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CASE REPORT - VASCULAR NEUROSURGERY - ANEURYSM

# Fenestration of the supraclinoid segment of the ICA and associated aneurysms: a case report with literature review

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## Abstract

The supraclinoid ICA fenestration (SIF) is considered an extremely rare congenital anomaly. However, most of the reported cases of SIF are associated with intracranial aneurysms either ruptured or unruptured. We report the case of a 55-year-old patient with a right SIF and an unruptured, large, wide-necked aneurysm located on the larger limb of the fenestration and a second small aneurysm distal to the SIF. The aneurysms were treated with a Pipeline flow-diverter stent, achieving the complete reconstruction of the anatomy of the carotid siphon. The literature concerning these peculiar anatomic conditions has been reviewed, allowing discussion about treatment of such associated lesions.

**Keywords** Supraclinoid · Carotid · Fenestration · Flow diverter · Pipeline · Aneurysm

## Case report

A 55-year-old male was referred to our institution for an acute ischemic stroke of the right posterior cerebral artery (PCA) territory with fluctuant mild left ataxic hemiparesis and left superior quadranopsia (NIHSS 4), that was treated by i.v. fibrinolysis. Anamnesis revealed hypertension under treatment and current smoking. No other pathologies in the clinical history had been reported. MRI showed ischemic thalamic and temporal lesions, occlusion of the P2 segment of the right PCA and, as incidental findings, two aneurysms of medium and small size of the right supraclinoid ICA associated with a small aneurysm at the right MCA bifurcation. Digital subtraction angiography (DSA) was scheduled about 1 month later, after a complete recovery of the patient, in order to analyze properly the aneurysms. The larger one measured 10.6 × 10.2 mm, with a large neck (7.4 mm), and it was located on the superior wall of the supraclinoid ICA, the smaller other one (4.2 × 4.4 mm, neck 3 mm) was detected on the medial wall of the same segment. Furthermore, the 3D rotational acquisition (3DRA) showed a fenestration of the inferior wall of the supraclinoid ICA with part of the neck of the larger aneurysm implanted on the smaller branch of the fenestration (Fig. 1a–c). After multidisciplinary discussion, endovascular treatment (EVT) of the two carotid aneurysms was scheduled, and it was decided that because of its small size (3 × 2.5 mm), the unruptured MCA aneurysm should be left untreated and followed up. The intention-to-treat strategy was to coil the larger aneurysm and to deploy a Pipeline Flex FD stent (Medtronic, Irvine, California) covering the supraclinoid carotid segment in order to treat both aneurysms. Dual antiplatelet premedication (Clopidogrel + ASA 75/75 mg, standard protocol at our institution) was administered and an in vitro assessment of the platelet function was performed the day of the procedure, showing proper results according to our internal protocol (PFA inhibition P2Y12 > 300 s, cutoff 108 s).

### Endovascular procedure and follow-up

EVT was performed under general anesthesia and through right femoral access. A long introducer sheath (Neuron Max; Penumbra Inc., Alameda, CA) was positioned in the right ICA, an intermediate catheter Sofia 6F (Microvention, Tustin, CA) was navigated until the cavernous segment of the ICA and a Marksman micro-catheter (Medtronic, Irvine, CA) was navigated to the middle cerebral artery passing

