13 Principles of Maxillofacial Angiography

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13.1 Materials

Angiography of the maxillofacial region consists of the selective catheterization of the internal maxillary artery to study its main trunk and branches. The injection of radiopaque contrast material achieves visualization of these vessels. Whether the interest of the study involves arteries or veins, a minimum of two orthogonal projections is mandatory. Continuous advancements of catheter material technology have made the catheterization of cervical cephalic vessels easier and more reliable. Several puncture techniques are available.

13.1.1 Puncture Techniques

13.1.1.1 Femoral Puncture

It is the most employed route for head and neck and cerebral angiography in general. Following local anesthesia, the common femoral artery is punctured directly under the inguinal ligament at the internal portion of the femoral head (Fig. 13.1).

This approach allows the operator to work at a distance from the X-ray tube and compress the punctured artery on stable osseous support after retrieving the catheterization material. Its primary disadvantage is that the common femoral artery is sometimes challenging to compress (for example, in obese patients), and the patient is required to stay in the hospital several hours before normal ambulation.

13.1.1.2 Brachial and Radial Puncture

Brachial puncture is rarely used and consists of the direct puncture of the brachial artery at the elbow level. It allows a more accessible axis of the arterial brachiocephalic trunk on the right and the subclavian artery and its branches on the left side. This approach has the advantage of an eas-

Fig. 13.1 Puncture at the level of the femoral head

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ier manual compression and is thus less likely to local complications like hematomas. Practically it is used only in the case of impossible femoral access. Nowadays, the radial approach is gaining popularity for diagnostic and interventional DSA as it allows easy compression and control of the puncture site and may be performed on a day care basis.

13.1.1.3 Direct Carotid Puncture

It consists of the direct puncture of the common carotid artery. It is rarely used and may constitute an alternative under challenging catheterizations of the common carotid artery (for example, tight loops or right aortic arch).

13.1.2 Complications

These are rare but may be potentially serious (death, persistent neurological deficits). For this reason, the indication for cervical angiography has to be carefully contemplated and should always be substituted by non-invasive imaging, if possible.

13.1.2.1 Neurological Complications

These are the gravest and occur in 2.6% of cases, more commonly in the context of severe atherosclerosis. They may consist in a transient (2.5%) or permanent neurological deficit (0.14%). The most common mechanism is either distal migration of a fragment of an atheromatous plaque or a thrombus during catheterization or an air bubble during the injection of contrast.

Another rarer complication is the dissection of the vessel wall that may occur during catheterization or injection of contrast material at a high rate (Fig. 13.2).

13.1.2.2 Local Complications

More frequent (4%) but less grave, they consist in the formation of a hematoma at the puncture site (Fig. 13.3) with or without retroperitoneal extension, pseudoaneurysms, or dissection. These complications are by no means trivial; a hematoma, for example, may rapidly expand and lead to hypovolemic shock.

Fig. 13.2 Internal carotid artery dissection secondary to catheter high-flow contrast injection seen as an irregularity of the vessel wall

Fig. 13.3 Post-angiography right groin hematoma

13.1.3 Angiography of the Supra-Aortic Trunks

Today, there is practically no indication for invasive angiography of the supra-aortic trunks (SAT) except in the setting of a pre-therapeutic evaluation (for example, before implanting a carotid stent). Non-invasive angiography is preferred whenever possible and includes Doppler ultrasonography, MRI angiography (MRA) (Fig. 13.4), and mostly CT angiography. The last technique offers morphological information for the lumen and the wall of the arteries with a satisfactory spatial resolution.

