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CASE REPORT - VASCULAR NEUROSURGERY - OTHER

Aberrant trans-osseous venous drainage of the superficial middle cerebral vein: case report

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Abstract

The superficial middle cerebral veins (SMCVs) are large veins to drain the brain and therefore anatomical knowledge of them is important for neurosurgeons and neuroradiologists. In a patient with a ruptured blister aneurysm, we incidentally found during angiography an aberrant drainage of the SMCVs, which penetrated the lateral part of the greater sphenoid wing and directly connected the SMCVs with the deep facial vein. Neurosurgeons usually need to remove that part of the greater sphenoid wing during the fronto-temporal approach. The existence of a well-developed current channel could be a contraindication for this type of procedure.

Keywords Superficial middle cerebral vein · Deep facial vein · Trans-osseous channel

Background and importance

The superficial middle cerebral veins (SMCVs) are one of the largest cerebral venous systems. The knowledge of this anatomy is important for neurosurgeons and neuroradiologists. We report here an aberrant venous drainage of the SMCVs, which was inconsistent with the anatomical and embryological line of thinking concerning the variations of the SMCV drainage in the past literature. The current aberrant SMCV drainage also has a significant impact on clinical practice, especially in neurosurgery.

Clinical presentation

A 49-year-old woman was transferred to our hospital due to the presence of a subarachnoid hemorrhage (SAH, WFNS grade I; Fig. 1a) after the rupture of a blister-like aneurysm of the supraclinoid segment of the internal carotid artery (ICA) (Fig. 1b). In the venous phase of the right ICA angiograms, we found an aberrant drainage of the right SMCVs (Fig. 2a, b), which directly emptied into the deep facial vein. The bone windows of the plain CT also revealed the bone canal (Fig. 2c, d) where the aberrant channel passed through the bone. The cone beam CT reconstructed from the 3D rotational angiography confirmed that the aberrant venous channel continuous to the SMCVs penetrated the lateral part of the greater sphenoid wing, through the trans-osseous channel, and emptied into the right deep facial vein (Fig. 3). Two flow-diverter stents were placed in the right ICA and healed the aneurysm (Fig. 1c). The patient totally recovered 3 weeks later.

Discussion

In the literature [2–4, 8, 9], there are several SMCV drainage variations; primitive tentorial sinus (PTS) type, paracavernous sinus (PCS) type, and the cavernous sinus (CS) type. However, the direct communication between the SMCVs and the external jugular system via the lateral aspect of the sphenoid bone has not been reported previously, to the best of our knowledge. Emphasizing the embryological development of the SMCVs [1, 4, 5, 7] is important to explain and to discuss these variations and the current aberrant channel (Fig. 4).

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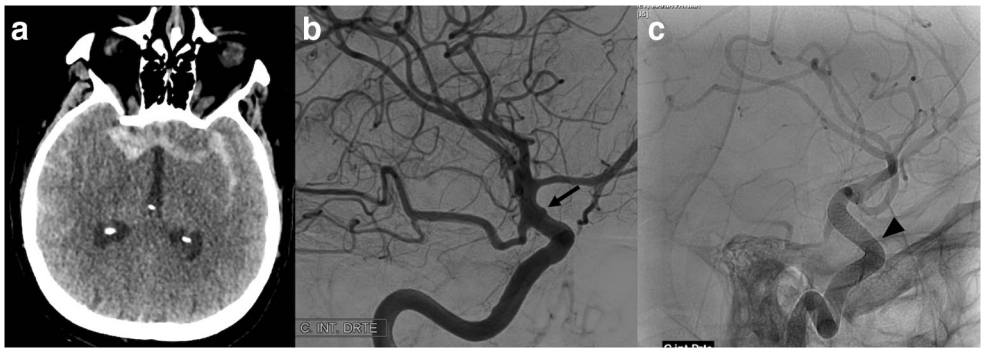