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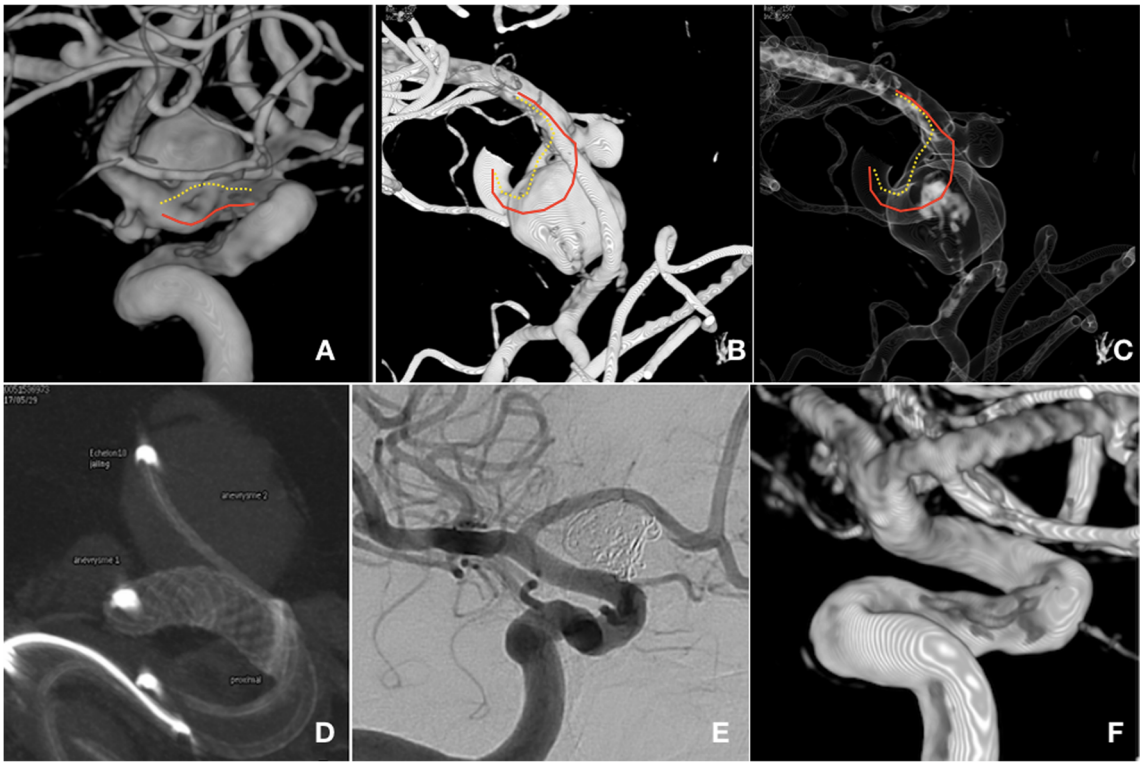


**Fig. 1** **a** 3D rotational angiography (infero-lateral view) of the right ICA revealing the SIF at the inferior wall of the carotid siphon and the two saccular aneurysms (the yellow dotted line highlights the smaller branch of the SIF and the red line the larger branch); **b** 3D rotational angiography (postero-superior view) of the right ICA showing the partial implantation of the larger aneurysm on the smaller branch of the SIF, confirmed in the transparent rendering (**c**); **d** VasoCT acquisition (Philips Allura Clarity, the Netherlands) showing the micro-catheter positioned in the larger aneurysm and the FD stent deployed with a "jailing" technique; 6-month follow-up angiography: 2D-DSA (**e**) with injection of the right ICA showing the complete occlusion of the two aneurysms and 3D rotational angiography (**f**) demonstrating the occlusion of the branch of the SIF where the neck of the larger aneurysm was partially placed

through the larger limb of the ICA fenestration. Successively, a second co-axial system, with an Envoy 6F (Cordis, Miami Lakes, FL) guiding catheter, was placed in the right common carotid artery and an Echelon 10 (Medtronic, Irvine, CA) micro-catheter was used to reach the larger aneurysm. A Pipeline Flex FD stent 4 × 12 mm was deployed covering both aneurysmal necks after five coils (Target, Stryker, Fremont, CA) and Microplex 10, Microvention, Tustin, CA) had been placed through a "jailing" technique in the larger aneurysm in order to achieve partial occlusion and to encourage intra-saccular thrombosis (Fig. 1d). No intra-procedural complications were observed. MRI/MR-angiography and DSA were performed after 3 and 6 months respectively, and showed the complete occlusion of the two aneurysms and of the ICA fenestration, without any sign of in-stent myo-intimal hyperplasia or stenosis (Fig. 1e–f) and the patient had a total recovery with an uneventful follow-up (mRS0).