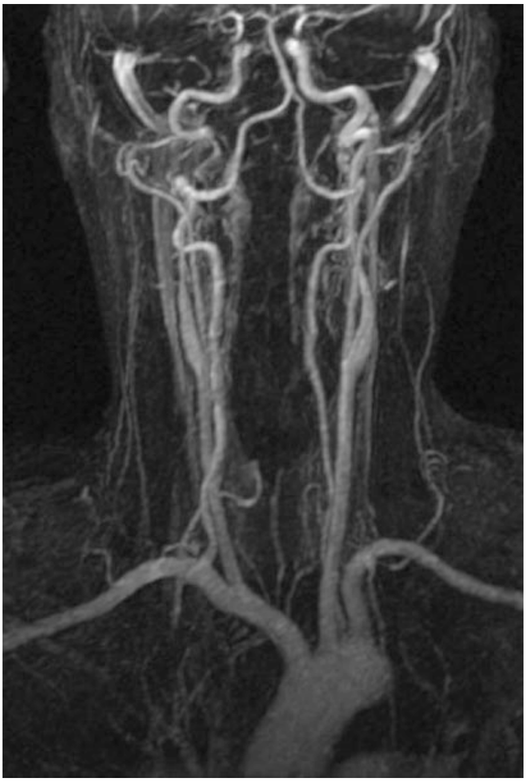

Fig. 13.4 Magnetic Resonance Angiography (MRA) of the aortic arch

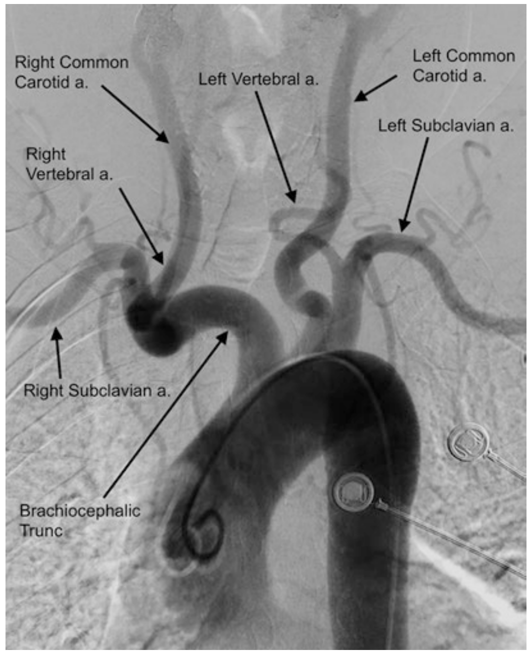

Fig. 13.5 Two-dimensional global aortic arch injection

13.1.4 Methods of Exploration

Angiography of the SAT is realized either with a global, high-rate aortic arch injection through a pigtail diagnostic catheter or after selective catheterization of the SATs. However, in severe atheromatous lesions, selective catheterization of the SATs entails the risk of dislodgment of an atheromatous plaque and subsequent ischemic stroke.

13.1.5 Radiologic Anatomy

The aortic arch is the origin of three arterial trunks that vascularize the neck and the head. At the proximal part of the aortic arch originates the arterial brachiocephalic trunk (ABCT). It gives off the proximal right common carotid artery (R CCA) and the right subclavian artery (RSA). After the origin of the ABCT follows the origin of the left common carotid artery (L CCA) and the left subclavian artery (LSA) (Fig. 13.5).

13.1.6 Anatomic Variations

According to Lippert (Fig. 13.6), the anatomy is modal in 77% of cases (the ABCT is the origin of the R CCA and the RSA, while the origins of the L CCA are located more distally on the aortic arch). Variations of the origins of the SATs occur in 23% of patients. The most frequent is the origin of the left common carotid artery from the proximal part of the arterial brachiocephalic trunk (13%) or directly from the arterial brachiocephalic (9%). A direct origin of the left common carotid artery from the arterial brachiocephalic trunk is commonly referred to as a “bovine” origin.

Another common variation is the origin of the right subclavian artery directly from the aortic arch distally on the left, after the origin of the left subclavian artery and not from the arterial brachiocephalic trunk. In this case, the right subclavian artery is referred to as “arteria lusoria” and courses behind the esophagus before following

