4 Anterior Cerebral Artery

The anterior cerebral artery (ACA) is the smaller of the two terminal branches of the internal carotid artery (ICA). It is considered the direct embryonic continuation of the ICA, whereas the middle cerebral artery (MCA) is only a secondary branch of this vessel (De Vriese 1905; Abbie 1934). The ACA can be divided into several segments (Huber 1979) (Fig. 4.1).

- A1 (precommunicating segment): from its origin to the anterior communicating artery (AcomA)
- Distally to the AComA, the ACA continues as the pericallosal artery:
- A2 (infracallosal segment)
- A3 (precallosal segment)
- A4 (supracallosal segment)

4.1 Precommunicating Segment

The first part of the artery is called the A1 or precommunicating segment. It arises at the carotid bifurcation, and it runs medially above the chiasma and optic nerve with a horizontal, sometimes descending, ascending, or tortuous course, joining the contralateral A1 by way of the AcomA. Its length is on average 12.7 mm (Perlmutter and Rhoton 1976) (Fig. 4.2).

Branches. Perforators are found along the length of the A1, but they are more numerous in its proximal section, arising from the superior surface (Dunker and Harris 1976; Perlmutter and Rhoton 1976; Rosner et al. 1984). A few perforators also arise from the AcomA (Dunker and Harris 1976; Perlmutter and Rhoton 1976; Rosner et al. 1984; Krayenbühl et al. 1972; Marinković et al. 1990). The perforators enter the anterior medial part of the anterior perforated substance (APS), supplying the suprachiasmatic anterior portion of the hypothalamus. Other perforators supply the optic nerve and chiasma.

The recurrent artery of Heubner, first described by Heubner (1872), is the largest and longest perforating artery. It commonly takes its origin from the distal A1 or proximal A2 segment, rarely from the

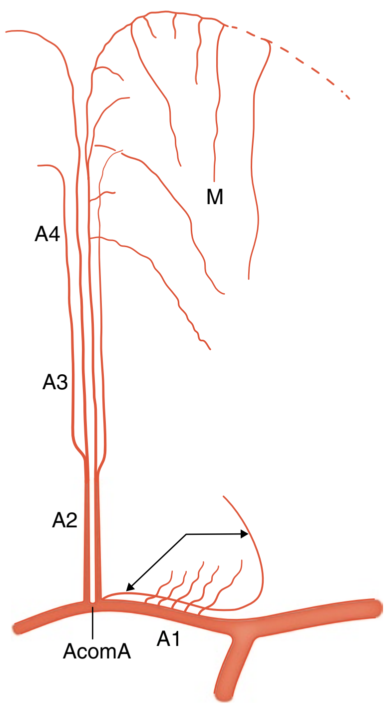

Fig. 4.1 Segments of the anterior cerebral artery: *A1*, *A2*, *A3*, and *A4*. Deep perforators arising from the *A1*. Artery of Heubner (*double arrow*) arising from *A1–A2*. Medullary arteries (*M*, *short and long branches*) arising from cortical branches. Leptomeningeal anastomosis with the MCA (--------)

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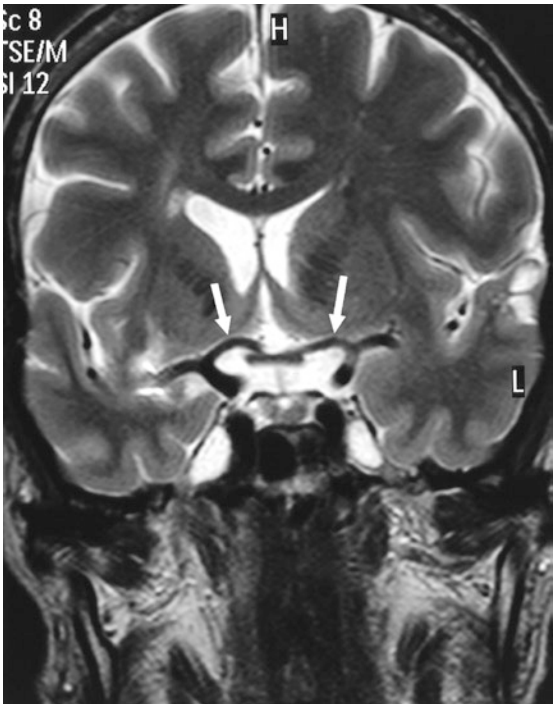

Fig. 4.2 Coronal MRI, T2-weighted image showing the relationship of the A1 to the chiasma (*arrows*)

AcomA. It can have a common origin with the frontopolar artery (Perlmutter and Rhoton 1976; Rosner et al. 1984).

In its course, the artery of Heubner runs back parallel to the A1 and M1 segments to enter the APS anterior to the other perforators of the A1. It can occur as a single or sometimes multiple branches, supplying the inferior part of the head of the nucleus caudatus, the inferior part of the anterior limb of the internal capsule, and adjacent part of the globus pallidus and putamen (Perlmutter and Rhoton 1976; Rosner et al. 1984) (Figs. 4.3, 4.4, 4.8c, and 4.10).

The AComA and the A1-A2 junction are typical sites of aneurysm, which can have a close relationship with the artery of Heubner. When surgical or endovascular treatment is planned, it is very useful to attempt to identify this artery on the angiogram.

