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MEDICAL IMAGING

CT angiographic depiction of a supraclinoid ICA fenestration mimicking aneurysm, confirmed with catheter angiography

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Abstract Fenestrations (segmental duplications) of the intracranial arteries are rare anomalies that have been associated with aneurysms. Fenestrations of the supraclinoid ICA are extremely rare, with only a few reported cases. We present a supraclinoid ICA fenestration, which on axial CTA images initially mimicked an aneurysm, but was correctly delineated as a fenestration on multiplanar reformatted and 3D reconstructed images. Confirmation was made with conventional angiography. To our knowledge, this represents the first time that this rare variant has been identified with cross-sectional imaging. A review of the literature including proposed embryology is provided.

Keywords Fenestration · Internal carotid artery · Computed tomography · Digital subtraction angiography · Anatomic variation

Case report

A 73-year-old-male patient with metastatic melanoma and peripheral left hemisphere brain metastases developed severe headache and neurological decline immediately post-craniotomy for tumor resection. Unenhanced CT showed more subarachnoid hemorrhage than expected post-operatively. CT angiography (CTA) was requested to exclude the possibility of peri-operative rupture of an undiagnosed aneurysm. The patient had no previous neuro-angiography studies. The metastatic lesions were remote from the Circle of Willis.

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CTA examinations were performed on a GE Medical Systems (Waukesha, WI, USA) Lightspeed Plus 4-section helical CT with a 6.3-MHU Performix tube. Images were obtained from skull base to vertex by using helical HQ mode with 3.75 mm/rotation, 1.25 mm collimation, pitch 0.75:1, and 0.6 mm reconstruction interval (120 kVp, 350 mA) following IV injection of 125 ml Omnipaque 300 at a rate of 4 ml/s, with a Smart Prep at the distal ICA at the C2 level.

Axial CTA source images (Fig. 1) demonstrated a focal outpouching of contrast in the right supraclinoid ICA, initially suspicious for aneurysm. However, there was continuity with the main vessel both superiorly and inferiorly, suggesting fenestration rather than aneurysm. Multiplanar reformats and volume rendered 3D reconstructions confirmed the presence of a fenestration (Fig. 2). No aneurysm was identified.

Conventional digital subtraction angiogram (DSA) was performed. This confirmed the presence of a right supraclinoid ICA fenestration, occurring between the ophthalmic and anterior choroidal arteries (Fig. 3). The posterior communicating origin was from the posterior limb of the fenestration, in its mid-portion. No aneurysm was identified. The subarachnoid hemorrhage was presumed post-surgical.

Discussion

Fenestration refers to segmental duplication of a vessel into two distinct endothelium-lined channels, which may or may not share adventitial covering, with continuity at the proximal and distal ends [14]. At the extreme is complete duplication of a vessel with duplicated origin [7]. Fenestrations are rare in the cerebral arteries other than anterior communicating (ACoA). The ACoA often has a complex anatomy

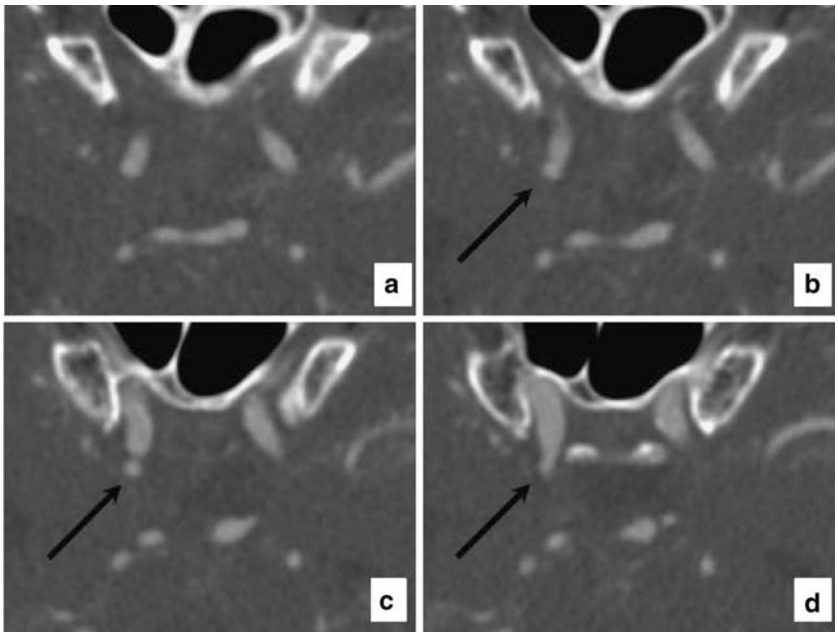

Fig. 1 **a**–**d** Sequential CTA axial images, superior to inferior showing a posteriorly directed outpouching of contrast off the right supraclinoid ICA (*arrows*) initially suggestive of an aneurysm. However, continuity with the ICA is demonstrated both superiorly and inferiorly, compatible with a fenestration