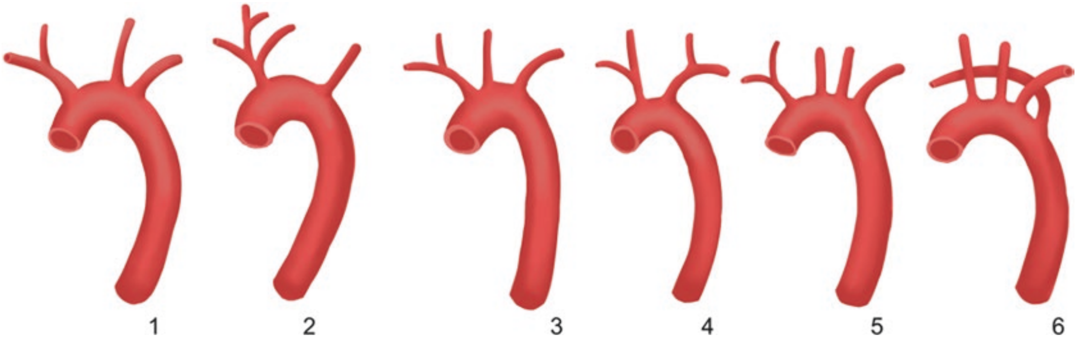

Fig. 13.6 Aortic arch variations (according to Lippert). (1) Normal (77%); (2) Origin of the left common carotid artery (LCCA) at the origin of the brachiocephalic trunk (BCT) (13%); (3) Origin of the LCCA directly from the BCT (9%); (4) Origin of the LCCA and of the left subclavian artery from a common trunk; (5) Origin of the right subclavian artery directly from the aortic arch; (6) Origin of the right subclavian artery distally on the aortic arch which then takes a retro-oesophageal course (arteria lusoria)

its usual course and may provoke dysphagia. This variation is the result of an abnormal fourth right aortic arch during fetal life.

Finally, a not uncommon variation is the direct origin of the left vertebral artery from the aortic arch (4%) between the origins of the left common carotid artery and the left subclavian artery.

13.1.7 Common Carotid Artery

It originates from the arterial brachiocephalic trunk on the right and the aortic arch on the left. It courses in the carotid sulcus medially to the internal jugular vein and the sternocleidomastoid muscle. Its terminal portion usually resides at the level of the body of the C4 vertebra and gives rise to the internal carotid artery (which vascularizes intracranial structures) and to the external carotid artery (which vascularizes the cervical facial area). However, the upper part of the common carotid may variate between C6 and the angle of the mandible.

13.1.8 External Carotid Artery

Among others, it vascularizes the face and the meninges and the extracranial portion of the cranial nerves.

Classical angiography of the external carotid artery is obtained only for vascular malformations and head and neck tumors. It arises from the carotid bifurcation.

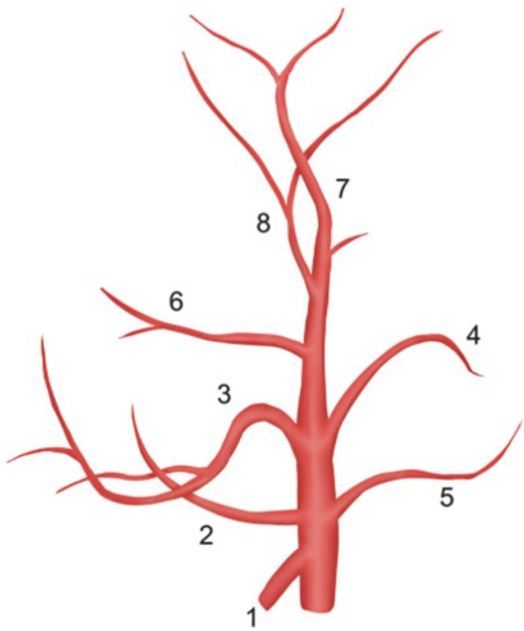

Fig. 13.7 The external carotid artery and its main branches; (1) Superior thyroidal artery; (2) Lingual artery; (3) Facial artery; (4) Auricular artery; (5) Occipital artery; (6) Internal maxillary artery; (7) Superficial temporal artery; (8) Middle meningeal artery. The ascending pharyngeal artery (not shown) is a small vessel that courses parallel to the main ECA trunk

13.1.8.1 The External Carotid Artery

It originates from the bifurcation of the common carotid artery (Fig. 13.7). In an anteroposterior view, the external carotid artery courses usually slightly mediately to the internal carotid artery. Another element that allows making the