4.2 Distal Segments

Distal to the junction with the AComA begins the segment called the pericallosal artery, which can be divided, according to its relationship with the corpus

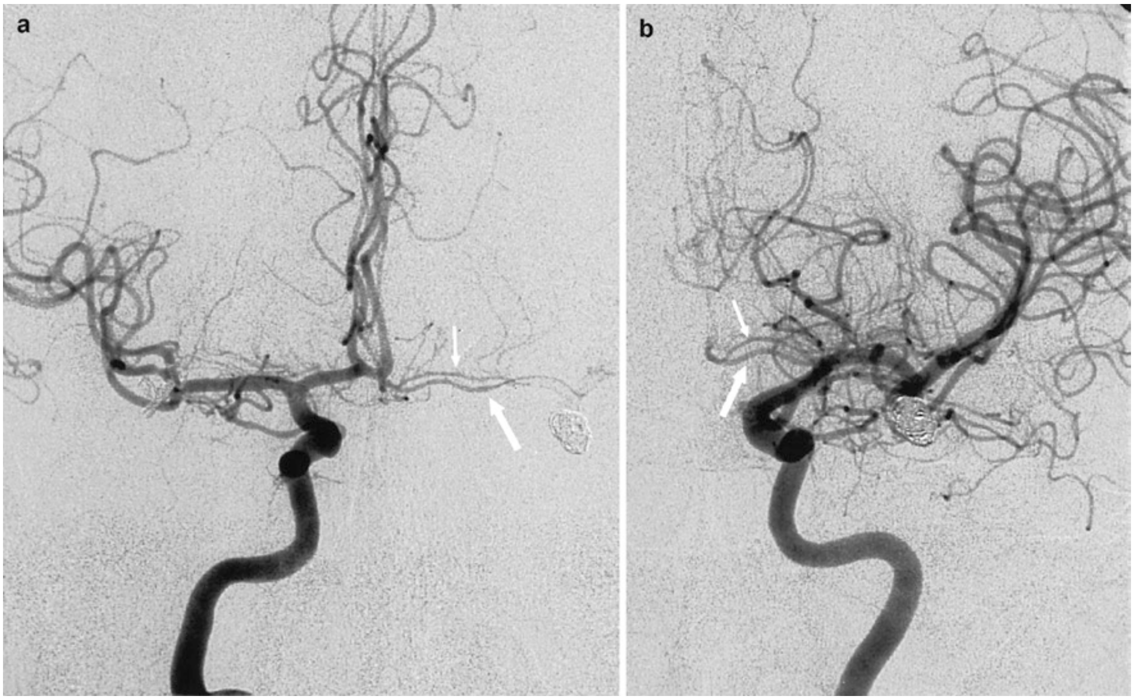

Fig. 4.3 *Right* (**a**) – *left* (**b**) AP carotid angiogram in a patient treated with coils for a ruptured left middle cerebral artery aneurysm. Well-developed A1 on the *right*. Hypoplastic *left* A1 segment (*large white arrow*). Artery of Heubner (*small white arrow*) running parallel to the A1 segment

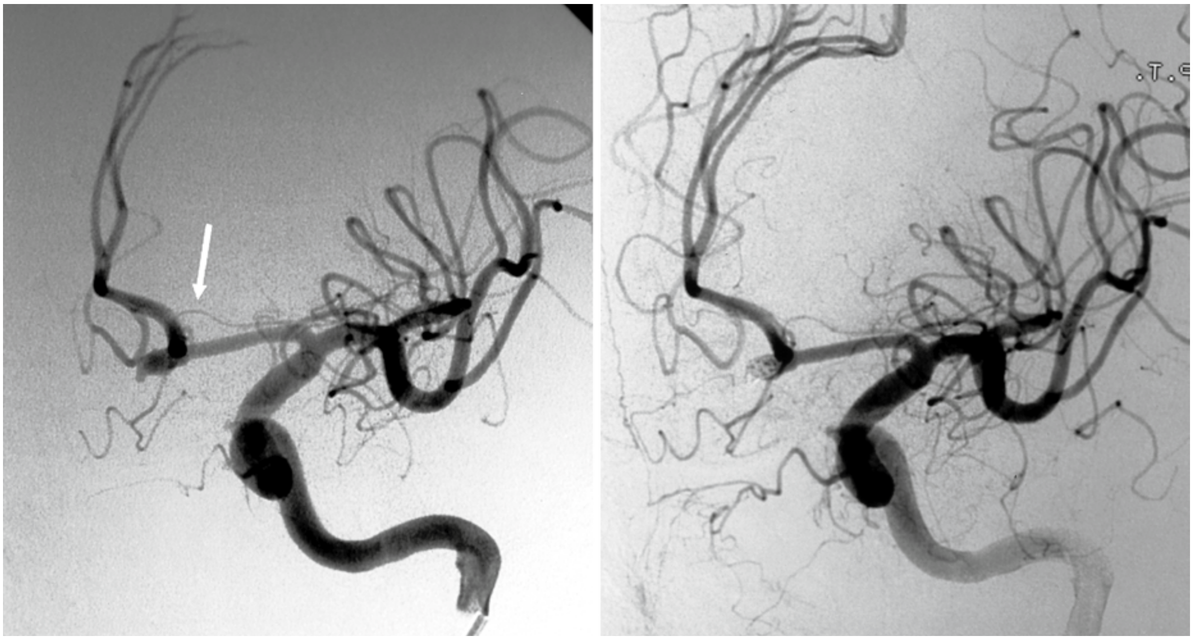

Fig. 4.4 Carotid angiogram, oblique view in a patient examined for ruptured aneurysm of the anterior communicating artery treated in the same section with coils. *Left*, artery of Heubner (*white arrow*) arising close to the aneurysm

callosum, into three further segments (Liu and Kricheff 1974; Huber 1979).