Fig. 1 Plain CT scan, axial view (**a**), the right internal carotid angiogram just after the onset (**b**), and the angiogram after the deployment of the flow diverters (**c**). Blister-like aneurysm of the anterior wall of the right ICA (black arrow) and flow diverters (black arrowhead)

At the early embryological stage, the primitive telencephalon is drained by the telencephalic vein (the future SMCVs) directly to primitive transverse sinus via the PTS. At this stage, the CS is described as pro-otic sinus (PoS) and it has connections with the facial veins via the primitive maxillary vein (future superior orbital vein) and the dorsal pharyngeal vein (future pterygoid plexus) but never has a connection with the PTS nor SMCVs. The PTS initially runs laterally to the telencephalon but along with the development of the hemispheres; it swings caudally and runs on middle fossa. In the following stage, the connection between the CS and the PTS, so-called cavernous sinus capture, is secondarily formed. The degree and the location of this connection explain the variations of the SMCV drainage. Whether the PTS runs medially and directly captured by the CS, it configures a CS-type SCMV drainage. In the PCS-type, the PTS runs on the relatively lateral aspect of the middle fossa and it is captured by the lateral wing of the CS. Afterwards, it directly continues with the dorsal pharyngeal vein (future pterygoid plexus). In the PTS-type, the PTS has not been captured by the CS and maintains its original morphological feature. It has been generally believed that SMCVs embryologically do not have any connection with the external jugular venous system, and that, even after the cavernous sinus capture, the SMCVs drain to the external jugular system only through the foramen ovale.

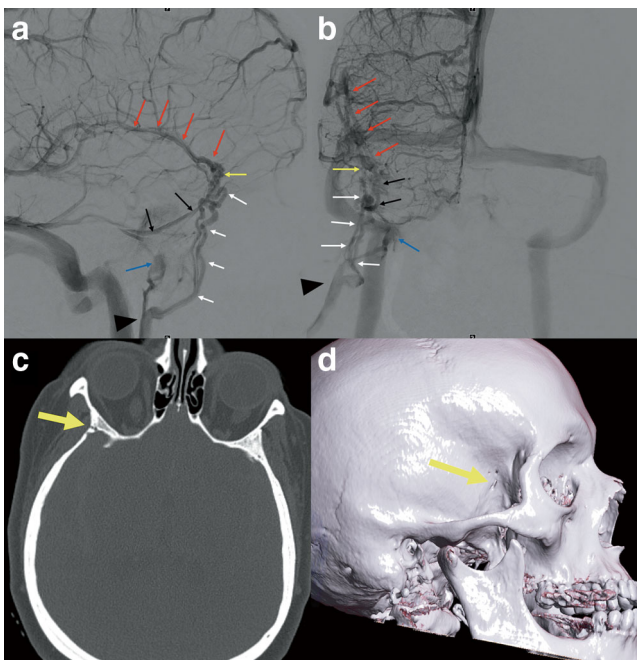

Fig. 2 Lateral (**a**) and anteroposterior (**b**) view of the venous phase of the right internal carotid angiogram, axial image (**c**) and 3D volume rendering image (**d**) of CT scan (bone windowing). The right superficial middle sylvian vein (red arrows) is directly drained to the two deep facial veins (white arrows) and also drained via a paracavernous sinus (black arrows) to the pterygoid plexus (blue arrows), both of which empty into the same common trunk (black arrowhead). In the bone CT (c, d), the bone canal (yellow arrow) was found where the aberrant venous channel is located

Previous anatomical studies are consistent with the abovementioned embryological knowledge; San Millan described a cadaver study concerning the termination of SMCVs [6]; all SMCVs ran under the lesser sphenoid wing in the form of arachnoid veins before joining the CS or PCS; none of them had any connection with the extradural channel laterally to the sphenoid wing. Likewise, all of the other articles concerning the SMCV drainage pattern have reported the anatomical variations mentioned above or a modification [2–4, 8, 9]. Accordingly, the current aberrant SMCV drainage route contradicts the classical anatomical and embryological perceptions concerning SMCVs. Therefore, to explain the current variation, a modification of the classical views of the anatomy and embryology on SMCVs appears to be necessary and we assume that the current aberrant channel could be embryologically explained by the following descriptions.