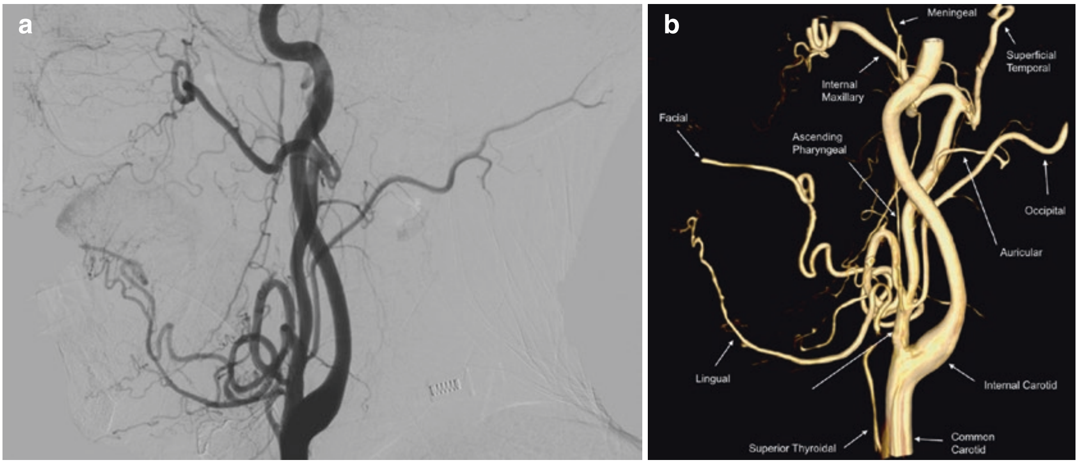

Fig. 13.8 Global injection of the common carotid artery, lateral view (**a**) two-dimensional angiography and (**b**) annotated three-dimensional angiography

distinction from the internal carotid artery is the presence of multiple branches, while the internal carotid artery has none at the level of the neck.

These branches, from proximal to distal, all the following (Fig. 13.8a, b):

The Superior Thyroidal artery.
The Lingual artery.
The Facial artery.
The Ascending Pharyngeal artery.
The Occipital artery.
The Auricular artery.
The Superficial Temporal artery.
The Internal Maxillary artery.

13.1.8.2 The Ascending Pharyngeal Artery

The ascending pharyngeal artery vascularizes the posterior portion of the pharynx, the medial part of the cranial base, the petrous bone, and the posterior part of the posterior foramen lacerum. It also gives a meningeal branch for the vascularization of the posterior fossa.

13.1.8.3 The Occipital Artery

The occipital artery vascularizes the posterior neck as well as the occipital region. It almost constantly gives a meningeal branch that courses under the lateral sinus and vascularizes to the meninges of the posterior fossa. Usually, it also presents one or two anastomoses with the homolateral vertebral artery.

13.1.8.4 The Internal Maxillary Artery

The internal maxillary artery vascularizes the nasal fossa, the sphenoid sinus, the orbital walls, and the anterior and middle cranial fossa (Fig. 13.9). It gives off three segments:

Mandibular Segment (Proximal)

This segment is the origin of a significant vessel:

The middle meningeal artery (MMA) is the first and the largest branch of the internal maxillary artery. The MMA courses superiorly. It traverses the foreman spinosum and is visualized as a sharp anterior curve on lateral angiography before entering the cranium. The accessory meningeal artery is another smaller branch with a more anterior origin of the mandibular segment of the internal Maxillary artery. It also has an ascending course and penetrates the cranial vault through the foramen ovale. Sometimes it gives off small cavernous branches through the foramen of Vesalius.

Pterygoid Segment (Middle)

It is located in the subtemporal fossa and crosses towards the pterygopalatine fossa.