4.2.1 Infracallosal Segment

This is also called the A2, and it runs into the interhemispheric fissure upward in front of the lamina terminalis to the genu of the corpus callosum. It gives off infraorbital and frontopolar branches, supplying, respectively, the frontobasal region (gyrus rectus, orbital gyri, olfactory bulb and tract) and the anterior medial part of the superior frontal gyrus (Figs. 4.5 and 4.6).

4.2.2 Precallosal Segment

This is also called the A3. It is a short segment and curves around the genu of the corpus callosum, to which it gives off small branches (Figs. 4.5 and 4.6). It gives off the callosomarginal artery, which, when well formed,

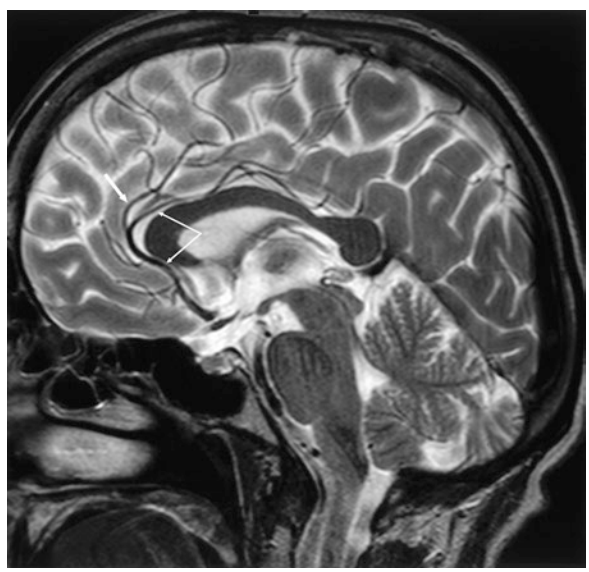

Fig. 4.5 T2-weighted sagittal MRI image. Infra-, pre-, and supracallosal segments of the pericallosal artery (*arrow with angle*). The supracallosal segment runs with an undulating course above the corpus callosum, partially in the pericallosal cistern and partially superior to it. From its precallosal segment arises the callosomarginal artery (*arrow*)

