Imaging Evaluation and Treatment of Vascular Lesions at the Skull Base

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KEYWORDS

• Paraganglioma • Juvenile nasopharyngeal angiofibroma • Cavernous carotid fistula
• Dural arteriovenous fistula • Preoperative embolization • Dissection

KEY POINTS

- Arterial and venous anomalies at the skull base tend to be asymptomatic; however, failure to recognize them can also have major clinical implications.
- Vascular tumors at the skull base may arise de novo in the skull base or originate in the orbits or sinonasal cavities and involve the skull base by extension.
- Preoperative embolization can be a useful and cost-effective adjunctive tool before surgical resection of hypervascular skull base tumors.
- Intracranial dural arteriovenous fistulas account for 10% to 15% of intracranial arteriovenous malformations, and they most commonly involve the wall of a major dural venous sinus.
- At the skull base, these lesions can involve the cavernous sinus and posterior fossa skull base veins.

INTRODUCTION

The skull base, which is composed of osseous, vascular, and cartilaginous elements, represents the interface between the cranial cavity and the face and neck. Major vascular and neural structures traverse the skull base through paired and unpaired foramina. Vascular skull base abnormalities generally arise owing to congenital abnormalities, consequent to dural arteriovenous shunts, trauma, or as a result of neoplastic transformation of vascular and nonvascular cellular elements.

A detailed discussion of all such abnormalities being beyond the scope of this review, we confine ourselves to a discussion of the more common, clinically relevant entities (**Box 1**), with an emphasis on those for which surgical and/or image-guided treatment options are available. A brief overview of the principles and practice of endovascular treatment strategies for some of these vascular lesions is also provided.

CONGENITAL VASCULAR VARIANTS OF THE SKULL BASE

The major vessels that traverse the skull base include the internal carotid and vertebral arteries and the internal jugular veins. In addition to these, meningeal branches of the external carotid artery (ECA) and emissary veins pass through the skull

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Box 1
Vascular abnormalities at the skull base

- Congenital vascular variants of skull base
  - Aberrant internal carotid artery
  - Dehiscence of the internal carotid artery
  - Persistent carotid basilar anastomoses
  - Persistent stapedial artery
  - High riding jugular bulb, jugular bulb dehiscence, jugular bub diverticulum
  - Sigmoid sinus wall anomalies
  - Posterior fossa emissary veins
- Hypervascular tumors of the skull base
  - Paraganglioma
  - Metastases
  - Juvenile nasopharyngeal angiofibroma
  - Intratemporal benign vascular tumors
- Dural arteriovenous and carotid cavernous fistulae
- Arterial dissection and aneurysms

base. Congenital variants are more common in the venous circulation and rarely tend to be of clinical significance. Although arterial variations are less commonly encountered in routine practice, failure to recognize them can have major clinical implications.

Aberrant Internal Carotid Artery

The most common congenital arterial variant at the skull base is the aberrant internal carotid artery (ICA).[1] Here, the ICA deviates from its normal anteromedial course through the petrous carotid canal to extend laterally into the middle ear. This variant is thought to arise when the cervical portion of the ICA fails to develop normally, or regresses. Consequently, 2 embryonic vessels, the inferior tympanic and caroticotympanic arteries, enlarge to reconstitute the ICA at the level of the missing segment. Because the inferior tympanic artery normally extends laterally through the temporal bone and into the middle ear via the inferior tympanic canaliculus, the aberrant ICA follows a similar course.[1] On otologic examination, an aberrant ICA appears as a vascular, pulsatile, retrotympanic structure. On imaging, the aberrant ICA is evident as an absent or hypoplastic vertical segment of the carotid canal with a corresponding enlarged inferior tympanic canaliculus and canal and a reduced caliber aberrant ICA traversing through it.[2] On angiography, there is an enlarged tympanic branch of ascending pharyngeal artery and a more lateral and posterior route of the petrous part of ICA than usual with a focal pinched contour of the vessel.[3] Failure to recognize this entity may lead to inadvertent biopsy, because these lesions can be mistaken for a vascular tumor, with catastrophic consequences.

Dehiscence of the Internal Carotid Artery

Dehiscence of the ICA canal is an anatomic variant that generally does not merit treatment consideration. Dehiscence of the carotid canal may cause pulsatile tinnitus and can present as a vascular retrotympanic mass. On imaging, thinning or absence of the normal bony covering of the ICA will be present, typically near the basal turn of the cochlea.[4]

Persistent Carotid–Vertebrobasilar Anastomoses

Failure of vessels to regress during embryonic development results in various persistent carotid–vertebrobasilar anastomoses. The persistent trigeminal artery is the most common and most cephalic of these[5] with a reported prevalence of 0.1% to 0.6%.[6] This artery originates from the ICA after its exit from the carotid canal and anastomoses with the midbasilar artery. The part of the basilar artery that is caudal to the anastomosis with the trigeminal artery is usually hypoplastic. Associated anomalies include intracranial aneurysms, which are seen in approximately 14% of patients.[7] Additional variants of the persistent trigeminal artery are not discussed here. The persistent hypoglossal artery is the second most common carotid–vertebrobasilar artery anastomosis, with a prevalence of 0.02% to 0.10%.[8] The persistent hypoglossal artery originates from the ICA at the levels of the C1 through C3 vertebral bodies and courses through the hypoglossal canal to anastomose with the basilar artery; this artery does not pass through the foramen magnum. A persistent proatlantal intersegmental artery has been reported in the medical literature to originate from the common carotid artery bifurcation, ECA, or ICA at the levels of the C2 through C4 vertebral bodies; it joins the horizontal part of the vertebral artery in the suboccipital region.[9] The medical literature contains a few descriptions of a persistent otic artery arising from the petrous ICA within the carotid canal, coursing laterally through the internal auditory canal, and anastomosing with the proximal basilar artery.[9]

Persistent Stapedial Artery

Occasionally, a persistent stapedial artery (PSA) may be a cause of pulsatile tinnitus and a vascular retrotympanic mass.[4,10] This vessel can be