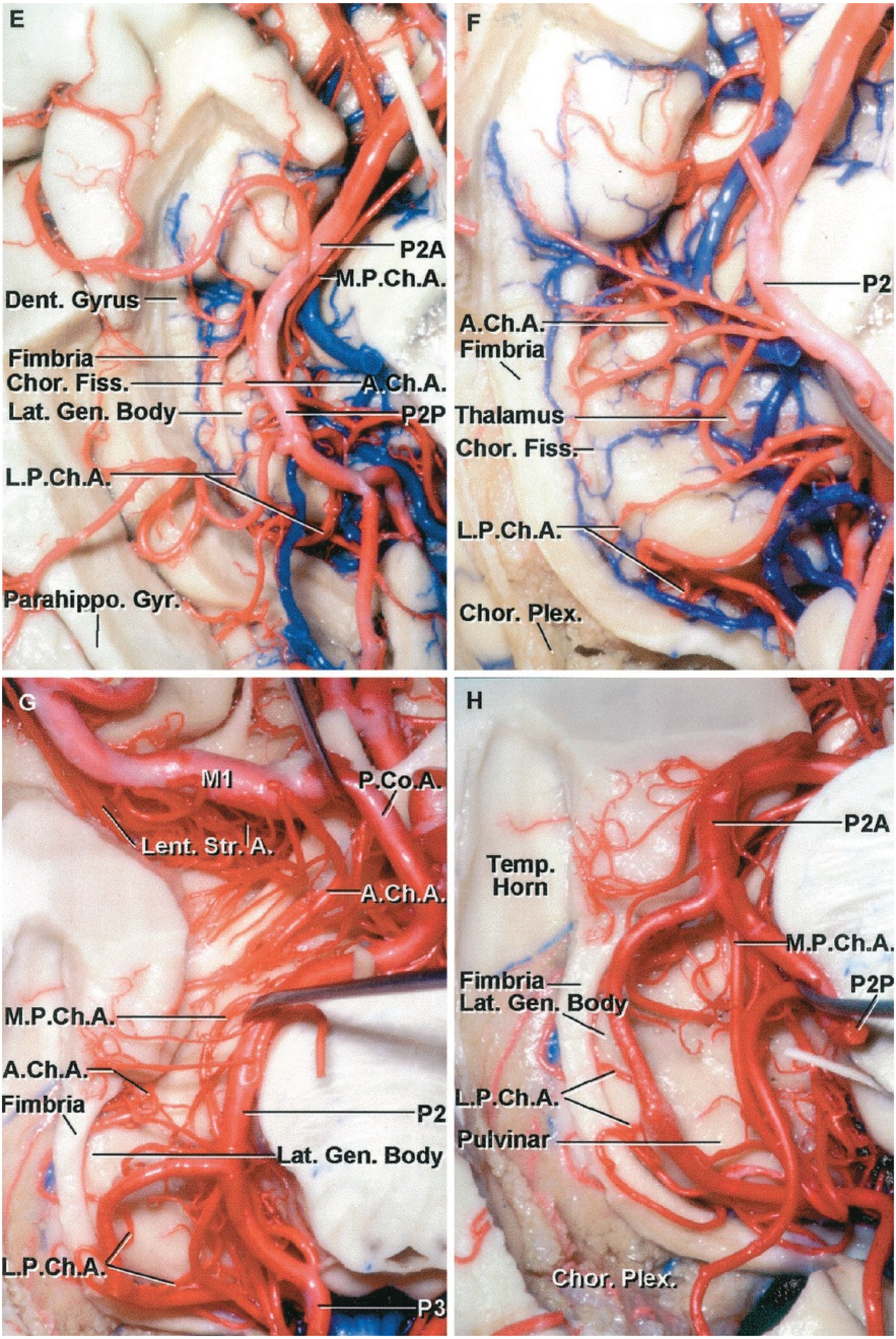
A hypoplastic arterial segment is defined as one having a diameter of 1 mm or less. In our study, PComA hypoplasia was found unilaterally in 26% and bilaterally in 6%, and a fetal configuration, in which the PCA arises predominantly from the carotid artery, was found unilaterally in 20% and bilaterally in 2% (37). Eight percent had a hypoplastic communicating artery on one side and a fetal complex on the other side. Absence of either the communicating artery or a P1 segment is very uncommon. The PComA is described above.

The posterior portion of the circle of Willis sends a series of perforating arteries into the diencephalon and midbrain that may become stretched around suprasellar tumors or posterior circle aneurysms (Figs. 2.33 and 2.34). Some of the perforating branches arising from the upper part of the basilar artery overlap with some of those arising from the posterior circle. The risks of occlusion of these vital perforating vessels during tumor or aneurysm surgery include visual loss, somatesthetic disturbances, motor weakness, memory deficits, autonomic imbalance, diplopia, alterations of consciousness, abnormal movements, and endocrine disturbances.


A
M.C.A.
P.Co.A.
CN III
P1
P2A
M.P.Ch.A.
P2P
P3
P4
B
CN III
M.P.Ch.A.
P2A
Crural Cist.
Ambient Cist.
P2P
M.P.Ch.A.
Quad. Cist.
C
CN II
Chiasm
Car. A.
M.P.Ch.A.
CN III
P2
P2
3rd Vent.
M.P.Ch.A.
P3
Int. Cer. V.
Calc. A.
V. Of Galen
D
P.Co.A.
A.Ch.A.
For. Monro
Chor. Plex.
P1
CN III
CN III
P1
Fornix
M.P.Ch.A.
P3
P3

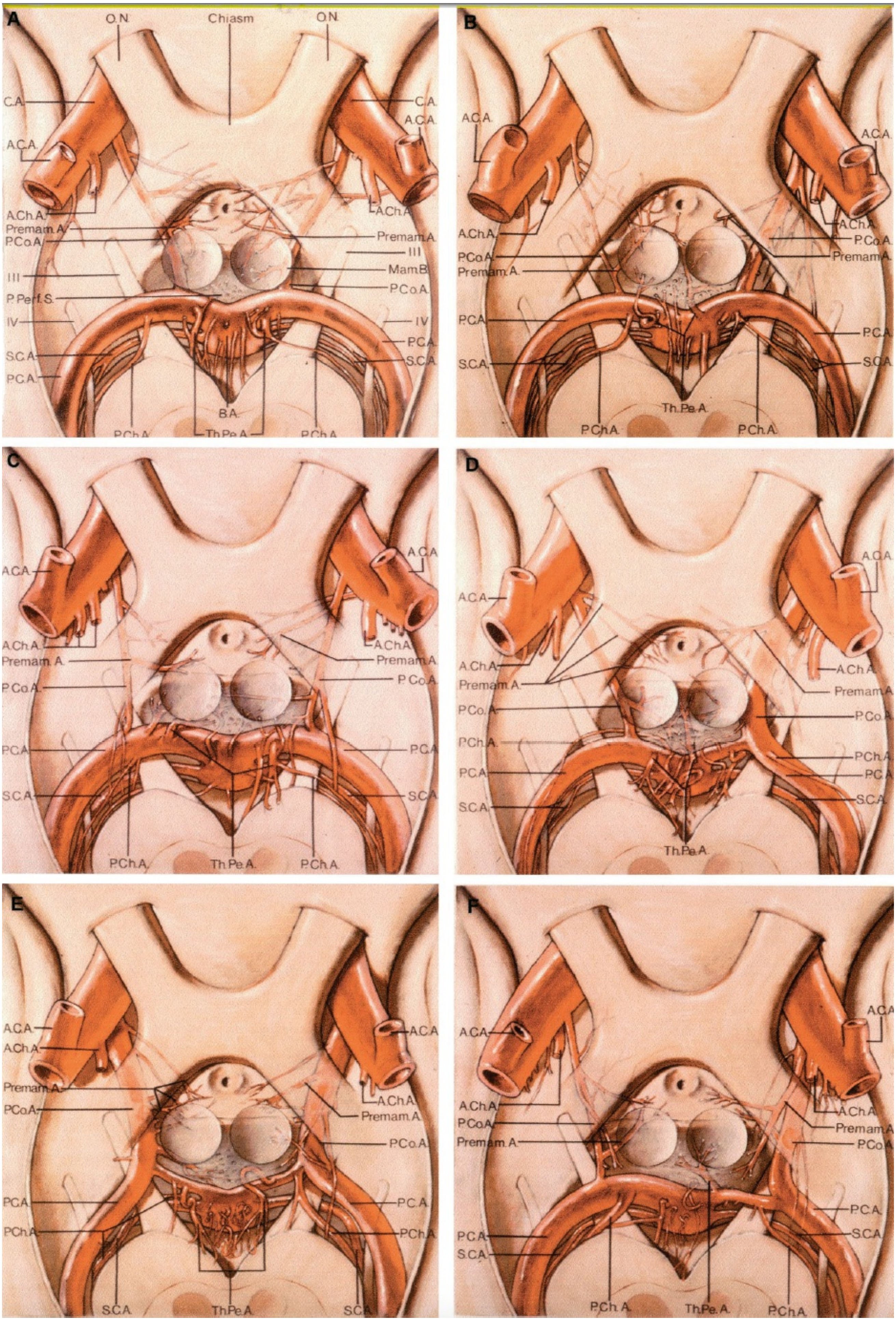
Click here to view the interactive module and related content for this image.

FIGURE 2.33 A-D. Posterior choroidal arteries. A, inferior view of the posterior cerebral artery. The medial posterior choroidal artery arises from the P1 and encircles the brainstem on the medial side of the P2 and P3, giving off small branches to the brainstem along its course. The P3 is formed by the branches in the quadrigeminal cistern. B, enlarged view. The medial posterior choroidal artery encircles the brainstem in the crural, ambient, and quadrigeminal cisterns and turns forward beside the pineal in the quadrigeminal cistern to reach the roof of the third ventricle. C, inferior view of the posterior cerebral arteries in another specimen, with the floor of the third ventricle removed. The medial posterior arteries encircle the midbrain and turn forward in the quadrigeminal cistern to reach the roof of the third ventricle. Some of the medial part of the right parahippocampal gyrus has been removed to expose the branches arising from the P2. D, enlarged view. The lower layer of tela in the roof of the third ventricle has been opened to expose the medial posterior choroidal arteries coursing in the velum interpositum with the branches of the internal cerebral vein. The choroid plexus in the body of the lateral ventricle is continuous at the posterior margin of the foramen of Monro with the choroid plexus in the roof of the third ventricle, which has been removed.