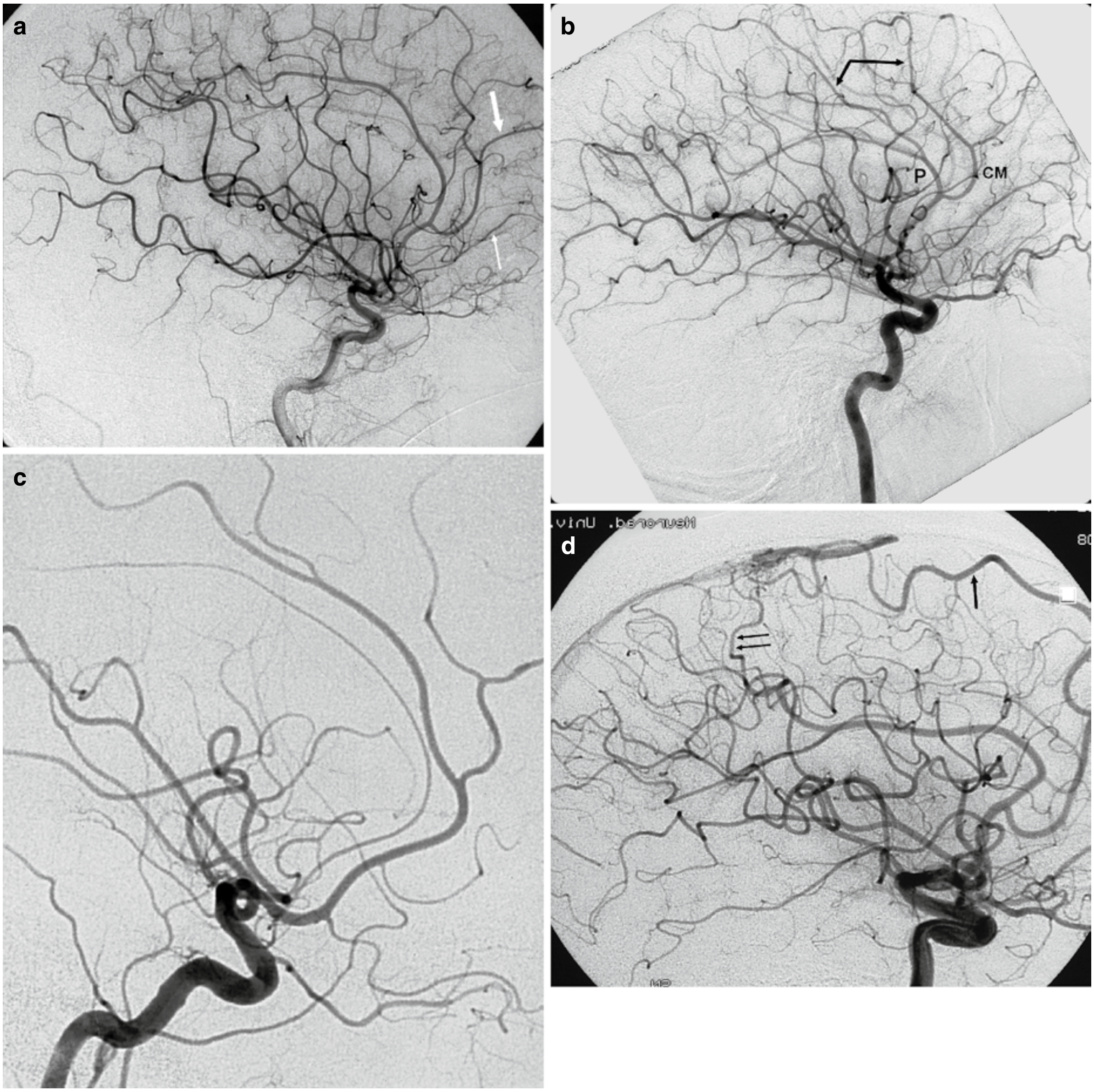

Fig. 4.6 Lateral angiograms. (**a**) Well-developed callosomarginal artery, though the pericallosal artery is hypoplastic. Fronto-orbital artery (*small white arrow*), frontopolar artery (*large white arrow*). (**b**) Pericallosal artery (*P*) in its course along the corpus callosum. Callosomarginal artery (*CM*), frontal and parietal branches (*arrow with angle*). (**c**) Hypoplastic pericallosal atery and well-developed callosomarginal arteries arising as a separate trunk. (**d**) Well-developed callosomarginal artery (*large arrow*) supplying small-convexity angiomas. Another branch (*double arrow*), probably a dilated paracentral artery, arises from the dilated pericallosal artery

runs posteriorly in the cingulate sulcus above the gyrus cinguli and appears on the lateral angiogram superior and on the anterioposterior (AP) view slightly medial to the pericallosal artery. The more distal branches extend to the paracentral and precuneus lobes.

The callosomarginal artery can be absent or developed only in its frontal portion. In such cases, its branches are replaced by arteries arising from the presupracallosal segment of the pericallosal artery.

4.2.3 Supracallosal Segment

This segment is also called the A4 (Figs. 4.5 and 4.6). It is the more distal segment of the pericallosal artery. It runs posteriorly in the pericallosal cistern, above the surface of the corpus callosum, toward the splenium. Its posterior extent depends on the size of the posterior pericallosal branch (artery of the splenium) of the posterior cerebral artery. Occasionally, it can extend below the corpus callosum toward the foramen of Monro (Perlmutter and Rhoton 1978), as in embryological life. The supracallosal artery may have an undulating course and sometimes show an upward distension in its midportion. The artery can be well formed, hypoplastic, or uni- or bilaterally absent.

A meningeal branch can arise from the presupracallosal segment, and this branch supplies the inferior portion of the falx (Lasjaunias and Berenstein 1990). It anastomoses with the branches of the middle meningeal artery, which descend along the falx. The meningeal branch can also be connected with the meningeal branch that arises from the posterior cerebral artery (see Sect. 7.1).

4.2.4 Cortical Branches

Several arteries arise from the supracallosal segment of the pericallosal artery and/or callosomarginal artery and run on the medial surface of the hemisphere. There is a close relationship between the pericallosal and callosomarginal arteries; when one of these is hypoplastic or absent, the other can replace its vascular territory.

From anterior to posterior, the cortical branches are represented first by the frontal branches. The second artery is the small paracentral branch, which runs toward the paracentral lobule and extends to the central sulcus, supplying the paracentral lobule and superior part of the precentral and postcentral gyri. The more distal arteries are the inferior and superior parietal branches. The superior parietal artery is usually a large branch that runs in the marginal segment of the cingulate sulcus and marks the boundary between the paracentral lobule and precuneus, with branches supplying both arteries (Figs. 4.5 and 4.6).

4.3 Anatomical Variations

One A1 segment is hypoplastic (diameter of 1.5 mm or less) in 10% of cases and severely hypoplastic (diameter of less than 1 mm) or absent in 1% (Perlmutter and Rhoton 1976; Huber 1979; Yaşargyl 1984a, 1984b) (Figs. 4.3, 4.7 and 7.2). This variation is frequently associated with aneurysm of the AComA (Perlmutter and Rhoton 1976; Huber 1979; Yaşargyl 1984a, 1984b).Two or three AComAs may be present in up to 40% of cases (Perlmutter and Rhoton 1976; Marinković et al. 1990) (Fig. 4.8). The same artery can be hypoplastic, being as small as 0.2 mm (Perlmutter and Rhoton 1976.

Another, more infrequent, variation is a duplicated A1. In such cases, the inferior branch, which arises from the ICA, close to the origin of the ophthalmic artery, has an ascending course and passes inferiorly to the optic nerve; the superior branch has a normal origin from the distal ICA and runs superiorly to the nerve. The superior branch can be hypoplastic or absent (Turnbull 1962; Nutik and Dilenge 1976; Milenkovic 1985; Friedlander and Ogilvy 1996; Morris 1997). The A1 segment may have a normal origin, but along its course it features duplication or fenestration (Fig. 4.9).

The pericallosal artery can be unique (azygos pericallosal artery); in other cases, there may be a third branch, which can predominate over the others (Perlmutter and Rhoton 1976; Dunker and Harris 1976; Marinković et al. 1990) (Figs. 4.10–4.12). In these cases, aneurysms are also frequently present and involve the AComA or pericallosal artery. The artery of Heubner is rarely absent on one side. One should bear in mind that if the A1 is hypoplastic, the artery of Heubner may be very large and can be confused with the A1. Variations concerning the pericallosal and callosomarginal arteries have already been described.