According to Padget [5], the stem of the PTS, the anterior dural plexus, occasionally has a connection with the PoS laterally to the trigeminal nerve [5] (Fig. 4), which was also illustrated by Butler [1]. They did not mention its fate, and we could not find any descriptions concerning the embryonic connection between the PoS and the deep facial vein in the lateral aspect of the sphenoid bone. However, if one considers that the PoS embryologically has multiple plexiform connections with the deep facial vein and that only a thin mesenchymal tissue is interposed between the facial veins and the PoS without any solid bone at the early embryonic stages [5], one

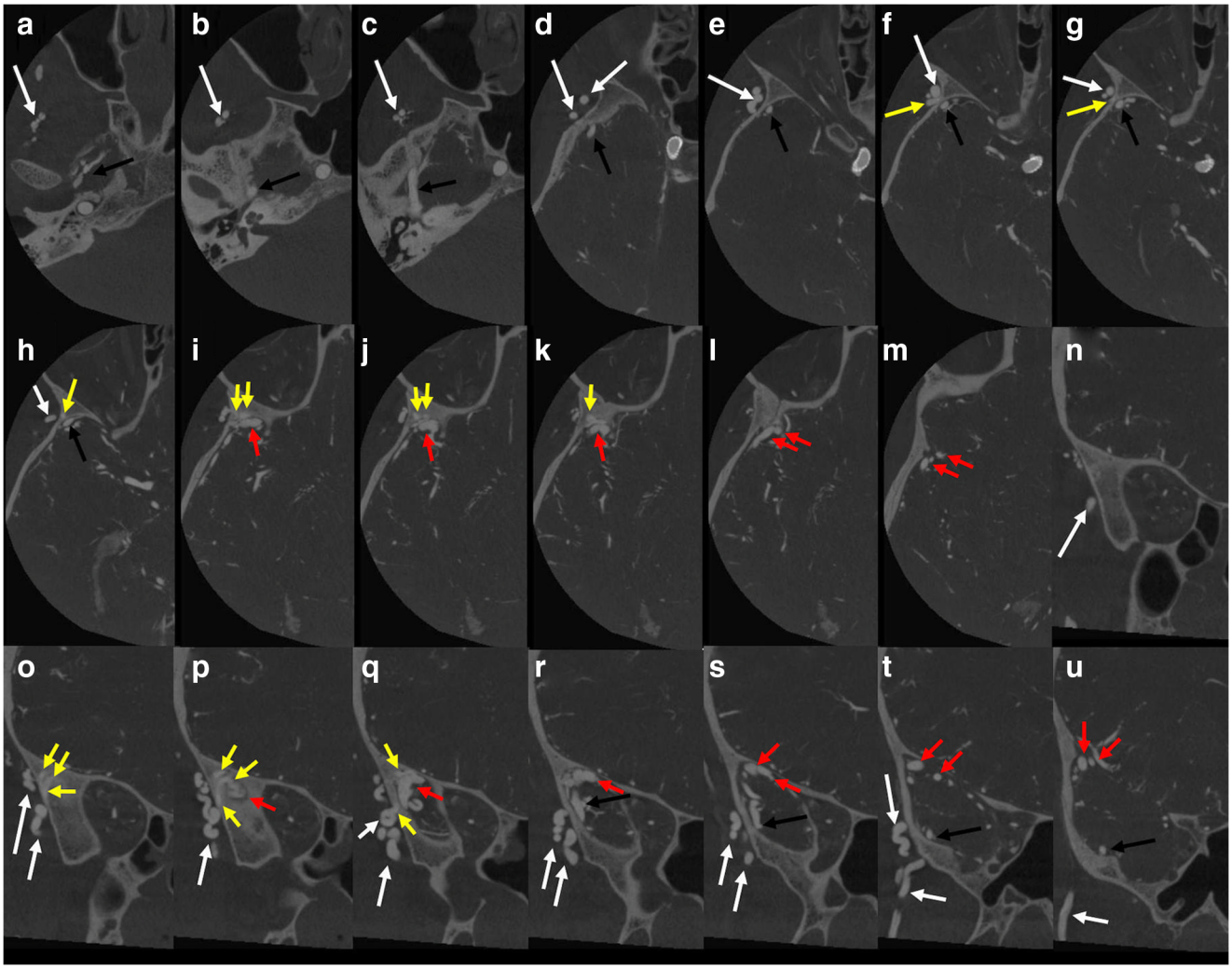

Fig. 3 The axial (**a**–**m**; caudal to cranial) and the coronal (**n**–**u**; anterior to posterior) images of the cone beam CT (XperCT) reconstructed from the 3D rotational angiography via the right internal carotid artery. The current aberrant venous channel (yellow arrow), the SMCVs (red arrow), the deep facial vein (white arrow), and another drainage route via the paracavernous sinus (black arrow)

can suppose that the lateral part of the PoS could connect with the deep facial vein. The current anatomical feature may thus correspond to the remnant of this connection as it usually regresses prenatally.

The current case might also influence the clinical procedure. During the fronto-temporal approach, neurosurgeons remove the greater sphenoid wing [10] through which this vein passes. Such an aberrant channel must be preserved during craniotomy

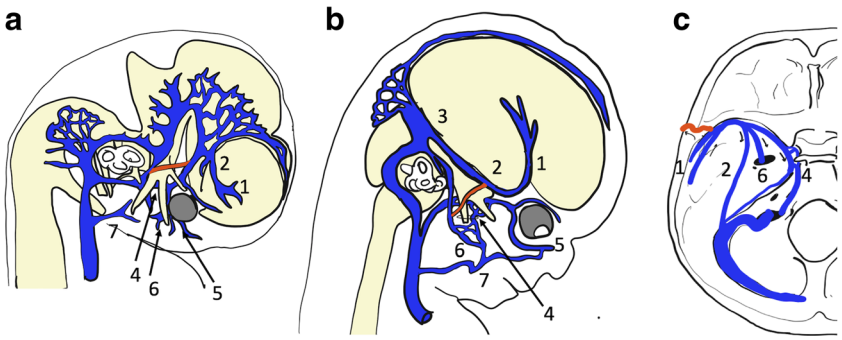