E
P2A
M.P.Ch.A.
Dent. Gyrus
Fimbria
Chor. Fiss.
A.Ch.A.
Lat. Gen. Body
P2P
L.P.Ch.A.
Parahippo. Gyr.
F
P2
A.Ch.A.
Fimbria
Thalamus
Chor. Fiss.
L.P.Ch.A.
Chor. Plex.
G
M1
P.Co.A.
Lent. Str. A.
A.Ch.A.
M.P.Ch.A.
A.Ch.A.
Fimbria
P2
Lat. Gen. Body
L.P.Ch.A.
P3
H
P2A
Temp. Horn
M.P.Ch.A.
Fimbria
P2P
Lat. Gen. Body
L.P.Ch.A.
Pulvinar
Chor. Plex.

Click here to view the interactive module and related content for this image.

FIGURE 2.33 E-H. E, the medial part of the left parahippocampal gyrus has been removed to expose the lateral posterior choroidal arteries arising from the P2 and passing through the choroidal fissure located between the fimbria and thalamus to reach the choroid plexus in the temporal horn. Perforating branches like the thalamogeniculate arteries also arise from the P2 and ascend to penetrate the lower surface of the thalamus in the region of the geniculate bodies. F, enlarged view with the lower part of the hippocampal gyrus removed while preserving the fimbria. The P2 has been retracted medially to expose the lateral posterior choroidal arteries passing through the choroidal fissure located between the fimbria and thalamus to enter the choroid plexus in the temporal horn. The anterior choroidal artery is also seen passing through the fissure. G, another specimen. The M1 and P1 and P2 give rise to a series of perforating branches that enter the basal surface of the brain. The P2 has been retracted to expose the lateral posterior choroidal branches passing laterally through the choroidal fissure to reach the choroid plexus in the temporal horn and atrium. The parahippocampal gyrus has been removed. The fimbria and thalamus border the choroidal fissure. The lateral geniculate body protrudes from the lower margin of the thalamus. H, enlarged view. The lateral posterior choroidal artery passes laterally through the choroidal fissure to reach the choroid plexus. The medial posterior choroidal encircles the brainstem. A., arteries, artery; A.Ch.A., anterior choroidal artery; Calc., calcarine; Car., carotid; Cer., cerebral; Chor., choroid, choroidal; Cist., cistern; CN, cranial nerve; Dent., dentate; Fiss., fissure; For., foramen; Gen., geniculate; Gyr., gyrus; Int., internal; Lat., lateral; Lent. Str., lenticulostriate; L.P.Ch.A., lateral posterior choroidal artery; M.C.A., middle cerebral artery; M.P.Ch.A., medial posterior choroidal artery; Parahippo., parahippocampal; P.Co.A., posterior communicating artery; Plex., plexus; Quad., quadrigeminal; Temp., temporal; V., vein; Vent., ventricle.


A
O.N.
Chiasm
O.N.
C.A.
C.A.
A.C.A.
A.C.A.
A.Ch.A.
A.Ch.A.
Premam.A.
P.Co.A.
Premam.A.
III
III
Mam.B.
P.Co.A.
P.Perf.S.
IV
IV
P.C.A.
S.C.A.
S.C.A.
P.C.A.
B.A.
P.Ch.A.
Th.Pe.A.
P.Ch.A.
B
A.C.A.
A.C.A.
A.Ch.A.
A.Ch.A.
P.Co.A.
P.Co.A.
Premam.A.
Premam.A.
P.C.A.
P.C.A.
S.C.A.
S.C.A.
Th.Pe.A.
P.Ch.A.
P.Ch.A.
C
A.C.A.
A.C.A.
A.Ch.A.
A.Ch.A.
Premam. A.
Premam.A.
P.Co.A.
P.Co.A.
P.C.A.
P.C.A.
S.C.A.
S.C.A.
P.Ch.A.
Th.Pe.A.
P.Ch.A.
D
A.C.A.
A.C.A.
A.Ch.A.
A.Ch.A.
Premam.A.
Premam.A.
P.Co.A.
P.Co.A.
P.Ch.A.
P.Ch.A.
P.C.A.
P.C.A.
S.C.A.
S.C.A.
Th.Pe.A.
E
A.C.A.
A.C.A.
A.Ch.A.
A.Ch.A.
Premam.A.
Premam.A.
P.Co.A.
P.Co.A.
P.C.A.
P.C.A.
P.Ch.A.
P.Ch.A.
S.C.A.
Th.Pe.A.
S.C.A.
F
A.C.A.
A.C.A.
A.Ch.A.
A.Ch.A.
P.Co.A.
Premam.A.
Premam.A.
P.Co.A.
P.C.A.
P.C.A.
S.C.A.
S.C.A.
P.Ch.A.
Th.Pe.A.
P.Ch.A.

Click here to view the interactive module and related content for this image.

FIGURE 2.34. Superior view of the basilar, superior cerebellar, P1, and distal segments of posterior cerebral, posterior communicating, internal carotid, and proximal anterior choroidal arteries. The arterial branches below the posterior perforating substance, mamillary bodies, optic tracts, chiasm, and nerves are shown in half tone. The third and fourth nerves course between the superior cerebellar and posterior cerebral arteries. Arterial branches to the upper pons, posterior mesencephalon, interpeduncular fossa, posterior perforating substance, mamillary bodies, tuber cinereum, optic tracts, and chiasm arise from the basilar, P1, posterior communicating, and internal carotid arteries. A, normal configuration of the posterior half of the circle of Willis; both P1s are larger than communicating arteries and the latter are not hypoplastic (diameter more than 1 mm). The right superior cerebellar artery is duplicated. The largest right P1 branch gives rise to both the thalamoperforating and the posterior choroidal arteries. Only two perforating arteries arise on the right P1. The left posterior choroidal arises on P2. Both premamillary arteries (largest communicating trunk to premamillary area) arise from the middle third of the PComAs. AChAs arise as a single trunk. B, hypoplastic left communicating artery. Thalamoperforating artery arises on P1 medial to the posterior choroidal arteries on both sides. The left premamillary artery arises from the posterior and the right from the anterior portion of the PComA. The superior cerebellar arteries are duplicated on both sides. C, PComAs are hypoplastic bilaterally. The largest right P1 branch gives rise to both the thalamoperforating and the PChAs. The thalamoperforating artery arises medial to the posterior choroidal artery on the left P1. The premamillary artery arises from the anterior third of the right PComA and from the middle third on the left. The left anterior choroidal arises from the carotid as two trunks. D, fetal origin of the right posterior cerebral artery. The thalamoperforating artery on the right arises near the basilar bifurcation. The right posterior choroidal artery arises on P2. The left posterior choroidal artery arises medial to the thalamoperforating artery. The right

premamillary artery arises from the anterior portion of the communicating artery. The left premamillary area is supplied by a group of nearly equal-sized arteries. The anterior choroidal artery bifurcates immediately after origin on the left. E, bilateral fetal origin of the posterior cerebral artery. The right posterior choroidal artery arises lateral to the thalamoperforating artery. The largest left P1 branch gives rise to the thalamoperforating and choroidal arteries. The right premamillary artery arises from the middle portion of the communicating artery. A premamillary arterial complex is present on the left. F, fetal type of right posterior cerebral origin and hypoplastic left communicating artery. The right posterior choroidal artery arises lateral to the well-developed thalamoperforating artery. No thalamoperforating branches are present on the left. The right premamillary artery arises from the anterior and the left from the posterior portion of the communicating artery. A., artery; A.C.A., anterior cerebral artery; A.Ch.A., anterior choroidal artery; B., body; B.A., basilar artery; C.A., carotid artery; Mam., mamillary; N., nerve; O., optic; P.C.A., posterior cerebral artery; P.Ch.A., posterior choroid artery; P.Co.A., posterior communicating artery; P.Perf.S., posterior perforated substance; Premam., premamillary; S.C.A., superior cerebellar artery; Th.Pe., thalamoperforating. (From, Saeki N, Rhoton AL Jr: Microsurgical anatomy of the upper basilar artery and the posterior circle of Willis. J Neurosurg 46:563–578, 1977 [37].)

The Posterior Cerebral Artery

The PCA arises at the basilar bifurcation, is joined by the PComA at the lateral margin of the interpeduncular cistern, encircles the brainstem passing through the crural and ambient cisterns to reach the quadrigeminal cistern, and is distributed to the posterior part of the hemisphere (Figs. 2.1, 2.3, 2.7–2.9, 2.12, 2.13, 2.33, and 2.34). The posterior cerebral artery supplies not only the posterior part of the cerebral hemispheres, as its name implies, but also sends critical branches to the thalamus, midbrain, and other deep structures, including the choroid plexus and walls of the lateral and third ventricles. Embryologically, it arises as a branch of the internal carotid artery, but by birth its most frequent origin is from the basilar artery. The basilar bifurcation, and thus the PCA origin, may be located as far caudal as 1.3 mm below the pontomesencephalic junction and as far rostral as the mamillary bodies and adjacent floor of the third ventricle, which may be elevated by a high bifurcation. The artery usually bifurcates opposite the interpeduncular fossa, but some bifurcations may be as low as the upper pons or so high that they indent the mamillary bodies and floor of the third ventricle. The average separation between the basilar bifurcation and mamillary bodies is 8.1 mm (range, 0–14 mm). There is widening of the basilar artery at the bifurcation in 16% of cases, giving the basilar apex and bifurcation a cobra-like appearance (37, 43).

PCA Segments

The PCA is divided into four segments, P1 through P4 (Figs. 2.12–2.14 and 2.33) (37, 43).

P1 Segment

The P1 segment, also called the precommunicating segment, extends from the basilar bifurcation to the junction with the PComA. A fetal configuration, in which the P1 has a smaller diameter than the PComA and the PCA arises predominantly from the carotid artery, occurs in approximately one-third of hemispheres. A normal configuration, in which the P1 segment is larger than the PComA, is found in nearly two-thirds of hemispheres. A few hemispheres will have a PComA and P1 of the same diameter. A fetal configuration may be present on both sides.