4.4 Vascular Territories

The vascular territories supplied by the perforating branches arising from the A1 and by the recurrent artery of Heubner have already been described. These branches are end arteries, without anastomoses to each other or with the branches descending through the white matter (medullary arteries). The distal segments of the ACA supply the frontobasal region and medial surface of the hemisphere in the frontoparietal region.

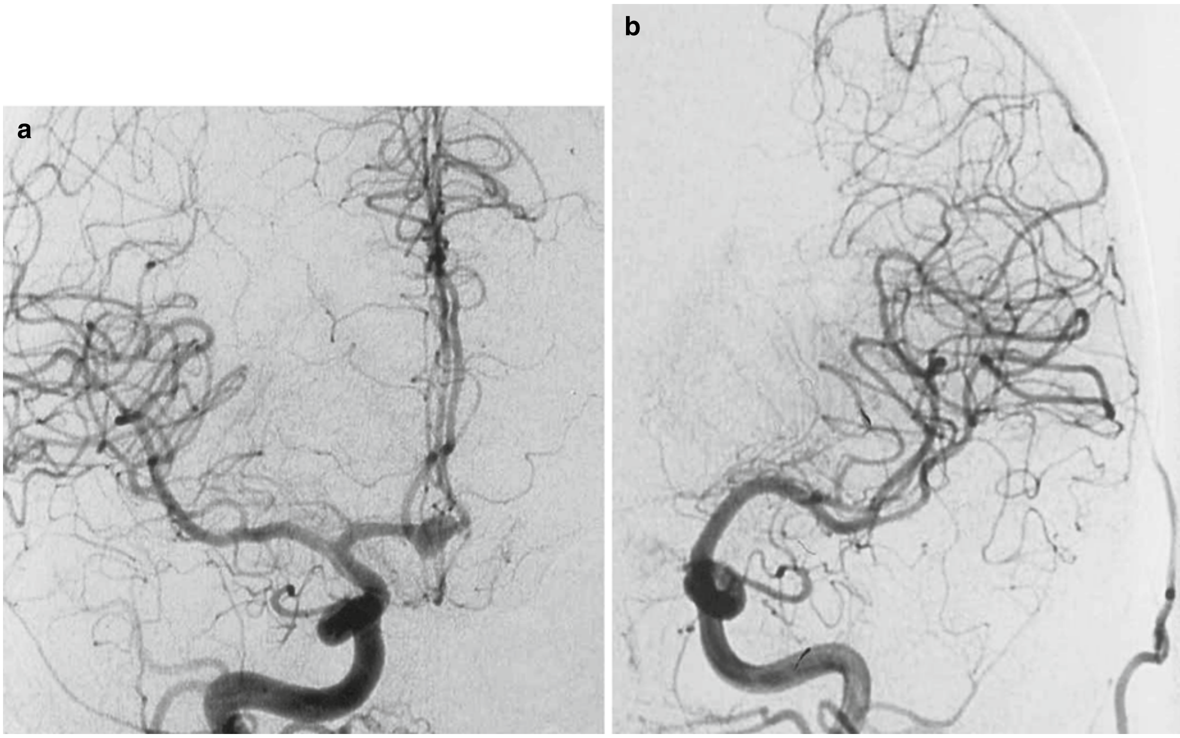

Fig. 4.7 Hypo/aplastic left A1 segment in a patient with aneurysm of the anterior communicating artery well developed right A1