## Discussion

The supraclinoid ICA fenestration (SIF) is considered an extremely rare congenital anomaly and etiology is not clearly understood. It is thought that, during the early embryonic stages (4 to 5 mm), there is a failure in the splitting of the terminal ICA segment into rostral and caudal divisions [2, 10, 16, 17]. Another possible mechanism of ICA fenestration is the persistence of the small plexiform channels temporarily connected between two intracranial primitive carotid arteries and separated by branching embryonic vessels at the 4- to 5-mm embryonic stage [10, 16]. The real incidence of intracranial fenestrations is unknown; however, Van Rooij et al. [17] reported an overall frequency of about 28% even if the authors estimate that 40% would be more realistic because of the limited sample of their study and also because 3D rotational angiography was not performed for all the arteries. In their paper, a SIF was observed in 2% of the cases.

### Fenestrations and development of cerebral aneurysms

Most of the reported cases of SIF are associated with aneurysms, although fenestrations of other cerebral arteries seem to be more frequent and not necessarily associated with other malformative lesions [1]. Van Rooij et al. [17] and Bharatha et al. [2] showed no significant difference in the incidence of

**Table 1** Literature describing the cases of supraclinoid ICA fenestrations from 1984 to 2017

| Authors | Age | Sex | Localization of the fenestration | Side | Aneurysm at ICA fenestration | Size | Other aneurysm associated | SAH from aneurysm at fenestration | Treatment of the aneurysm at fenestration | Clinical outcome |
|---|---|---|---|---|---|---|---|---|---|---|
| Yock 1984 [18] | 41 | F | Supraclinoid ICA | Right | Yes | Small < 2 mm | No | Yes | Wrapping | No deficits |
| Findlay 1987 [5] | 28 | F | Supraclinoid ICA | Right | No | | Yes (ruptured ACoA) | No | / | No deficits |
| Takano 1991 [15] | 51 | F | Supraclinoid ICA | Right | No | | | No | / | No deficits |
| Hattori 1992 [7] | 38 | F | Supraclinoid ICA | Left | No | | Yes (unruptured left ICA bifurcation) | No | / | |
| Banach 1993 [1] | 37 | F | Supraclinoid ICA | Left | Yes | Not specified | Yes (ruptured right PCom) | No | Clipping | No deficits |
| Katsuta 1993 [9] | 46 | F | Supraclinoid, A1 | Right | No | | Yes (ruptured SCA) | No | / | |
| NG 2006 [11] | 34 | F | Supraclinoid ICA | Right | Yes (2 aneurysms at the fenestration) | Not specified (small) wide neck | No | No | Clipping (larger sac) stent-assisted coiling (smaller sac) | No deficits |
| Bharatha 2007 [2] | 73 | M | Supraclinoid ICA | Right | No | | | No | / | No deficits |
| Chen 2007 [3] | 31 | M | Supraclinoid and paraclinoid ICA, left A1 | Bilateral | Yes (right ICA) | 2 × 3 mm wide neck | No | No | Wrapping | Right hemiparesis (2 previous ischemic strokes, left M1 stenosis) |
| Onoda 2008 [12] | 42 | F | Supraclinoid ICA | Left | Yes | 4 mm | No | No | Wrapping | No deficits |
| Plumb 2009 [14] | 48 | F | Supraclinoid ICA | Left | Yes | 8 mm | No | No | Clipping | No deficits |
| Van Rooij 2009 [17] | NA | NA | Supraclinoid ICA | NA | Yes | Not specified (small) wide neck | NA | NA | NA | NA |
| Dey 2011 [4] | 39 | F | Supraclinoid ICA | Right | Yes | 8.9 mm wide neck | No | No | Clipping | No deficits |
| | 32 | F | Paraclinoid ICA | Right | Yes | 3.9 mm wide neck | No | Yes | Clipping | No deficits |
| Ichikawa 2011 [8] | 47 | F | Supraclinoid and Paraclinoid ICA aneurysms | | Yes (2 aneurysms at the fenestration) | 7 mm 7 mm wide neck | | No | Balloon-assisted coiling | No deficits |
| Nakiri 2011 [10] | 47 | F | Supraclinoid ICA | | Yes | 12 × 6 mm wide neck | No | No | Trispan + coiling | No deficits |
| | 44 | M | Supraclinoid ICA | | Yes (2 aneurysms at the fenestration) | 6 × 5.5 mm; < 2.5 mm | | Yes | Stenting + coiling | Visual deficit (already at the admission for SAH), no other symptoms |