P1 length varies, being longer if there is a fetal pattern. Average P1 length, which ranges from 3 to 14 mm, is approximately 9.0 mm in the group with a fetal configuration as compared with 7.0 mm in a normal pattern (37). The oculomotor nerve passes below and slightly lateral to the PComA if a normal configuration is present; but if a fetal pattern is present, P1 is longer and the nerve courses beneath or medial to the communicating artery.

The relatively constant branches arising from the P1 are 1) the thalamoperforating artery, which by definition enters the brain through the posterior perforated substance; 2) the medial posterior choroidal artery directed to the choroid plexus in the third ventricle and lateral ventricle; 3) the branch to the quadrigeminal plate; and 4) rami to the cerebral peduncle and mesencephalic tegmentum. The superior cerebellar artery (SCA) arises from the basilar artery at a level between the P1 origin and 7 mm below (average, 2.5 mm) (37). The SCA may infrequently have a common origin with the P1 or arise from P1. The initial segment gives rise to perforating vessels whose termination may overlap with those arising from the basilar apex and P1.

P2 Segment

The P2 segment begins at the PComA, lies within the crural and ambient cisterns, and terminates lateral to the posterior edge of the midbrain. The P2 is divided into an anterior and posterior part because the surgical approaches to the anterior and posterior halves of this segment often differ, and because it is helpful in identifying the origin of the many branches that arise from P2. The anterior part is designated the P2A or crural or peduncular segment because it courses around the cerebral peduncle in the crural cistern. The posterior part is designated the P2P or the ambient or lateral mesencephalic segment because it courses lateral to the midbrain in the ambient cistern. Both segments are approximately 25 mm long. The P2A begins at the PComA and courses between the cerebral peduncle and uncus that forms the medial and lateral walls of the crural cistern, and inferior to the optic tract and basal vein that crosses the roof of the cistern, to enter the proximal portion of the ambient cistern. The P2P commences at the posterior edge of the cerebral peduncle at the junction of the crural and ambient cisterns. It courses between the lateral midbrain and the parahippocampal and dentate gyri, which form the medial and lateral walls of the ambient cistern, below the optic tract, basal vein, and geniculate bodies and the inferolateral part of the pulvinar in the roof of the cistern, and superomedial to the trochlear nerve and tentorial edge.

P3 Segment

The P3 or quadrigeminal segment proceeds posteriorly from the posterior edge of the lateral surface of the midbrain and ambient cistern to reach the lateral part of the quadrigeminal cistern and ends at the anterior limit of the calcarine fissure. The PCA often divides into its major terminal branches, the calcarine and parieto-occipital arteries, before reaching the anterior limit of the calcarine fissure. The average length of the P3 segment is 2 cm. The P3s from both sides approach each other posterior to the colliculi. The point where the PCAs from each side are nearest is referred to as the collicular or quadrigeminal point. The separation averages 8.9mm(range, 3.5–17 mm) (43). The artery forming the collicular point is the PCA trunk in approximately half of the hemispheres, and in the other half, in which the PCA bifurcates into its terminal branches before reaching the collicular point, it is formed by the calcarine artery.

P4 Segment

The P4 segment includes the branches distributed to the cortical surface. Posteriorly, it begins at the anterior end of the calcarine sulcus.

PCA Branches

The PCA gives rise to three types of branches: 1) central perforating branches to the diencephalon and midbrain; 2) ventricular branches to the choroid plexus and walls of the lateral and third ventricles and adjacent structures; and 3) cerebral branches to the cerebral cortex and splenium of the corpus callosum (Fig. 2.33). The central branches include the direct and circumflex perforating arteries, including the thalamoperforating, peduncular perforating, and thalamogeniculate arteries. The ventricular branches are the lateral and medial posterior choroidal arteries. The cerebral branches include the inferior temporal group of branches, which are divided into hippocampal and the anterior, middle, posterior, and common temporal branches, plus the parieto-occipital, calcarine, and splenial branches.

The long and short circumflex and thalamoperforating arteries arise predominantly from P1, and the other PCA branches most frequently arise from P2 or P3. The hippocampal, anterior temporal, peduncular perforating, and medial posterior choroidal arteries most frequently arise from P2A. The middle temporal, posterior temporal, common temporal, and lateral posterior choroidal arteries most frequently arise from P2P. The thalamogeniculate arteries arise only slightly more frequently from P2P than from P2A. The calcarine and parieto-occipital arteries most frequently arise from P3.

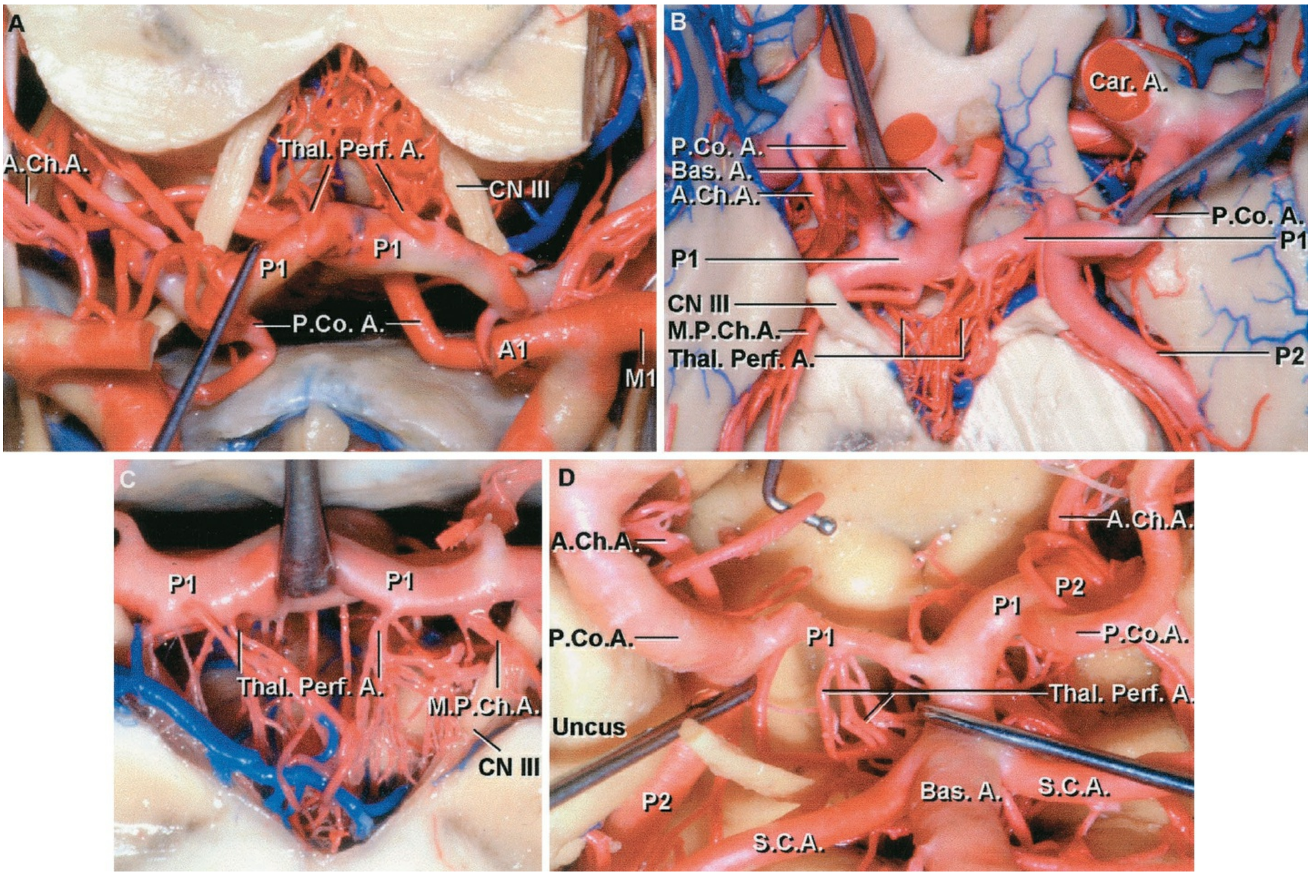
Perforating Branches

The central branches are divided into two groups: direct perforating and circumflex arteries (Figs. 2.34 and 2.35). The direct perforating branches pass directly from the parent trunk to the brainstem. This group includes the thalamoperforating

arteries that arise from P1 and the thalamogeniculate and peduncular perforating arteries that arise from P2. The circumflex branches encircle the brainstem for a variable distance before entering the diencephalon and mesencephalon are divided into long and short groups, depending on how far they course around the brainstem.

An average of four, but as many as a dozen perforating branches, the largest of which may have a diameter of 1.5 mm, arise mainly from the superior and posterior surfaces of the P1, course superiorly and posteriorly, and divide into numerous branches that terminate in the interpeduncular fossa, posterior perforated substance, cerebral peduncle, mamillary bodies, and posterior midbrain. Perforating branches rarely arise from the anterior side of the basilar apex, but they arise from the anterior surface in a third of P1s, and terminate in the posterior perforated substance and mamillary bodies. The largest P1 branch is a thalamoperforating artery (42% of hemispheres), a posterior choroidal artery (40%), or a large trunk from which both arteries arise (18%) (37). The P1s with the larger branches tend to have few perforating branches. P1s having only one or two P1 perforators tend to have larger branches. If the largest P1 branch is relatively small, there will be more P1 branches. More perforating vessels arise on P1 lateral to the largest perforator than medial to it.