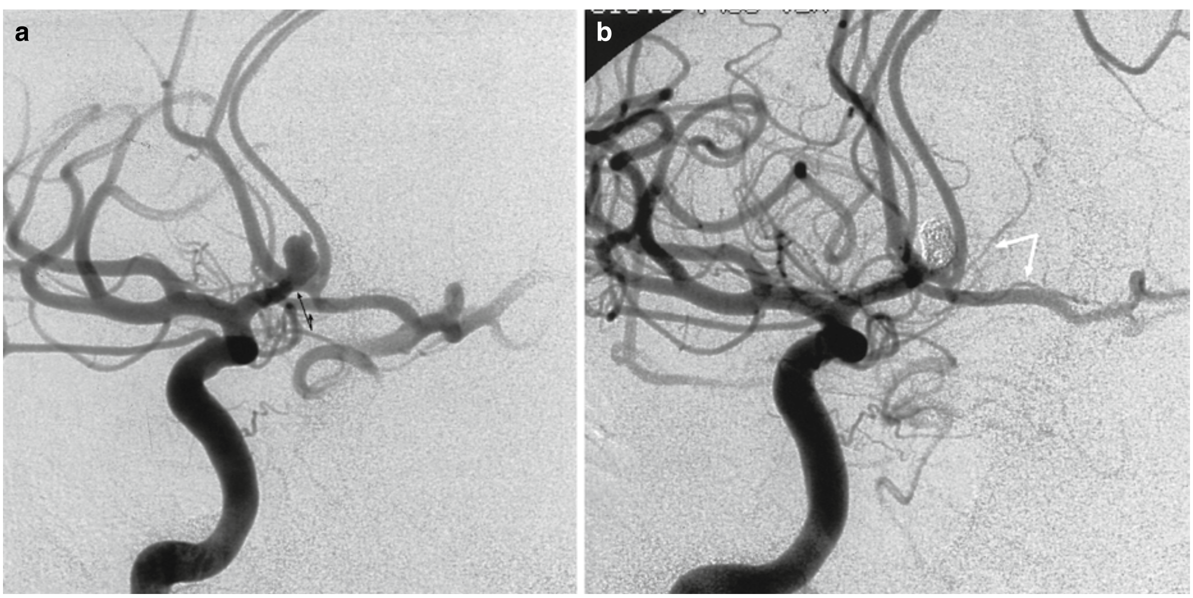

Fig. 4.8 (**a**) Internal carotid angiogram (*oblique view*) in a patient with ruptured aneurysm with the neck in the angle of the A1–A2 segments of the right anterior cerebral artery. Duplication of anterior communicating artery (*arrows with angle*). In cases with such anomalies, many projections are frequently necessary in an attempt to identify the aneurysm neck. (**b**) Angiogram post-coiling. The artery of Heubner, arising as a common trunk with the frontopolar artery (*white arrows with angle*) is visible. (**c**) Another patient with an anomaly involving the anterior communicating artery, carotid angiogram, oblique view. There is triplication of the anterior communicating artery (*arrows*). The artery of Heubner is well visualized (*arrowheads*). There is an origin of the ophthalmic artery from the cavernous portion of the internal carotid artery. (**d**) Carotid angiogram of the same patient, better indicating the anomalous origin of the ophthalmic artery

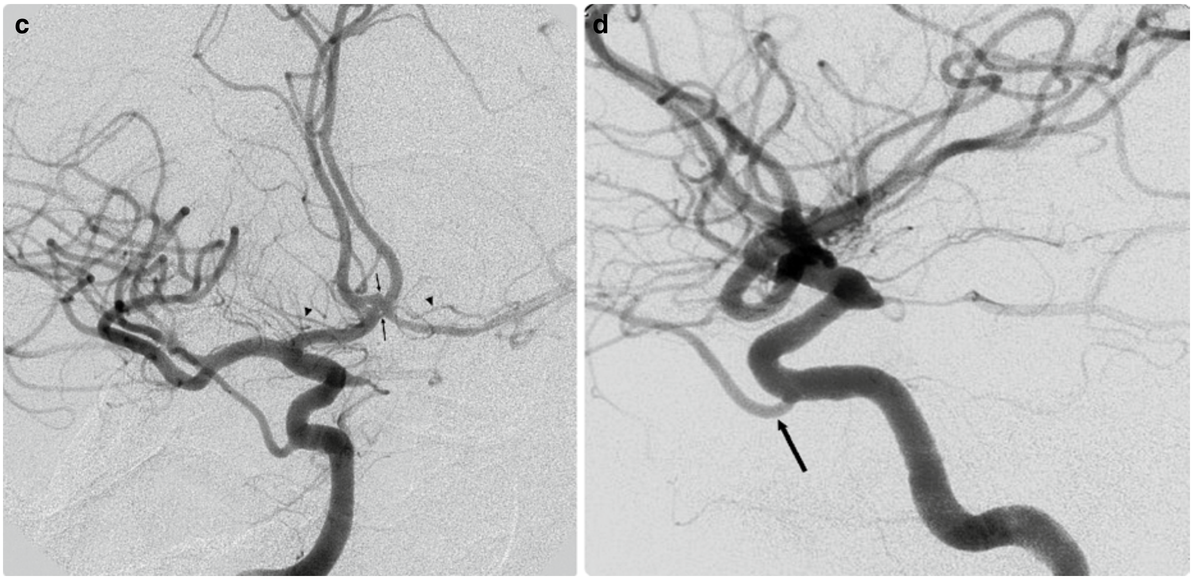

Fig. 4.8 (continued)

Fig. 4.9 Duplication of the A1

The involved branches extend also to the cortex of the convexity for about 1–3 cm. Among these branches, the paracentral and, partially, the superior parietal arteries are involved in the supply of the medial and superior section of the primary motor cortex.

Along its course, the pericallosal artery gives off perforators for the corpus callosum, septum pellucidum, fornix, and anterior commissure. From the distal branches, running on the surface of the cortex, arise small arteries that supply the brain parenchyma. These arteries enter the parenchyma with a perpendicular course and can be subdivided into cortical, medullary, and corticomedullary arteries. The first of these supply the cortex and end with horizontal branches in the various cellular layers. The medullary arteries supply the superficial (short medullary branches) and deep white matter (long medullary branches). The latter run toward the ventricular wall. The corticomedullary arteries have aspects of both. These arteries are end arteries (De Reuck 1972). In their course, the medullary arteries are surrounded by a thin space (perimedullary spaces, Virchow-Robin spaces). It had been supposed that the perivascular space was continuous with the subarachnoid space. This, however, was not confirmed by electron microscopy (Hutchings - Weller 1986), which showed that the pia mater represents a clear barrier, separating the subarachnoid space from the subpial space and perivascular space. But neither the subarachnoid space nor the pia matter extends into the brain, accompanying the blood vessels as they run into the perivascular space.

Conversely, potential leptomeningeal (pial) anastomoses are present at the surface of the hemisphere in the border zone of the vascular territories between superficial branches of the ACA, MCA, and the posterior cerebral artery (PCA). Anastomoses are also present between both posterior pericallosal arteries arising from the ACA and PCA (see Fig. 4.1).

