Clinical and Anatomic Insights From a Series of Ethmoidal Dural Arteriovenous Fistulas at Barrow Neurological Institute

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BACKGROUND: **Ethmoidal dural arteriovenous fistulas (dAVFs) have a malignant natural history and an anatomy that make endovascular therapy challenging. Their uniqueness begs for stratified analyses, but this has largely been precluded by their rarity. We sought to summarize the anatomic, presentation, treatment approaches, and clinical outcomes of patients with these lesions.**

METHODS: **We reviewed our prospectively maintained institutional database to identify patients diagnosed with ethmoidal dAVFs from January 1, 2000, to December 31, 2015. We evaluated demographic, presentation, angiographic, treatment, and follow-up data.**

RESULTS: **In total, 27 patients with ethmoidal dAVFs underwent endovascular and/or surgical treatment. Mean patient age was 62 years old and there was a male sex predilection (67% men; 2:1 male-female ratio). All dAVFs exhibited direct cortical venous drainage; venous ectasia was present in 59% of cases. Of the dAVFs, 30% drained posteriorly into the basal vein of Rosenthal or the sylvian veins. Embolization with casting of the draining vein was successful in 2 of 9 cases (22%), including 1 successful transvenous case. There were no clinical or permanent complications from embolization; specifically, no patients experienced visual loss after treatment. Surgical treatment with successful dAVF obliteration was carried out in 24 of 24 patients (100%). One patient declined surgical treatment after attempted endovascular embolization. There were no permanent complications after surgical treatment and no cases of wound infection or cerebrospinal fluid leakage.**

CONCLUSIONS: **Surgical disconnection remains the gold standard in the treatment of ethmoidal dAVFs. Embolization is a consideration for well-selected cases with favorable arterial or venous access anatomy.**

INTRODUCTION

The natural history of cerebral dural arteriovenous fistulas (dAVFs) is largely predicated on the presence of cortical venous drainage.[1-5] Ethmoidal dAVFs, also termed anterior fossa or cribriform plate dAVFs, are notorious for their proclivity to drain directly into cortical veins, and thus to have a malignant natural history.[5-9] In contrast to the anatomy of cranial dAVFs in other locations, ethmoidal dAVF angiographic anatomy, largely based on ophthalmic artery ethmoidal branch supply, makes them challenging endovascular targets.[6,8,10] Their relative rarity has precluded a meaningful analysis of their angiographic anatomy and treatment results; the largest previously reported series included 24 patients collected from 3 institutions.[6] Herein, we present a 15-year, single-institution cohort of patients with these lesions and evaluate their anatomy, treatment approaches, and results.

METHODS

We performed a retrospective analysis of a prospectively maintained patient database to identify patients diagnosed with ethmoidal dAVFs from January 1, 2000, to December 31, 2015. We extracted patient demographic information, symptoms at the time of clinical presentation, and detailed angiographic information for each dAVF, including specific feeding arteries, venous drainage

Key words
- Anterior fossa
- AVF
- dAVF
- Dural arteriovenous fistula
- Ethmoidal
- Fistula

Abbreviations and Acronyms
dAVF: Dural arteriovenous fistula

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pattern, and the presence of venous ectasia. Treatment approach (endovascular and/or surgical), angiographic results, procedural complications, and follow-up results were evaluated.

All patients underwent initial diagnostic cerebral angiography. The decision to attempt endovascular treatment was predicated on initial referral pattern (endovascular service vs. surgical service), a subjective assessment of transarterial/transvenous accessibility of the fistula point, and a general assessment of patient comorbidities. Surgical and endovascular treatments are carried out under general endotracheal anesthesia with neurophysiologic monitoring (somatosensory evoked potentials and electroencephalography). Endovascular procedures are generally carried out with a 6F guide catheter and liquid embolic—compatible microcatheters while the patient is under systemic heparinization. All procedures were carried out during a period when glue and Onyx were available as embolisates, the latter serving as our general preference for these fistulae. After embolization, control angiography is scrutinized for residual arteriovenous shunting, and, importantly, embolisate penetration of the draining vein.

Surgical disconnection is carried out as delineated in a previous report from our institution.[11] Disconnection is done most often using an orbitocranial approach to expose the draining vein. After disconnection of the vein, intraoperative indocyanine green angiography is now ubiquitously used.