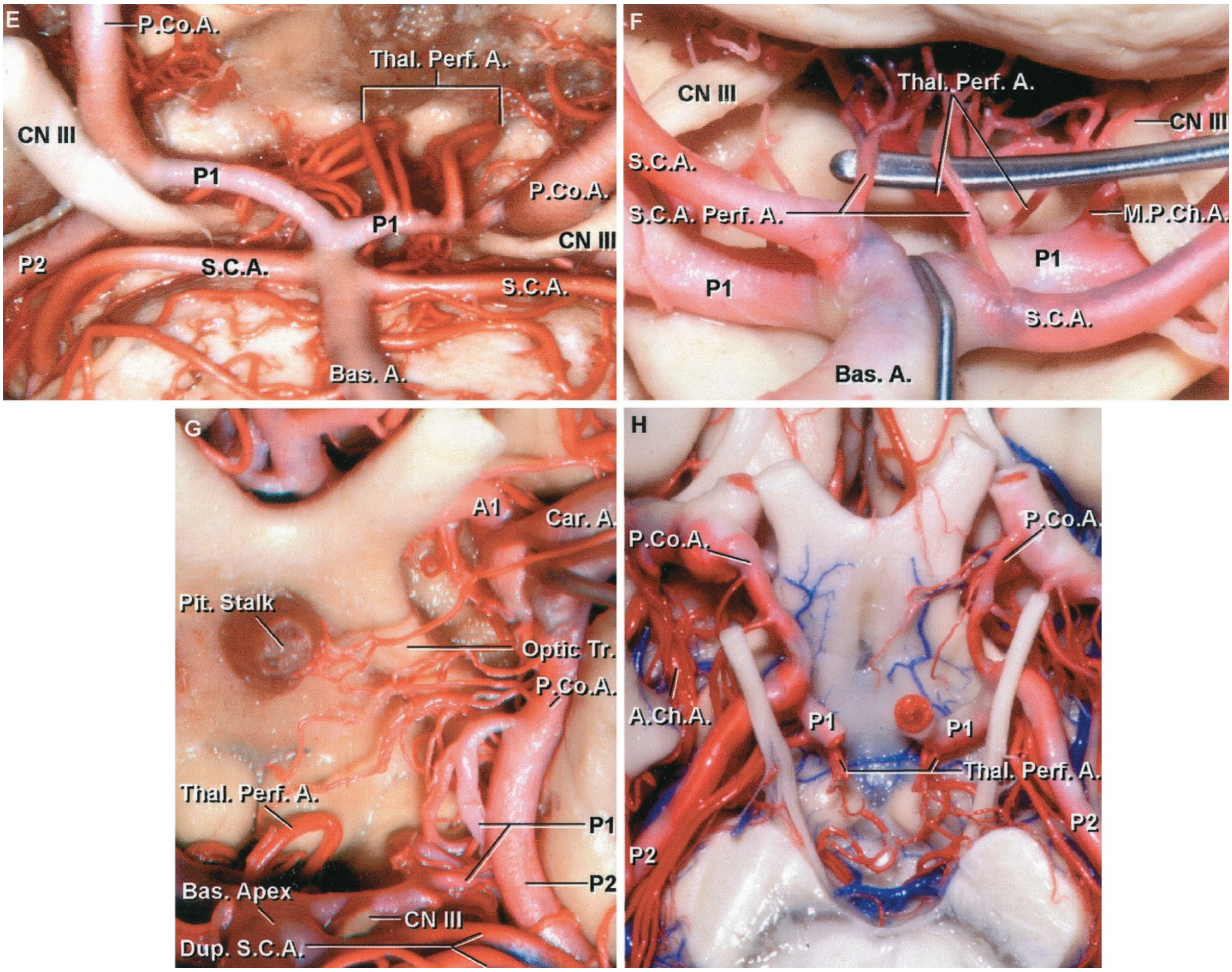
The posterior and lateral surfaces of the upper centimeter of the basilar artery is also a rich source of perforating arteries that overlap with those arising from the P1. An average of 8 (range, 3–18) branches arise from the upper centimeter; approximately half arise from the posterior surface and a quarter from each side (37). The more medial branches, called median or paramedian branches, enter the midbrain and pons near the midline, and the lateral ones, called transverse or circumferential branches, terminate in the lateral pons, peduncle, and posterior perforated substance.



[Click here](#) to view the interactive module and related content for this image.

FIGURE 2.35 A-D. Perforating branches of the P1 and the PComA. A, superior view of the thalamoperforating arteries arising from the P1 segment. The left thalamoperforating artery is larger than the right one. The medial part of the A1s was removed to provide this view of the basilar apex. B, inferior view of another basilar bifurcation. Both P1s contribute to the tuft of thalamoperforating arteries entering the interpeduncular fossa. The right AChA courses above and lateral to the PComA and turns laterally above the uncus. An MPChA arises from the

right P1. C, superior view of the thalamoperforating arteries arising from P1. The basilar artery, below the P1 origins, also send perforating branches in the same area. D, inferior view. The right P1 is much smaller than the left P1, but the right P1 gives rise to a tuft of thalamoperforating arteries that pass upward to enter the interpeduncular fossa. A nerve hook holds up a premamillary branch of the PComA.



Click here to view the interactive module and related content for this image.

FIGURE 2.35 E-H. E, both P1s are smaller than the PComAs, but both P1s give rise to thalamoperforating arteries. The smaller, or left, P1 gives rise to more and larger perforating arteries than the larger, right, P1. F, the dissector holds up two perforating branches that arise from the origin of the superior cerebellar artery and enter the brain through the same area as the thalamoperforating arteries. G, the left PCA has a fetal origin of

the PComA. A series of perforating arteries arises from the PComA and enters the diencephalon medial to the optic tract in the region of the mamillary bodies and floor of the third ventricle. The P1 pursues a tortuous course to its junction with the P2.H, inferior view. The lateral parts of the P1s give rise to thalamoperforating arteries. Perforating branches also arise from the PComA. A., artery; A.Ch.A., anterior choroidal artery; Bas., basilar; Car., carotid; CN, cranial nerve; Dup., duplicate; M.P.Ch.A., medial posterior choroidal artery; P.Co.A., posterior communicating artery; Perf., perforating; Pit., pituitary; S.C.A., superior cerebellar artery; Thal. Perf., thalamoperforating; Tr., tract.

Thalamoperforating Arteries

The thalamoperforating arteries arise on the P1 and enter the brain by passing through the posterior perforated substance and the medial part of the cerebral peduncles in the area behind the mamillary bodies in the upper part of the interpeduncular fossa (Fig. 2.35). The branches of the PComA that enter the same area are referred to as premamillary arteries. The majority of thalamoperforating arteries originate on the middle third of P1 as the P1 branch nearest the basilar bifurcation, but they may also arise on the medial or lateral third. If the first branch is not a thalamoperforating artery, it is a circumflex branch that terminates in the peduncle or posterior mesencephalic area. The thalamoperforating artery is the largest P1 branch in most cases (37). They almost always arise from the posterior or superior aspect of P1 and only infrequently from the anterior surface. A P1, even when of normal or large size, may infrequently not give rise to a thalamoperforating artery, in which case, the contralateral side will have well-developed thalamoperforating branches that supply the area normally perfused by the absent thalamoperforating artery. They supply the anterior and part of the posterior thalamus and hypothalamus, the subthalamus and the medial part of the upper midbrain, including the substantia nigra, red nucleus, oculomotor and trochlear nuclei, oculomotor nerve, mesencephalic reticular formation, pretectum, rostromedial floor of the fourth ventricle, and the posterior portion of the internal capsule (39, pp 96–99; 43).

Deficits related to the loss of these arteries include somatesthetic disturbances caused by involvement of the afferent pathways in the medial lemniscus or thalamus; motor weakness caused by involvement of the corticospinal tracts in the internal capsule or peduncle; memory deficits caused by involvement of hypothalamic pathways entering and exiting from the mamillary bodies; autonomic imbalance caused by disturbance of sympathetic and parasympathetic centers in the anterior and posterior diencephalon; diplopia caused by involvement of the extraocular nerves or nuclei in the midbrain; alterations of consciousness caused by ischemia of the midbrain reticular formation; abnormal movements caused by involvement of cerebellothalamic circuits in the midbrain and thalamus; and endocrine disturbances caused by involvement of the hypothalamic-pituitary axis Occlusion of the thalamoperforating arteries, depending on the size of the area of ischemia, may produce a variety of more focal syndromes including contralateral hemiplegia, cerebellar ataxia, or a “rubral” tremor associated with ipsilateral oculomotor nerve paresis (Nothnagel’s syndrome). If the lesion affects the subthalamus, it may produce contralateral hemiballismus, which abates into choreiform movements with time or treatment (43).

Peduncular Perforating Arteries

The peduncular perforating branches, usually two or three, but as many as six, arise from the P2 segment and pass directly from the PCA into the cerebral peduncle. They supply the corticospinal and corticobulbar pathways as well as the substantia nigra, red nucleus, and other structures of the tegmentum, and may send branches to the oculomotor nerve.

Circumflex Branches

The circumflex groups of arteries arise from the P1 and P2 and encircle the midbrain parallel and medial to the PCA. They are divided into a short and long circumflex group. The short circumflex branches reach only as far as the geniculate bodies. The long circumflex branches reach the colliculi. The short circumflex arteries course medial to the P2 and the medial posterior choroidal and the long circumflex arteries, and send branches to the cerebral peduncle as they proceed to their distal termination, which may range from the posterolateral border of the peduncle to the medial geniculate bodies. Those arising from P2 supply only the geniculate bodies and the midbrain tegmentum. The short circumflex arteries may send rami to the area of the interpeduncular fossa and posterior perforated substance, which are supplied predominantly by the thalamoperforating arteries (37).

The long circumflex arteries, referred to as the quadrigeminal arteries, are present in almost all hemispheres, pass around the brainstem to reach the quadrigeminal cistern, and supply the quadrigeminal bodies. They encircle the midbrain medial to the PCA and send small rami to the cerebral peduncle and geniculate bodies and occasionally to the tegmentum, pulvinar, and end at the quadrigeminal plate. They usually arise from the P1 or P2A. The terminal branches of the long circumflex form a rich arterial network over the colliculi, where they anastomose with branches from the superior cerebellar artery. The superior colliculus is supplied by the branches arising from the PCA and the inferior colliculus is supplied by branches of the superior cerebellar artery. Occlusion of the long circumflex (quadrigeminal) artery may result in defects of vertical gauge caused by infarction of the posterior commissure or of the nuclei of Darkschewitsch or Cajal (Parinaud's syndrome) (40).