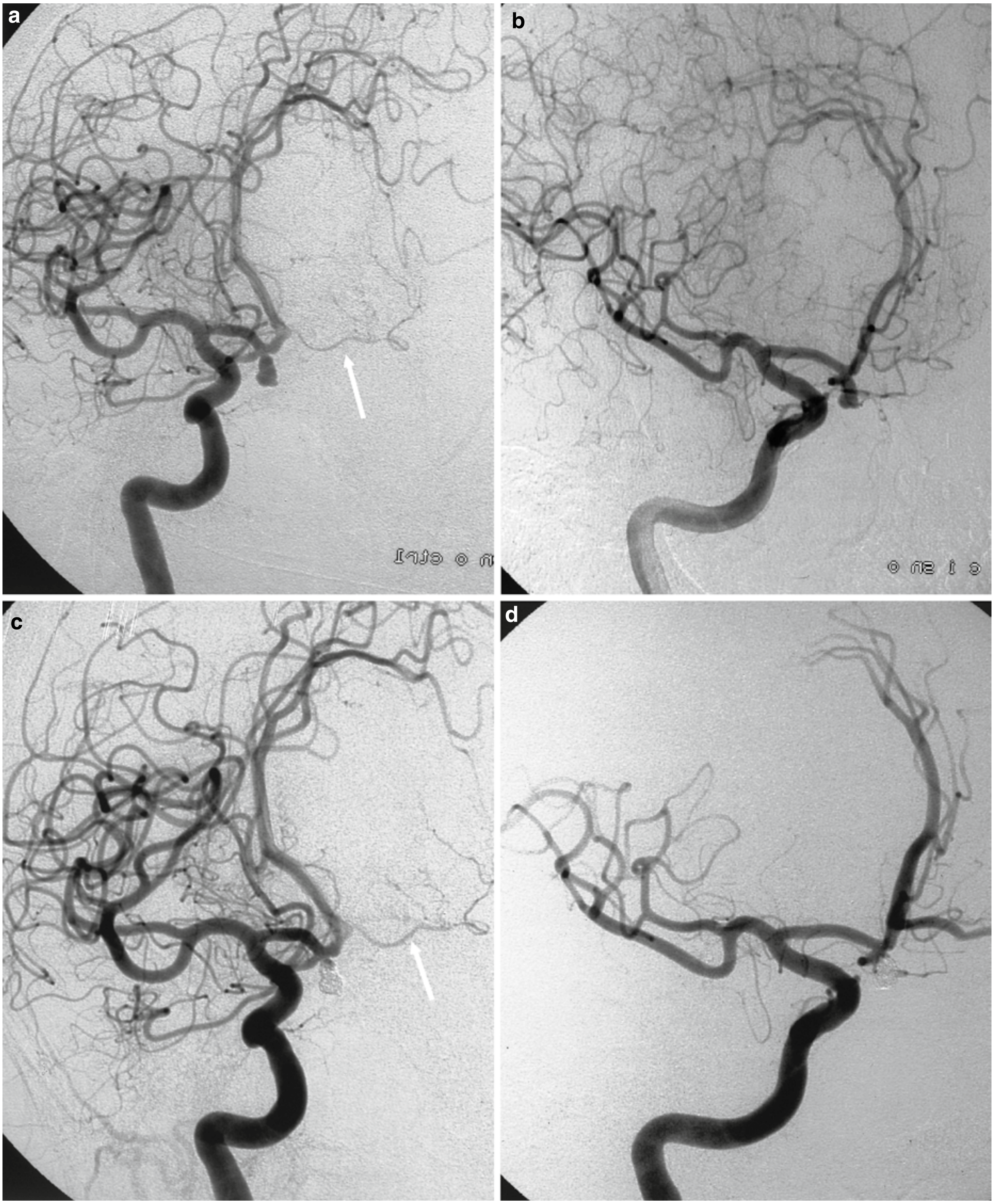

Fig. 4.10 Angiograms with two oblique views (**a** and **b**) in a patient with ruptured aneurysm in the angle of the A1–A2 of the right anterior cerebral artery. There is a unique pericallosal artery (azygos pericallosal artery). Notable is the artery of Heubner (*white arrow*), running parallel to the left A1. Control angiogram (**c** and **d**) after occlusion of the aneurysm with coils