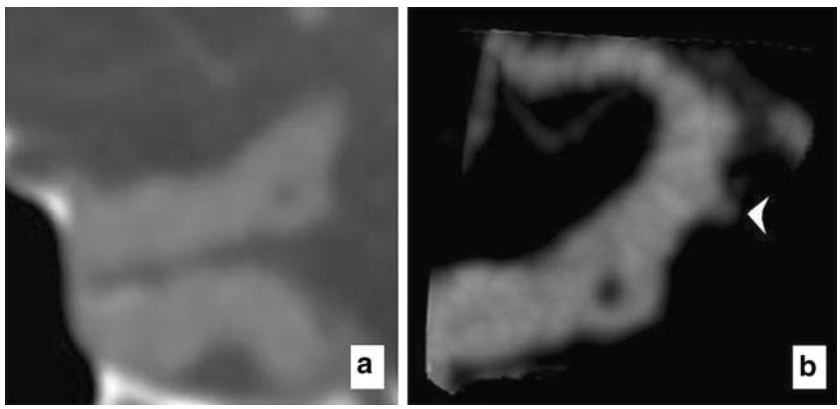

Fig. 2 Sagittal reconstruction (**a**) and 3D volume rendering (**b**) of CTA dataset through the fenestration. The anterior choroidal artery origin (*arrowhead*) could be resolved

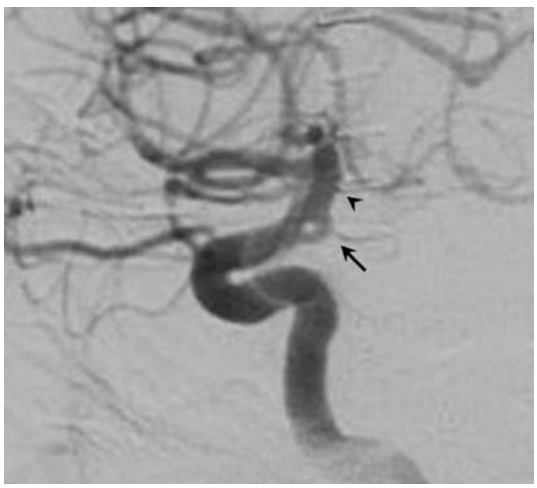

Fig. 3 Lateral projection DSA, right ICA injection, confirming the fenestration. The anterior choroidal (*arrowhead*) and posterior communicating (*arrow*) arteries are better shown

with duplicated, fenestrated or plexiform appearance in greater than 40–60% of cases at microsurgery, though this may not be apparent at angiography [5, 15, 17].

Aside from ACoA, fenestrations most frequently occur in the basilar and vertebral arteries, where the incidence at cadaveric studies has been reported to be as high as 5% [20]. However, the incidence at conventional angiography (0.49% vertebrobasilar; 0.71% total) [14] and MR angiography (1.7% vertebrobasilar) [19] has been much lower. The next most common locations are the MCA and ACA.

Fenestrations are thought to be congenital anomalies related to abnormal development of primitive embryologic vessels. Fenestrations of the basilar system are believed to be due to partial failure-of-fusion of the paired longitudinal neural arteries of the 5–7 mm embryo [13]. The etiology of fenestration in the anterior circulation is less clear, but in the ACA, ACoA and MCA may represent residual anastomoses between the primitive vascular network formed

between the anterior and middle cerebral arteries in the 4–5 mm embryo [1].

Segmental duplications of the supraclinoid ICA are extremely rare. To our knowledge, there have been only a few case reports in the English literature, which are summarized in Table 1.

Due to the rarity of this lesion, the embryologic basis is not well established. In the segmental model of embryologic development of the ICA proposed by Lasjaunias and Santoyo-Vasquez [9], the ICA develops as a succession of embryologic segments separated by branching of embryonic vessels. The terminal segment divides into a rostral and a caudal division. The rostral division gives rise to the ACA, MCA and anterior choroidal arteries, while the caudal division gives rise to the posterior cerebral artery by way of the posterior communicating artery.

A supraclinoid ICA fenestration could then presumably be a result of failure of complete division of the developing ICA, i.e., a persistent connection, as suggested by Lasjaunias et al. [10], or plexiform division, as proposed by Findlay [2], of the rostral and caudal branches. In our case, and in the previously reported cases, the fenestration appears to occur between the ophthalmic and anterior choroidal arteries, which would be compatible with this (Fig. 4). Alternatively, these fenestrations may represent the sequelae of incomplete regression of the rudimentary embryonic ACA origin of the ophthalmic artery, related to the primitive ventral ophthalmic artery that partially involutes and migrates in a complex fashion during development of the definitive ophthalmic artery. However, this is felt to be less likely due to the remoteness of the duplication from the ophthalmic origin (P. Lasjaunias, personal communication, 2006). A final possibility suggested by Banach et al. [1] is that these may represent the residua of a persistent connection between the left and right ICAs present at the 4–5 mm embryo stage.

Six of the eight reported supraclinoid ICA fenestrations (including our case) were on the right raising the possibility of a right-sided preponderance, but sample size is clearly limited.