Thalamogeniculate Arteries

The thalamogeniculate arteries arise directly from the P2 beneath the lateral thalamus and penetrate the part of the roof of the ambient cistern formed by the geniculate bodies and surrounding area. The PCA most commonly gives origin to two or three thalamogeniculate arteries, but there may be as many as seven. They arise near the junction of the crural (P2A) and ambient (P2P) segments, with a nearly equal number arising from each segment.

The thalamogeniculate arteries supply the posterior half of the lateral thalamus, posterior limb of the internal capsule, and the optic tract (39, pp 96–99). They meet the thalamoperforating branches of P1 near the middle of the thalamus and the thalamic branches of the PComA anteriorly in the lateral nucleus. The long and short circumflex and medial posterior choroidal arteries also send branches to this area as they encircle the brainstem, but the term thalamogeniculate arteries is reserved for those branches arising from the P2 and passing through the geniculate bodies and adjacent part of the roof of the ambient cistern.

Infarction of the area supplied by the thalamogeniculate arteries results in the thalamic syndrome of Dejerine and Roussy, consisting of a contralateral loss of superficial and particularly of deep sensation with an intense, intractable, hyperpathic pain on the affected side, with extreme hypersensitivity to mild touch, pain, and temperature stimuli, a contralateral hemiplegia, often transient and sometimes associated with choreoathetoid or dystonic movements of the paralyzed side, with possibly a homonymous hemianopsia (7, 22). There is usually a permanent disturbance of deep sensibility (position sense, heavy contact, and deep pressure) and, although the threshold to cutaneous stimuli is elevated, a threshold stimulus evokes a disagreeable burning, agonizing type of pain response, and there may be spontaneous pain. The limbs are affected more than the face.

In one such case reported in 1906, Dejerine and Roussy (7) found infarction in the posterior third of the lateral thalamic nucleus, part of the medial and centromedian nuclei and the pulvinar, the posterior limb of the internal capsule, and posterior part of the lentiform nucleus, but they did not find an occlusion of any PCA branch. The fact that the area is supplied not only by multiple thalamogeniculate arteries, but also by the circumflex and choroidal branches of the PCA, makes it unlikely that occlusion of a single thalamogeniculate artery would produce the complete syndrome. It would more likely be caused by a PCA occlusion proximal to the origin of all of these branches. Arterial occlusion is the most common cause of a typical thalamic syndrome, although vascular malformations or tumors of the thalamus may be a cause (43).

Ventricular and Choroid Plexus Branches

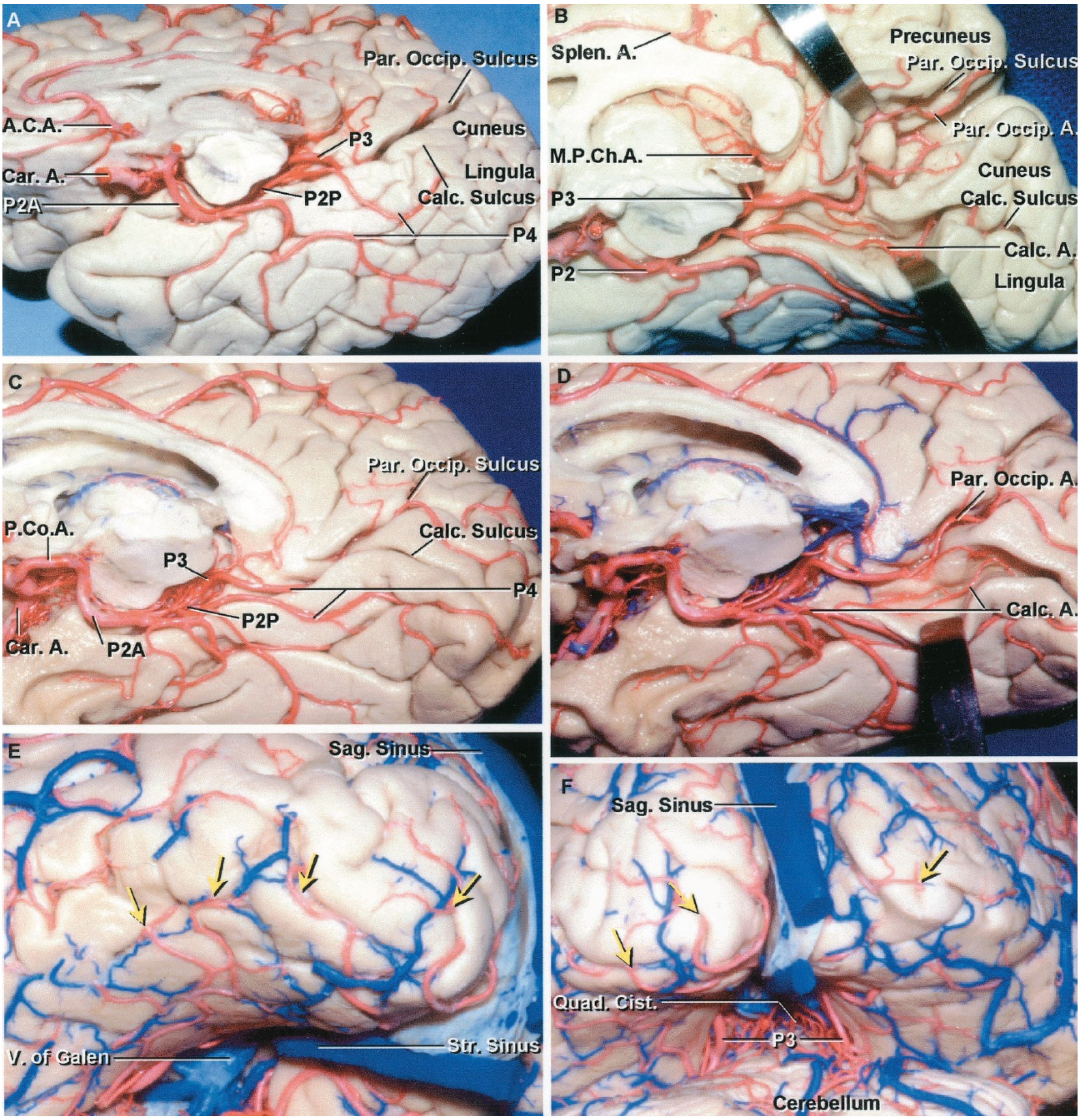
The posterior choroidal arteries, the branches of the PCA that enter the lateral and third ventricles to supply the choroid plexus and ventricular walls, are divided into medial and lateral groups referred to as the medial posterior (MPChA) and lateral posterior choroidal arteries (LPChA), depending on the origin and area of supply (Figs. 2.12, 2.13, and 2.33) (13). The MPChAs most frequently arise from the posteromedial aspect of the proximal half of the PCA or one of its branches, encircle the midbrain medial to the main trunk of the PCA, turn forward at the lateral side of the pineal gland to enter the roof of the third ventricle between the thalami, and finally course through the choroidal fissure and foramen of Monro to enter the choroid plexus in the lateral ventricle. The MPChAs send branches along their course to the peduncle, tegmentum, geniculate bodies (medial and lateral, but primarily the former), the colliculi, pulvinar, pineal gland, and medial thalamus.

Most hemispheres have a single MPChA, but there may be as many as three (43). Most arise in the P2, but they may arise from the P3 or from the parieto-occipital and calcarine branches. Those MPChAs arising from the parieto-occipital and calcarine arteries and the distal PCA course in a retrograde fashion from their origin to enter the roof of the third ventricle.

The LPChAs arise from the PCA or its branches and pass laterally through the choroidal fissure to supply the choroid plexus of the lateral ventricle. The number of LPChAs in one hemisphere ranges from one to nine (average, four) (13). They most commonly arise directly from the P2P, but may also arise from the P2A or P3, or from some of the PCA branches. The largest LPChAs arise directly from the P2P in the ambient cistern, pass laterally through the choroidal fissure to the choroid plexus of the temporal horn and the glomus of the plexus in the atrium, and anastomose on the choroid plexus within the branches of the AChA and MPChA. The LPChAs may send branches to the cerebral peduncle, posterior commissure, part of the crura and body of the fornix, the lateral geniculate body, pulvinar, dorsomedial thalamic nucleus, and the body of the caudate nucleus (13, 43).

Cortical Branches

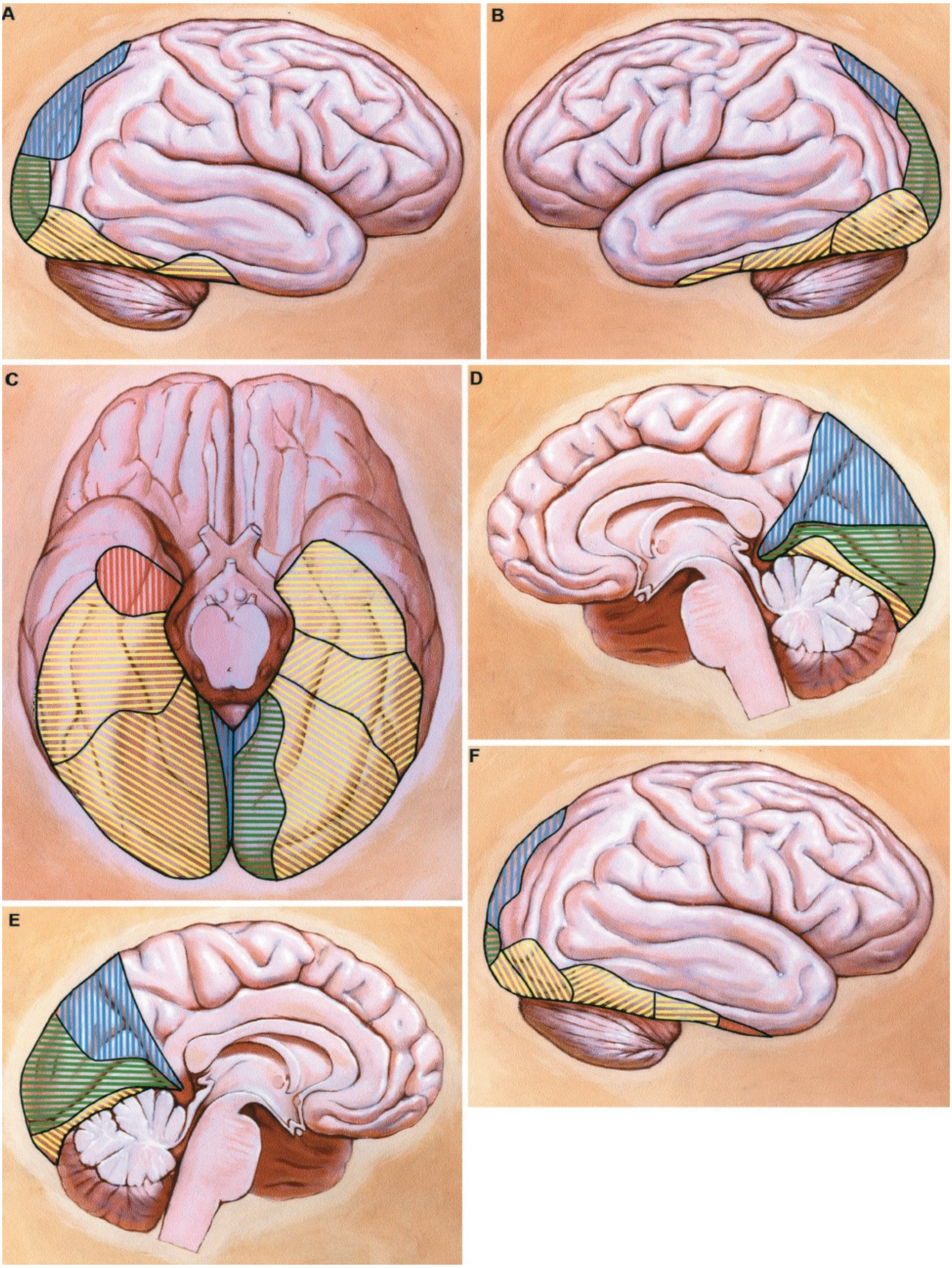
The cortical branches of the PCA are the inferior temporal, parieto-occipital, calcarine, and splenial branches (Figs. 2.36 and 2.37).