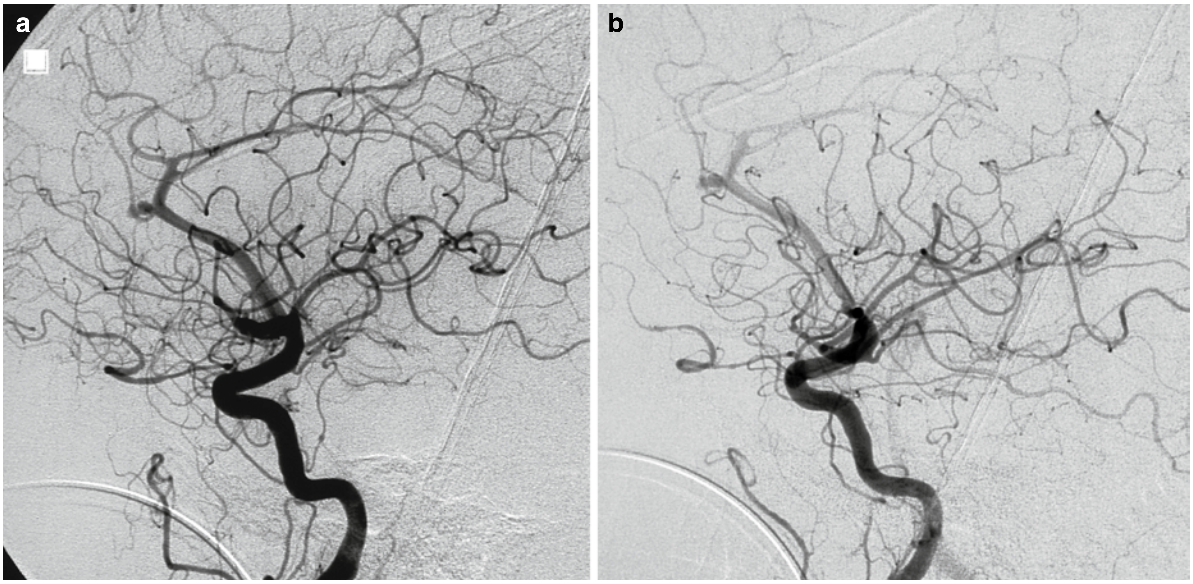

Fig. 4.11 Azygos pericallosal artery associated with a pericallosal aneurysm with subarachnoid hemorrhage. A large pericallosal artery (**a**) is evident on the left carotid angiogram. The same pericallosal artery (**b**) is visible on the right carotid angiogram, less injected owing to a hypoplastic A1 segment

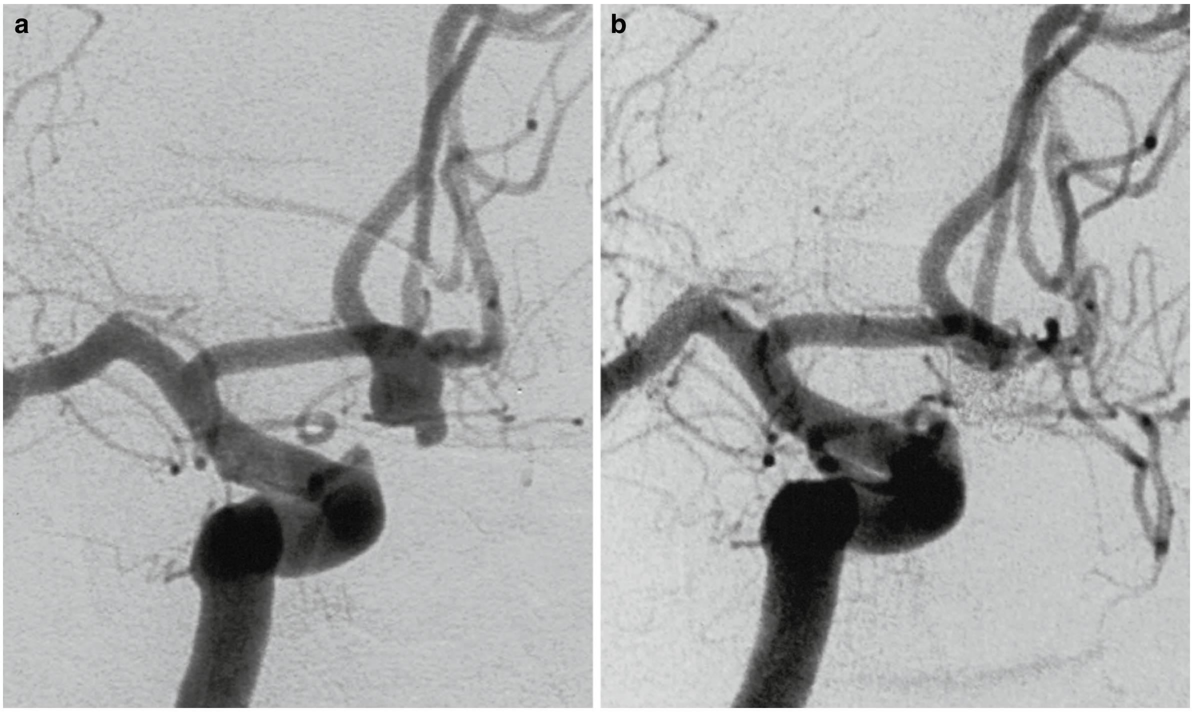

Fig. 4.12 Angiogram showing three pericallosal arteries (A. pericallosal triplex – arteria mediana corporis callosi) in a patient with ruptured aneurysm (**a**) treated with coils (**b**)

4.5 Angiogram

On the angiogram, the A1 segment is well recognizable in the AP oblique view (Figs. 4.3, 4.4, 4.7–4.10, and 4.12). It can be more difficult to make a precise identification of the AComA when bifurcation or trifurcation is present (Fig. 4.8). Among the perforators, the artery of Heubner can frequently be identified as a small branch, running back parallel to the A1 with a straight or undulating course (Figs. 4.3, 4.4, 4.8, and 4.10). See also Fig. 11.11 in Chap. 11.

The pericallosal and the callosomarginal arteries can be well discerned in the AP view. The course of these arteries as well as of their cortical branches, especially in the frontal area, may be more precisely demonstrated on the lateral angiogram. The posterior cortical branches (paracentral and parietal arteries) frequently cannot be identified because of overlapping with branches of the MCA. They can be identified when they are dilated and supply a vascular malformation (Fig. 4.6). Angio-MRI and Angio-CT are other diagnostic possibilities, though the angiogram offers better specific information. Some relationship to the cerebral parenchyma (chiasma, diencephalon, and corpus callosum) can be readily identified with MRI (Figs. 4.2 and 4.5).