Management of Major Vascular Injury During Endoscopic Endonasal Skull Base Surgery

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KEYWORDS

- Endoscopic skull base surgery • Internal carotid artery • Pseudoaneurysm
- Vascular injury

KEY LEARNING POINTS

At the end of this article, the reader will:

- Understand how major vasculature can be evaluated preoperatively.
- Understand how ischemia can be evaluated intraoperatively.
- Know which tumor types are at greatest risk for internal carotid artery (ICA) injury during endoscopic endonasal skull base surgery (ESBS).
- Know what techniques can be used to preserve a vessel injury during ESBS.
- Be able to determine if bleeding from the ICA or circle of Willis can be controlled during ESBS.
- Know how and when arteries can be evaluated following injury.
- Be able to identify the endovascular adjuncts that are currently available following vascular injury.

INTRODUCTION

The endoscopic endonasal approach to the ventral skull base has gained popularity over the past decade. Through collaboration between otolaryngologists and neurosurgeons, these approaches have provided increasingly expanded access to the skull base, in modules that extend from the crista galli to the odontoid process and laterally

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to the cavernous sinus, middle fossa, and orbit. Great advances have been made in instrumentation and reconstruction to allow the progression of these approaches.

During any surgery involving the skull base, surgeons must have anatomic knowledge of the internal carotid artery (ICA) with respect to the operative field and have strategies for dealing with inadvertent injury to this and other major vessels of the circle of Willis. There remains significant concern about the ability to manage such injuries when working with an endoscope through limited openings such as "keyhole" craniotomies or through the paranasal sinuses.

INJURY AVOIDANCE

- The best strategy for dealing with major vessels is to avoid injury.
- Understand the anatomic landmarks and course of the arteries and recognize how an individual tumor may have affected the anatomic location of the vessel.
- For the ICA, there are well-established landmarks to its various segments from an endonasal perspective.

Segment of internal carotid artery and anatomic landmark

Segment of ICA	Anatomic Landmark
Paraclinoid	Medial opticocarotid recess[1]
Anterior genu	Medial pterygoid plate/wedge[2]
Horizontal petrous	Vidian nerve[2]
Ascending/parapharyngeal	Eustachian tube[3]

All tumors of the skull base have the potential to

- Encapsulate
- Invade
- Displace the ICA

Cavernous and petroclival meningiomas can encircle the cavernous or petrous ICA and basilar artery, with narrowing of the vessel or invasion of the adventitia (**Fig. 1**). Pituitary adenomas can invade the cavernous sinus and encircle the ICA, but do not tend to invade the adventitia. Chondroid tumors, such as chordomas and chondrosarcomas, can significantly displace the ICA or basilar artery. Rarely, they can weaken or invade the adventitia (**Fig. 2**). Chondroid tumors were the most common tumor type injured during endonasal skull base surgery (ESBS) in the authors' series of more than 2000 patients.[4] Juvenile nasal angiofibromas (JNAs) frequently derive blood supply from the cavernous ICA via branches such as the vidian artery (**Fig. 3**) but are rarely adherent to the ICA. Nasopharyngeal and other paranasal sinus carcinomas can