The association of aneurysm with fenestration has been extensively reported in case reports, although the exact relationship is not well defined. Studies have demonstrated defects of the medial layer at the proximal and distal ends of fenestrations, similar morphology to Circle of Willis branch points [3]. Classically, fenestration-aneurysms are thought to arise at the proximal end of fenestrations due to a combination of hemodynamic stresses and medial defect. A similar risk of aneurysm to normal Circle of Willis branch points has been reported [14], however, in many case reports, fenestrations have been associated with aneurysms remote from the fenestration. Fenestrations have also been reported in association with AVMs and other developmental anomalies [18].

Regarding supraclinoid ICA fenestrations, ours was not associated with aneurysm but all but one of the other reported cases were seen in association with aneurysms either at the fenestration, elsewhere, or both. In the case of fenestration-aneurysms, prospective identification of the fenestration is critical as surgical/endovascular planning must take account of the resulting complex geometry [12].

Conclusion

We have reported a right supraclinoid ICA fenestration diagnosed at CTA and confirmed with conventional angiography. To our knowledge, this is the first report of this rare entity diagnosed non-invasively using cross-sectional imaging. It is important to note that on axial images, these lesions can mimic aneurysm. Review of multiplanar reformatted images and 3D reconstructions is critical to making the correct diagnosis.

Table 1 Summary of reported supraclinoid ICA fenestrations

References	Location	Aneurysm at fenestration	Aneurysm elsewhere	Diagnosed by
Yock [21]	Right supraclinoid ICA	Yes; proximal end of fenestration	No	Catheter angiography, surgery
Findlay et al. [2]	Right supraclinoid ICA	No	Yes; left ACoA	Catheter angiography
Takano [16]	Right supraclinoid ICA	No	No	Catheter angiography
Hattori et al. [6]	Left supraclinoid ICA	No	Yes; ipsilateral carotid terminus	Catheter angiography, surgery
Katsuta et al. [8]	Right supraclinoid ICA and right ACA A1	No	Yes; superior cerebellar artery origin	Catheter angiography, surgery
Banach [1]	Left supraclinoid ICA	Yes; proximal end of fenestration	Yes; right posterior communicating	Catheter angiography, surgery
Ng et al. [12]	Right supraclinoid ICA	Yes; two aneurysms arising from each limb of fenestration	No	Catheter angiography
Present study	Right supraclinoid ICA	No	No	CTA, Catheter angiography

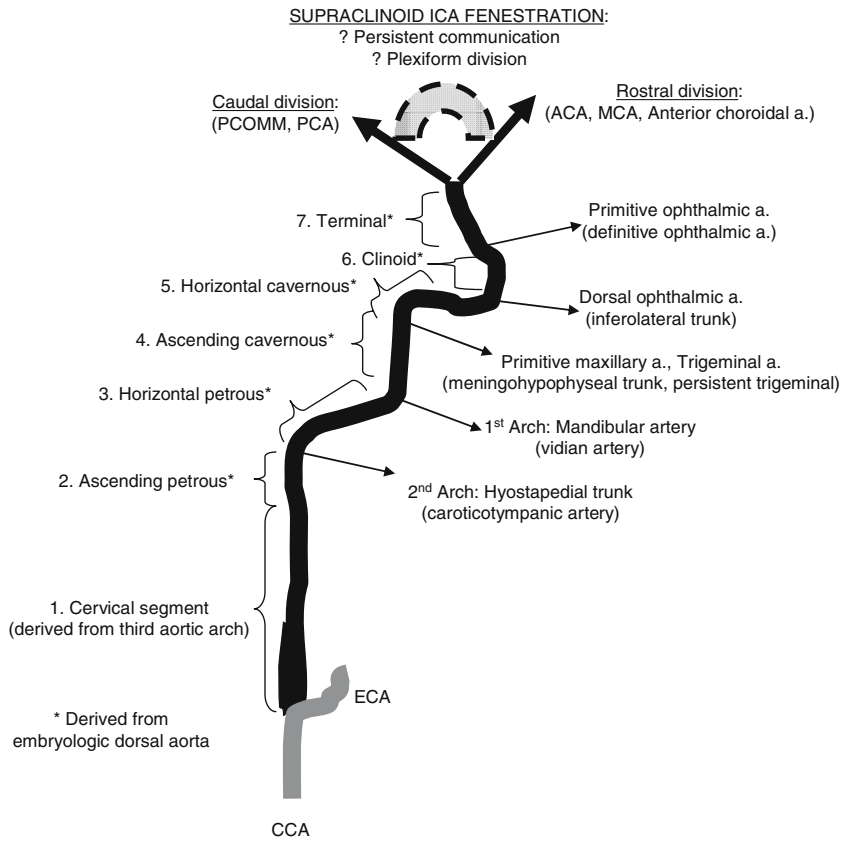

Fig. 4 Schema of ICA embryology including a proposed mechanism for supraclinoid ICA fenestration [4, 9–11]. Segments of the ICA are labeled to the *left*. The segments are defined by the branching of a series of embryologic vessels illustrated at *right* (adult vessels given in *parentheses*). Terminal segment (*7*) divides into rostral and caudal branches. Supraclinoid ICA fenestration could represent persistent communication or plexiform division

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