Fig. 4 Development of the venous channels and the cavernous sinus capture. **a** At 7 weeks of embryonic age. **b** At 9 weeks of embryonic age just before the cavernous sinus capture. **c** Cavernous sinus (CS) capture. (1) Telencephalic vein (future SMCV), (2) primitive tentorial sinus, (3) transverse sinus, (4) pro-otic sinus, (5) primitive maxillary vein, (6) dorsal pharyngeal vein, and (7) facial veins

by respecting the bone penetrated by the channel. However, the venous channel bridges from the bone above the surgical view to SMCVs on the brain surface and may severely restrict the surgical view during the dissection of the sylvian fissure; its excessive manipulation has a high risk of injury to the channel. Since in these situations the SMCVs drain a large territory of the cerebrum, its injury might have caused the severe venous infarction. Such an anatomical disposition should contraindicate a fronto-temporal approach and, in these cases, endovascular treatment should be preferred whenever possible depending on the lesion. Careful analysis of the venous drainage of the hemispheres allows us to recognize potential dangerous anatomical dispositions and to optimize safe surgical procedures.

Conclusion

We describe an aberrant venous drainage route of the SMCVs, which penetrated the greater sphenoid wing and connected the SMCVs directly with the deep facial vein. The current aberrant channel may be the remnant of the embryological anastomoses between the anterior dural plexus and the pro-otic sinus. In well-developed cases, its existence may be a contraindication for the fronto-temporal approach.

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Compliance with ethical standards

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

Patient consent The patient has consented to the submission of the case report for submission to the journal.

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