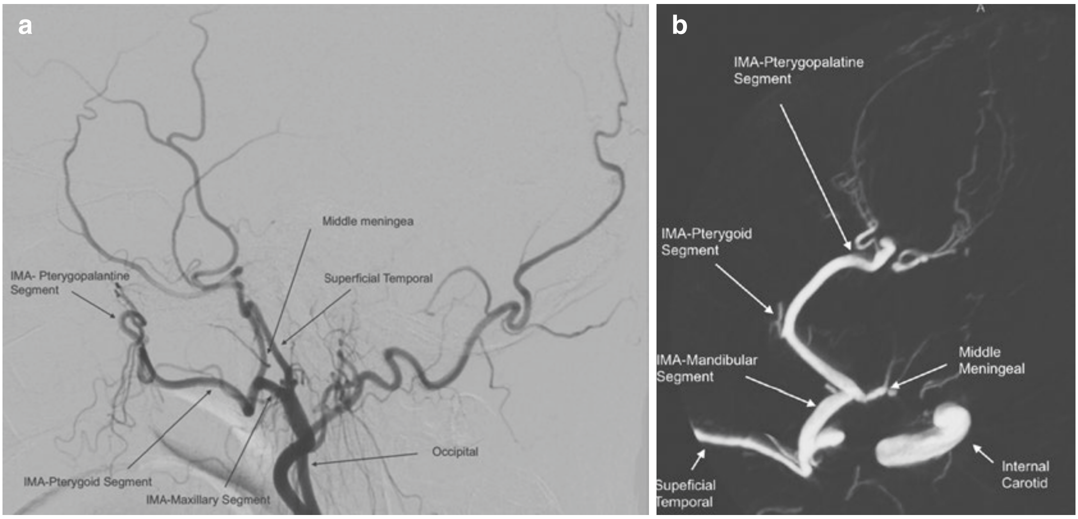

Fig. 13.9 (**a**) Selective external carotid injection, two-dimensional angiography, lateral view. (**b**) Axial reconstruction at the level of the infratemporal fossa

The main branches of this segment are the anterior and posterior deep temporal arteries, the masseteric and buccal arteries.

The Pterygopalatine (Distal) Segment

It makes a turn inside the pterygopalatine fossa anteriorly around the posterior wall of the maxillary sinus and posteriorly around the pterygoid process.

Its principal branches are (a) the superior alveolar artery (which originates before the pterygoid artery enters the pterygopalatine fossa), (b) the infra-orbital arteries (which course through the infra-orbital fissure), (c) the major palatine artery (which courses through the incisive canal), and (d) the sphenopalatine artery which is the terminal branch of the maxillary artery and courses medially through the sphenopalatine foramen to vascularize the nose.

The primary anastomoses between the ECA and the ICA are:

1. Between the angular artery (a branch of the facial artery) located near the inner canthus of the eye and branches of the ophthalmic artery.
2. Between the superficial temporal artery and the ICA through branches of the ophthalmic artery.
3. Between the internal maxillary artery and the ICA through the inferolateral trunk, through branches of the ophthalmic artery, or the vidian artery.
4. Between the ascending pharyngeal artery and the ICA, through the inferno lateral trunk, the vidian artery, and the caroticotympanic artery.

The anastomoses between the external carotid artery and the ophthalmic are a major collateral channel to the brain in the case of ICA occlusion.

13.1.9 Interior Carotid Artery (ICA)

Most of the time, on anteroposterior projections, the proximal ICA has a more lateral trajectory than the ECA.

The ICA (Fig. 13.10) has four segments: the cervical segment, the petrous segment, the intracavernous segment, and the supra-cavernous segment.

The first segment courses in the maxillopharyngeal space, along with the internal jugular vein. It then penetrates the petrous bone, courses in the carotid canal with a proximal vertical course and a distal horizontal course. The ICA enters the cranium through the foramen lacerum.

It then courses inside the cavernous sinus to penetrate in the subarachnoid spaces in its supra-clinoid portion (Fig. 13.11). It has an anterior portion which gives of the ophthalmic artery and a posterior portion, a few millimeters proximally to the posterior communicating artery and the anterior choroidal artery. Finally, it bifurcates into the anterior and the middle cerebral artery.

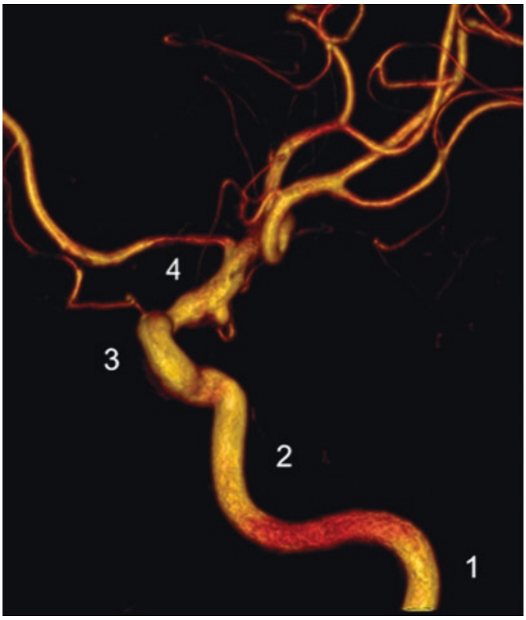

Fig. 13.10 The internal carotid artery has four segments; (1) Cervical segment; (2) Petrous segment; (3) Intracavernous segment; (4) Supra-cavernous segment

In its intracavernous course, the ICA presents several curves that form an italic "S" shape, open superiorly. This curved portion represents the carotid siphon. According to Fischer, the carotid siphon has five segments, with the most proximal named C5 and the most distal C1 (Fig. 13.11).