Click here to view the interactive module and related content for this image.

FIGURE 2.36. Posterior cerebral arteries. A, the P2 divides into a P2A, which passes through the crural cistern located between the posterior segment of the uncus and the cerebral peduncle, and a P2P, which courses through the ambient cistern, located below the lateral midbrain and parahippocampal gyrus. The P3 passes through the quadrigeminal cistern where it gives rise to the P4 formed by the cortical branches, including the parieto-occipital and calcarine arteries that course in the parieto-occipital and calcarine sulci where they are commonly hidden

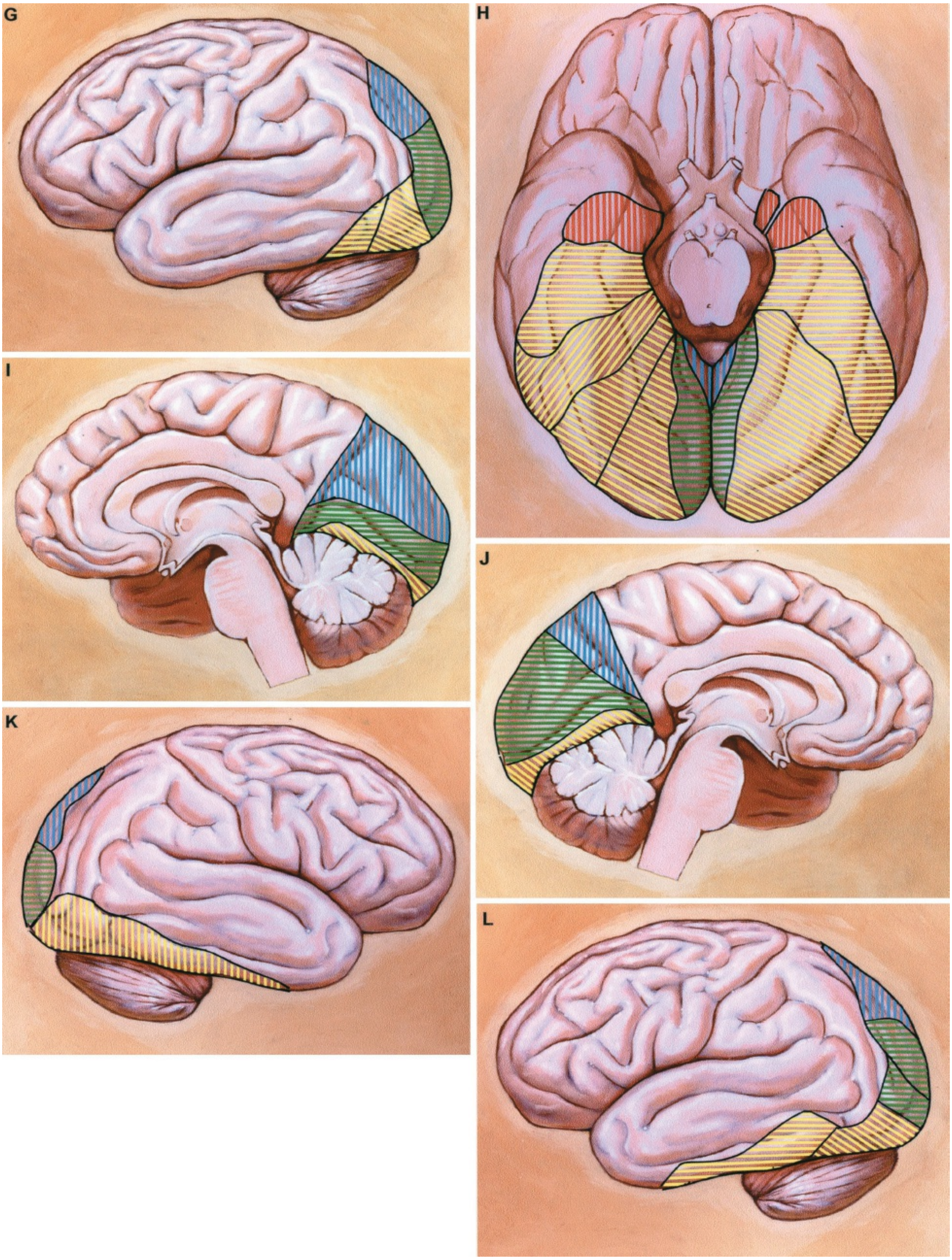
between the sulcal lips. B, the lips of the parieto-occipital and calcarine sulci have been retracted to expose the parieto-occipital and calcarine branches coursing along the sulci. A MPChA encircles the brainstem to reach the third ventricular roof. The cuneus forms the upper lip and the lingula forms the lower lip of the calcarine sulcus. The precuneus forms the upper lip and the cuneus forms the lower lip of the parieto-occipital sulcus. C, another hemisphere. The terminal branches of the PCA pass posteriorly within the parieto-occipital and calcarine sulci. The arrows are on branches that pass around the occipital pole to reach the adjacent lateral surface. D, the lips of the parieto-occipital and calcarine sulci have been retracted. The parieto-occipital artery courses within its sulcus. The calcarine artery courses just below the calcarine sulcus and gives rise to several small branches that course along the depths of the sulcus. E, posteroinferior view of occipital pole showing the branches (red arrow) of the PCA coursing around the occipital pole to reach the adjacent part of the lateral convexity. F, posterior view of both occipital lobes. The P4 branches course around the posterior and lower border of the occipital lobe to reach the lateral cortical surface. The P3s course on the quadrigeminal cistern. A., artery; A.C.A., anterior cerebral artery; Calc., calcarine; Car., carotid; Cist., cistern; M.P.Ch.A., medial posterior choroidal artery; P.Co.A., posterior communicating artery; Par. Occip., parieto-occipital; Quad., quadrigeminal; Sag., sagittal; Splen., splenial; Str., straight; V., vein.



Click here to view the interactive module and related content for this image.

FIGURE 2.37 A-F. Lateral, medial, and basal views of the brain with color-coded sectors representing specific PCA cortical branch distribution. The