RESULTS

During a 15-year period, 27 patients with ethmoidal dAVFs underwent endovascular and/or surgical treatment at our institution. Mean patient age was 62 years old, and there was a male sex predilection (67% men; 2:1 male-to-female ratio). Patient presentation was incidental in 48% of cases and due to hemorrhage in 37% and visual symptoms in 15%.

Angiographic Anatomy

All fistulas had ophthalmic artery ethmoidal branch supply, with bilateral supply in 93% of cases. Distal internal maxillary artery ethmoidal branch supply was seen in 66% of cases; it was bilateral in 48%. Middle meningeal artery branch supply was found in 22% of cases, and cavernous internal carotid artery dural branch supply was found in 7% of cases. Anterior cerebral artery branch supply was seen in 7% of cases. Flow-related feeding ophthalmic artery aneurysms were seen in 7% of cases.

In all 27 cases, venous drainage was direct into a cortical vein (Djindjian Type III/IV,[4] Borden-Shucart Type III,[1] Cognard Type III/IV[3]). Venous drainage was "typical" or anterior by orbitofrontal or frontopolar veins in 70% of cases (**Figure 1A**). In the remaining 30% of cases, venous drainage was posterior by posterior orbitofrontal or olfactory veins. In 19% of overall cases, venous drainage was posterior into the basal vein of Rosenthal (**Figure 1B**), and, in 11%, it proceeded posteriorly into superficial sylvian veins and ultimately into the vein of Trolard or Labbé (**Figure 1C,D**). Venous ectasia was found in 59% of cases (Djindjian Type IV[4]/Cognard Type IV[3]).[3,4] There was no significant association of drainage pattern with proclivity toward venous ectasia or rate of hemorrhagic presentation.

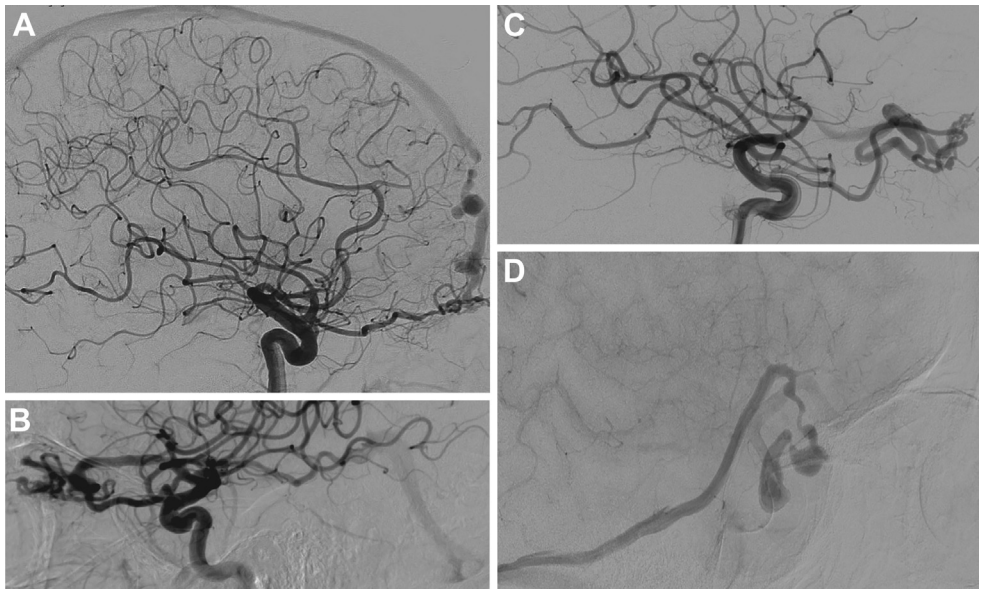

Figure 1. Venous drainage patterns of ethmoidal dural arteriovenous fistulas (dAVFs). (**A**) Lateral view of an internal carotid artery injection demonstrates an ethmoidal dAVF with "typical" anterior drainage into a frontopolar vein. (**B**) Lateral view of an internal carotid artery injection of an ethmoidal dAVF that drains posteriorly into the basal vein of Rosenthal. (**C**) Lateral view of an internal carotid artery injection of an ethmoidal dAVF that drains posteriorly (arterial phase), and (**D**) ultimately superficially into a sylvian vein and the vein of Labbé (capillary phase). (Used with permission from Barrow Neurological Institute, Phoenix, Arizona.)