The segments C4 and C3 are intracavernous and the C1 and C2 segment supra-cavernous.

The C5 segment gives the meningohypophyseal trunk, which vascularizes the hypophysis and the adjacent dura mater.

The C4 segment has an anterior horizontal orientation. Its main collaterals are the capsular arteries that vascularize the sellar diaphragm and the inferolateral trunk. The inferolateral trunk gives off three branches: superior, anterior, and posterior, and vascularizes the roof of the cavernous sinus and the occult motor nerves.

The C3 segment is curved anteriorly.

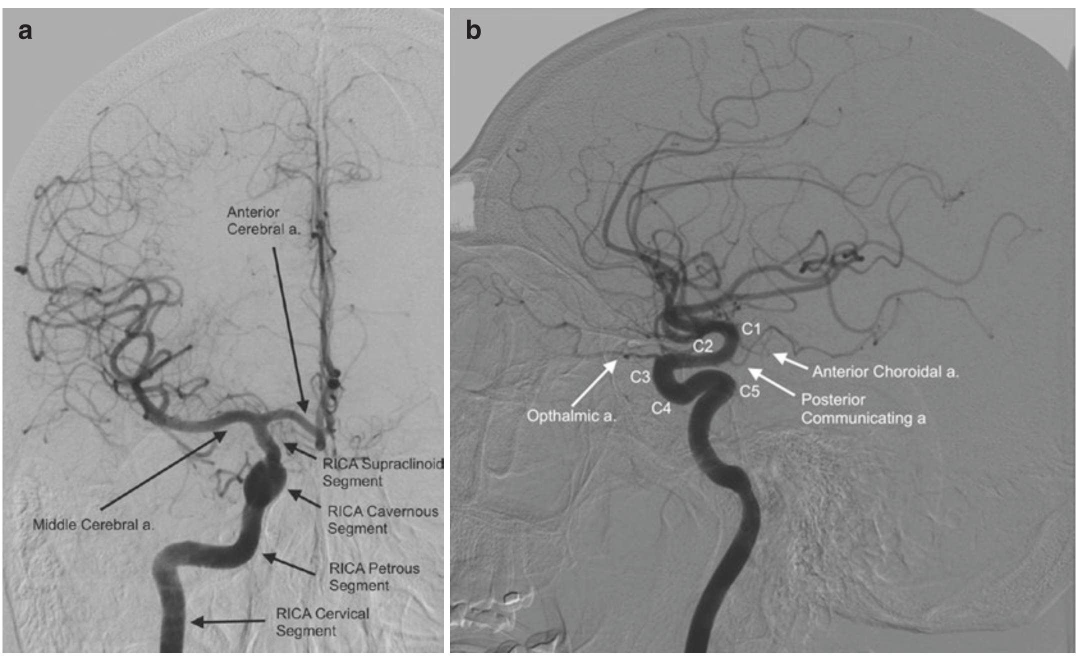

Fig. 13.11 Right internal carotid artery selective injection. (**a**) anteroposterior and (**b**) lateral view

The C2 segment is supracavernous and infraclinoidal and courses posteriorly horizontally or slightly superiorly. It gives off the superior hypophyses arteries that vascularize the anterior portion of the hypophysis.

The ophthalmic artery originates from the anterior portion of the superior C2 segment.

It is usually located in the subarachnoid space and more rarely intradural and courses anteriorly inside the optical canal, inferolateral to the optic nerve.

Finally, the C1 segment is supracavernous and supraclinoidal.

The ICA's supraclinoid portion gives four branches: the posterior communicating, the anterior choroidal, the anterior cerebral, and the middle cerebral artery.

13.2 Conclusion

Classical maxillofacial angiography is nowadays performed by non-invasive means, mainly CT or MR Angiography. It is indicated only for the assessment of lesions before endovascular embolization. Knowledge of normal anatomy and extracranial to intracranial anastomoses is paramount for preventing embolic complications during therapeutic embolization.

Further Reading

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