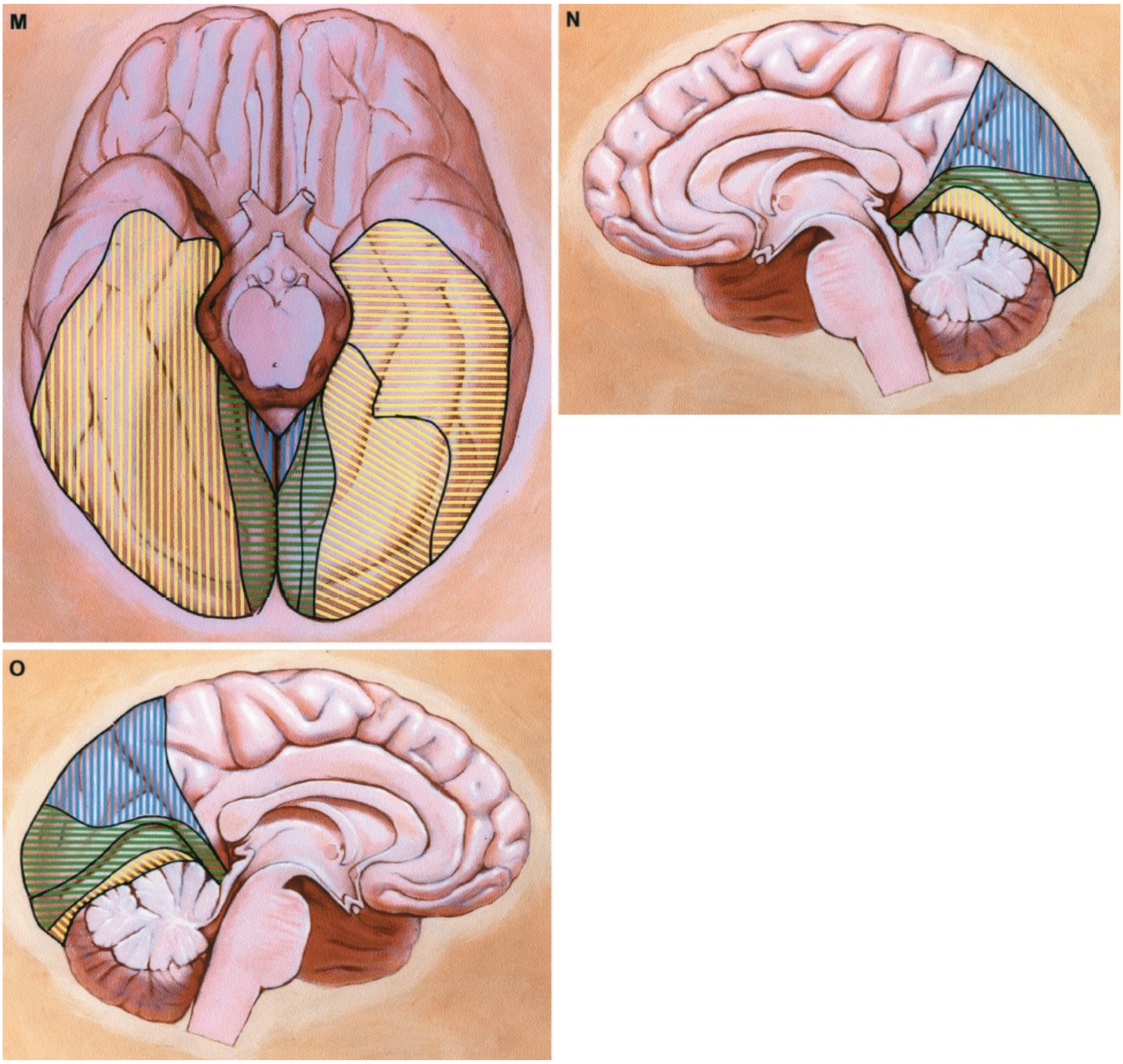
color code corresponding to each PCA branch is as follows: red, hippocampal artery; yellow, temporal arteries; green, calcarine arteries; and blue, parieto-occipital artery. The temporal arteries are further subdivided: transverse yellow stripes, anterior temporal artery; vertical yellow stripes, common temporal artery; diagonal stripes, angled upward to right, anterior temporal artery; and, diagonal stripes angled down to right, posterior temporal artery. The most common pattern (44% of hemispheres) is represented on the right cerebral hemisphere (A and D, and the left half of the basal view, C). This pattern includes hippocampal, anterior temporal, and posterior temporal arteries. The cortical distribution of the parieto-occipital artery is larger than that of the calcarine artery. The second most-common pattern (20% of hemispheres) is represented on the left cerebral hemisphere (B and E, and the right half of the basal view, C). This pattern includes anterior, middle, and posterior temporal, calcarine, and parieto-occipital arteries. In this pattern the anterior temporal artery supplies the region usually supplied by the hippocampal artery. The third most-common pattern (16% of hemispheres) is shown on the right hemisphere (F and I, and left half of basal view, H). In this pattern, there is a common temporal artery that supplies the entire inferior surface of the temporal lobe. The calcarine and parieto-occipital arteries are also present.



Click here to view the interactive module and related content for this image.

FIGURE 2.37 G-L. The calcarine and parieto-occipital arteries are also present. The fourth most common pattern (10% of hemispheres) is

depicted on the left hemisphere (G and J, and right half of basal view, H). This arrangement includes anterior and posterior temporal, calcarine, and parietooccipital arteries, but no hippocampal or middle temporal branches of the PCA. The area of the calcarine artery is split into two sectors to illustrate that there were two calcarine arteries arising from the PCA, as occurs in 10% of hemispheres.



[Click here](#) to view the interactive module and related content for this image.

FIGURE 2.37 M-O. The fifth most common pattern (10% of hemispheres) is illustrated on the right cerebral hemisphere (K and N, and left half of basal view, M). This pattern includes hippocampal, anterior, middle and

posterior temporal, calcarine, and parieto occipital arteries. The area supplied by the posterior temporal artery is split into two parts to show that two posterior temporal arteries arise from the PCA, as occurs in 6% of cerebral hemispheres. The parieto-occipital artery supplies the larger part of the medial surface. The last pattern illustrates some notable variants (L and O, and right half of basal view, M). Two hippocampal arteries arise from the PCA, a finding present in 12% of cerebral hemispheres. The anterior temporal artery supplies a smaller than usual amount of the anterior and lateral temporal surfaces, the remainder is supplied by the middle cerebral artery. The calcarine artery supplies an unusually large area on the medial surface. (From, Zeal AA, Rhoton AL Jr: Microsurgical anatomy of the posterior cerebral artery. J Neurosurg 48:534–559, 1978 [43].)

Inferior Temporal Arteries

The inferior temporal group of arteries arises from the PCA and the superior temporal arteries arise from the MCA. The inferior temporal arteries include the hippocampal and the anterior, middle, posterior, and common temporal arteries. These arteries supply the inferior parts of the temporal lobe. Branches of the inferior temporal arteries pass around the lower margin of the hemisphere to gain access to the lateral cerebral surface, reaching the middle temporal gyrus in 42% of hemispheres (43). They also give rise to some LPChAs. The inferior temporal arteries are divided into five groups based on the branches present and the area they supply:

- Group 1. All of the inferior temporal branches (hippocampal and anterior, middle, and posterior temporal arteries) are present (10% of hemispheres).
- Group 2. A single large trunk, the common temporal artery, arises from the PCA and branches to supply the entire inferior temporal lobe (16%).
- Group 3. Anterior, middle, and posterior temporal branches are present, but no hippocampal artery is present (20%).

- Group 4. Anterior and posterior temporal branches are present, but no hippocampal or middle temporal arteries are present (10%).
- Group 5. Hippocampal and anterior and posterior temporal branches are present, but no middle temporal artery is present. This is the most frequent pattern, present in 44% of hemispheres (43).

Hippocampal Arteries

The hippocampal artery, if present, arises in the crural or ambient cistern and is the first cortical branch of the PCA. It

supplies the uncus, anterior parahippocampal gyrus, hippocampal formation, and the dentate gyrus. A small branch may extend to the lateral surface of the temporal lobe and forward to the temporal tip. If the first cortical branch supplies a significant portion of the inferior temporal lobe in addition to the hippocampal gyrus, the branch is classified as an anterior temporal artery. Bilateral occlusion of the vessels to the medial temporal area supplied by the hippocampal artery may cause a severe memory loss and a deficit resembling Korsakoff's syndrome (43).

Anterior Temporal Artery

The anterior temporal artery is usually the second cortical PCA branch. It is the first branch if there is no hippocampal artery. It usually arises in the proximal part of the ambient cistern and supplies the anteroinferior surface of the temporal lobe, occasionally reaching a portion of the temporal pole and the lateral cerebral surface in the region of the middle temporal sulcus and gyrus.

Middle Temporal Artery

This artery arises in the crural and ambient cisterns and supplies the inferior surface of the temporal lobe. It is the smallest, is frequently absent, and has the fewest branches of the inferior temporal arteries.

Posterior Temporal Artery

This artery, present in almost all hemispheres, arises from the inferior or lateral aspect of the PCA, most commonly in the ambient, but occasionally in the crural or quadrigeminal cisterns, and runs obliquely posterolateral toward the occipital pole to supply the inferior temporal and occipital surfaces, including the occipital pole and lingual gyrus. It has the largest trunk diameter and number of branches of any temporal artery except a common temporal artery from which all the temporal branches arise. Deficits after occlusions of the posterior temporal artery include dysphasia, which has usually been mild and transient, an amnestic syndrome, usually transient with homonymous hemianopsia, but without hemiparesis or sensory loss and inability to match colors to their names (21).

Common Temporal Artery

The common temporal artery, seen in slightly fewer than 20% of hemispheres, arises in the crural or ambient cisterns as a single PCA branch that supplies the majority of the inferior surface of the temporal and occipital lobes.

Parieto-occipital Artery

The parieto-occipital artery, one of the two terminal branches of the PCA, is present in almost all hemispheres. It consistently arises as a single branch and runs in the parieto-occipital fissure to supply the posterior parasagittal region, cuneus, precuneus, lateral occipital gyrus, and, rarely, the precentral and superior parietal lobules. It arises in the ambient or quadrigeminal cisterns. The arteries with a more proximal origin tend to be larger and donate branches to the midbrain, thalamus, pulvinar, and lateral geniculate bodies as they pass posteriorly within the hippocampal fissure. Those arteries with a proximal origin also send branches through the choroidal fissure to the choroid plexus in the lateral ventricle. This artery occasionally sends branches to the third ventricle in the area supplied by the MPChA or to the splenium of the corpus callosum.

Calcarine Artery

The calcarine artery, a terminal PCA branch, is present in all hemispheres.

It courses within the calcarine fissure to reach the occipital pole, and has branches that fan out to the lingual gyrus and the inferior cuneus. It usually arises directly from the PCA in the ambient or quadrigeminal cisterns, but occasionally is a branch of the parieto-occipital artery. The calcarine artery supplies the visual cortex, and the hallmark of an occlusion of this vessel is a homonymous visual field defect, usually with macular sparing. Occlusion may be associated with pain in the ipsilateral eye. Bilateral occipital lobe infarction may result in blindness with preserved pupillary reflexes or in Anton's syndrome, in which there is cortical blindness, confabulation, denial of blindness, and preservation of the pupillary reaction to light. The visual field may recover after ligation or occlusion of the calcarine artery (19).

Splenial Artery

The PCA, or its branches, gives rise to branches supplying the splenium of the corpus callosum in all hemispheres. They may arise from the following arteries: parieto-occipital, calcarine, medial posterior choroidal, posterior temporal, and lateral posterior choroidal. The splenial arteries anastomose with branches of the pericallosal artery a few centimeters anterior to the posterior tip of the splenium as previously noted. Retrograde filling of this artery through the pericallosal artery suggests occlusion of the PCA proximal to the origin of the splenial artery. Infarction of the dominant occipital pole (producing a hemianopsia) plus the splenium of the corpus callosum in the distribution of the splenial artery interrupts the fibers between the intact occipital pole and contralateral angular gyrus, resulting in the syndrome of dyslexia without dysgraphia (43).