**Table 1** (continued)

| Authors | Age | Sex | Localization of the fenestration | Side | Aneurysm at ICA fenestration | Size | Other aneurysm associated | SAH from aneurysm at fenestration | Treatment of the aneurysm at fenestration | Clinical outcome |
|---|---|---|---|---|---|---|---|---|---|---|
| Park 2012 [13] | 44 | M | Supraclinoid ICA and MCA | Left | Yes | 4.5 × 3.4 mm | Yes (ruptured MCA) | Yes | Balloon-assisted coiling | No deficits |
| Uchino 2016 [16] | 73 | F | Paraclinoid ICA | | Yes | −/ (small) | | No | Follow-up | No deficits |
| Our present case | 55 | M | Supraclinoid ICA | | Yes | 10.6 × 10.2 mm wide neck | Yes (unruptured MCA) | No | Coiling + Stent FD | No deficits |

aneurysms among fenestrated and non-fenestrated arteries; however, other authors [10, 14, 17] supported the hypothesis of a possible major predisposition for the aneurysmal development in some particular localizations, such as the supraclinoid ICA and the vertebro-basilar junction. Intracranial arterial fenestrations were investigated also in histological studies [6] which evoked the presence of some defects of the medial layer at both proximal and distal edges of all the fenestrations that could predispose to aneurysm formation.

## Treatment of associated aneurysms and review of the literature

Almost all the aneurysms described in the previous reports were treated either by microsurgery or by EVT. We exhaustively reviewed the literature (Table 1) describing the cases of supraclinoid ICA fenestrations from 1984 to 2017 and included 20 reported cases (including our patient) of SIFs with or without associated aneurysms, distinguishing those ones located at the level of the fenestration and those located elsewhere, their size, the treatment, and the clinical outcome. Among them, 15 patients (15/20, 75%) harbored 18 aneurysms associated with a SIF, 4 of them being ruptured. The aneurysms were treated by clipping or wrapping in eight cases and by EVT in five patients with six aneurysms, while in another one, a conservative strategy was chosen. Dey et al. [4] reported two cases of aneurysms associated with SIF treated by clipping, and further reviewed 12 other patients with SIF from the literature. However, in three out of these reviewed cases, the SIF was not associated with an aneurysm [5, 7, 9], which could lead to an erroneous interpretation of the frequency of this association. Moreover, Dey et al. [4] claimed that the presence of a fenestration could make the endovascular treatment more challenging or not feasible without the sacrifice of the associated vessels. Our up-to-date review supports different considerations. Four cases of aneurysms located at the level of a SIF and successfully treated by embolization were reported by Nakiri et al. [10], Park et al. [13], and Ichikawa et al. [8]. Different techniques were used, including stent-assisted or balloon-assisted coiling and the use of a Trispan device (Boston Scientific). In our case, we decided to treat the two unruptured aneurysms by coiling the larger one and deploying a FD stent inside the larger limb of the SIF, in order to cover also the other aneurysmal neck. The present case and the others previously reported in literature [8, 10, 13] about the EVT of aneurysms associated with SIF suggested that this strategy could provide good anatomical and clinical results.

## Compliance with ethical standards

The patient has consented to submission of this case report to the journal.

**Conflict of interest** The authors declare that they have no conflict of interest.

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