Lateral Convexity Branches

All the cortical branches of the PCA may send branches to the lateral surface of the hemisphere, but of the seven cortical arteries, the posterior temporal artery is the most common site of origin of lateral cortical branches. The next most common source is the parieto-occipital artery. If a revascularization procedure using microvascular anastomoses between the superficial temporal or occipital arteries and a cortical branch of the PCA were undertaken, the area supplied by the posterior temporal artery would show the most promise of revealing a vessel of sufficient caliber to be used as a recipient, there being a higher than 75% chance of finding a vessel of sufficient size within this area (43). This corresponds with the region immediately anterior to the preoccipital notch. The majority of the cortical branches of the PCA are 0.4 to 0.6 mm in diameter when they pass around the margin to the lateral cerebral surface.

IIIrd and IVth Cranial Nerves

The relationship between the oculomotor and trochlear nerves and the PCA and SCA is constant (Figs. 2.1 and 2.3) (32). The oculomotor nerve consistently passes between the PCA and SCA near their origin, and the trochlear nerve passes between the two on the lateral margin of the brainstem. The relationship is unaltered even when the superior cerebellar origin is duplicated. When the SCA arises as duplicate trunks, the nerves pass between the superior trunk of the SCA and the PCA. The PCA consistently courses above the trochlear. A tortuous SCA may occasionally loop above a trochlear nerve.

Discussion

The PCA, more than any other intracranial vessel, subserves the function of vision. It supports a long list of ocular functions that include papillary reflexes, eye movement, visual memory, intrahemispheric transfer of visual information, binocular and visual spatial integration through its supply to the optic tracts, geniculate bodies, colliculi, extraocular nerves and their nuclei, the geniculocalcarine tracts, and the striate and peristriate cortex. The dysfunction caused by occlusion of the individual PCA branches has been reviewed in the subsection related to those branches. Occlusion of various branches may also lead to somesthetic disturbances caused by involvement of afferent pathways in the medial lemniscus or thalamus, motor weakness caused by involvement of the corticospinal tracts in the internal capsule or peduncle, memory deficits caused by involvement of the hypothalamic pathways entering and exiting the mamillary bodies, autonomic imbalance caused by disturbances of the sympathetic and parasympathetic pathways in the anterior and posterior diencephalon, alterations of consciousness caused by ischemia of the midbrain reticular formation, abnormal movements caused by involvement of cerebellothalamic circuits in the midbrain and thalamus, and endocrine disturbances caused by involvement of the hypothalamic pituitary axis.

Vascular complications in pituitary surgery result mainly from carotid artery injury and circulatory embarrassment after occlusion of the carotid artery. Occlusion of the perforating branches of the posterior circle is commonly neglected in discussions regarding complications in pituitary surgery. The arterial branches reviewed in this study, which would be stretched around the margin of suprasellar tumors, have the potential, when occluded, to cause personality disorders, memory disturbances, extraocular palsies, visual loss, and altered states of consciousness (12, 34). The branches stretched around pituitary tumors are discussed further in Chapter 8.

Contributor: Albert L. Rhoton, Jr, MD

Content from Rhoton AL, Jr. The supratentorial cranial space: microsurgical anatomy and surgical approaches. *Neurosurgery* 2002;51:S1-iii–S1-vi. doi.org/10.1097/00006123-200210001-00001. With permission of Oxford University Press on behalf of the Congress of Neurological Surgeons.

The Neurosurgical Atlas is honored to maintain the legacy of Albert L. Rhoton, Jr, MD.

REFERENCES

1. Abbie AA: The clinical significance of the anterior choroidal artery. *Brain* 56:233–246, 1933.
2. Baptista AG: Studies on the arteries of the brain: Part II—The anterior cerebral artery: Some anatomic features and their clinical implications. *Neurology* 13:825–835, 1963.
3. Chater N, Spetzler RF, Tonnemacher K, Wilson CB: Microvascular bypass surgery: Part 1—Anatomical studies. *J Neurosurg* 44:712–

714, 1976.

4. Cooper IS: Surgical alleviation of Parkinsonism: Effects of occlusion of the anterior choroidal artery. *J Am Geriatr Soc* 2:691–718, 1954.
5. Cooper IS: Surgical occlusion of the anterior choroidal artery in Parkinson- ism. *Surg Gynecol Obstet* 99:207–219, 1954.
6. Critchley M: The anterior cerebral artery, and its syndromes. *Brain* 53:120– 165, 1930.
7. Dejerine J, Roussy G: Le syndrome thalamique. *Rev Neurol* 14:521–532, 1906.
8. Dunker RO, Harris AB: Surgical anatomy of the proximal anterior cerebral artery. *J Neurosurg* 44:359–367, 1976.
9. Epstein F, Ransohoff J, Budzilovich GN: The clinical significance of junctional dilatation of the posterior communicating artery. *J Neurosurg* 33:529–531, 1970.
10. Fisher CM: Clinical syndromes in cerebral thrombosis, hypertensive hemorrhage, and ruptured saccular aneurysm. *Clin Neurosurg* 22:117–147, 1975.
11. Foix CH, Chavany JA, Hillemand P: Obliteration de l'artère choroidienne anterieure. Ramollissement cerebral hémiplégie, hémianesthesie et hémianopsie. *Soc d'Ophtal* May, 1925.
12. Fujii K, Chambers SM, Rhoton AL Jr: Neurovascular relationships of the sphenoid sinus: A microsurgical study. *J Neurosurg* 50:31–39, 1979.
13. Fujii, K, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the choroidal arteries: Lateral and third ventricles. *J Neurosurg* 52:165–188, 1980.
14. Gibo H, Carver CC, Rhoton AL Jr, Lenkey C, Mitchell RJ: Microsurgical anatomy of the middle cerebral artery. *J Neurosurg* 54:151–169, 1981.
15. Gibo H, Lenkey C, Rhoton AL Jr: Microsurgical anatomy of the supraclinoid portion of the internal carotid artery. *J Neurosurg*

55:560–574, 1981.

16. Harris FS, Rhoton AL Jr: Microsurgical anatomy of the cavernous sinus: A microsurgical study. *J Neurosurg* 45:169–180, 1976.
17. Hassler O, Saltzman GF: Angiographic and histologic changes in infundibular widening of the posterior communicating artery. *Acta Radiol* 1:321–327, 1963.
18. Heubner O: *Die luetische Erkrankung der Hirnarterien*. Leipzig, Vogel, 1874, p 183.
19. Hoyt WF, Newton TH: Angiographic changes with occlusion of arteries that supply the visual cortex. *N Z Med J* 72:310–317, 1970.
20. Liu Q, Rhoton AL Jr: Middle meningeal origin of the ophthalmic artery. *Neurosurgery* 49:401–407, 2001.
21. Mohr JP, Leicester J, Stoddard LT, Sidman M: Right hemianopia with memory and color deficits in circumscribed left posterior cerebral artery territory infarction. *Neurology* 21:1104–1113, 1971.
22. Newton TH, Hoyt WF, Margolis MT: Pathology of the posterior cerebral artery, in Newton TH, Potts PC (eds): *Radiology of the Skull and Brain*. St. Louis, C.V. Mosby, 1974, Vol II, Book 2, pp 1580–1627.
23. Ono M, Ono M, Rhoton AL Jr, Barry M: Microsurgical anatomy of the region of the tentorial incisura. *J Neurosurg* 60:365–399, 1984.
24. Padget DH: The development of the cranial arteries in the human embryo. *Contrib Embryol* 32:205–262, 1948.
25. Paullus WS, Pait TG, Rhoton AL Jr: Microsurgical exposure of the petrous portion of the carotid artery. *J Neurosurg* 47:713–726, 1977.
26. Perlmutter D, Rhoton AL Jr: Microsurgical anatomy of the anterior cerebral- anterior communicating-recurrent artery complex. *J Neurosurg* 45:259–272, 1976.
27. Perlmutter D, Rhoton AL Jr: Microsurgical anatomy of the distal anterior cerebral artery. *J Neurosurg* 49:204–228, 1978.

28. Rand RW, Brown WJ, Stern WE: Surgical occlusion of the anterior choroidal arteries in Parkinsonism. *Neurology* 6:390–401, 1956.
29. Renn WH, Rhoton AL Jr: Microsurgical anatomy of the sellar region. *J Neurosurg* 43:288–298, 1975.
30. Rhoton AL Jr: Microsurgical treatment of occlusive cerebrovascular disease. *Compr Ther* 5:39–47, 1979.
31. Rhoton AL Jr: Anatomy of saccular aneurysms. *Surg Neurol* 14:59–66, 1980. 32.
32. Rhoton AL Jr: The cerebellar arteries. *Neurosurgery* 47[Suppl 1]:S29–S68, 2000. 33.
33. Rhoton AL Jr, Fujii K, Fradd B: Microsurgical anatomy of the anterior choroidal artery. *Surg Neurol* 12:171–187, 1979.
34. 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.
35. Rhoton AL Jr, Saeki N, Perlmutter D, Zeal A: Microsurgical anatomy of common aneurysm sites. *Clin Neurosurg* 26:248–306, 1979.
36. Rosner SS, Rhoton AL Jr, Ono M, Barry M: Microsurgical anatomy of the anterior perforating arteries. *J Neurosurg* 61:468–485, 1984.
37. Saeki N, Rhoton AL Jr: Microsurgical anatomy of the upper basilar artery and the posterior circle of Willis. *J Neurosurg* 46:563–578, 1977.
38. Stehbens WE: Aneurysms and anatomic variation of cerebral arteries. *Arch Pathol* 75:45–64, 1963.
39. Stephens RB, Stilwell DL: *Arteries and Veins of the Human Brain*. Springfield, Charles C Thomas, 1969, p 181.
40. Toole JF, Cole M: Ischemic cerebrovascular disease, in Baker AB, Baker LH (eds): *Clinical Neurology*. Hagerstown, Harper and Row, 1976, vol 1, pp 15–16. 41.
41. Viale GL, Turtas S, Pau A: Surgical removal of striate arteriovenous malformations. *Surg Neurol* 14:321–324, 1980.

42. Waddington MM, Ring BA: Syndromes of occlusions of middle cerebral artery branches. *Brain* 91:685–696, 1968.
43. Zeal AA, Rhoton AL Jr: Microsurgical anatomy of the posterior cerebral artery. *J Neurosurg* 48:534–559, 1978.