CASE REPORT

Importance of source images of time-of-flight magnetic resonance angiography in the diagnosis of low-flow dural arteriovenous fistulae after traumatic brain injury

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SUMMARY

Three-dimensional time-of-flight (TOF) magnetic resonance angiography (MRA) can reliably detect dural arteriovenous fistula (dAVF); however, TOF source images should be checked in cases with low-flow dAVFs. A 69-year-old woman reported intractable pulsatile tinnitus after head trauma. It was difficult to diagnose dAVF using conventional MRA, but it was confirmed using a TOF source image. Cerebral angiography revealed a dAVF with a small shunted pouch draining into the sigmoid sinus, accompanying the arterial jet flow. Transarterial embolisation of the shunted pouch completely obliterated the dAVF. The patient's tinnitus immediately disappeared after embolisation. This case suggests that a low-flow Borden type I dAVF is undetectable using conventional MRA, and we emphasise the importance of evaluating TOF source images. Transarterial embolisation of the shunted pouch while preserving the normal sinus flow was safe and effective.

BACKGROUND

Dural arteriovenous fistula (dAVF) is a rare but important differential diagnosis of pulsatile tinnitus.¹ Tinnitus caused by dAVF is characterised by pulsatility.² For non-invasive examination, time-of-flight (TOF) magnetic resonance angiography (MRA) with maximum-intensity projection (MIP) imaging usually shows abnormal flow-related enhancement of affected sinuses; however, it is not always easy to detect these findings, especially in cases of low-flow dAVF. Because the diagnostic sensitivity of the TOF MRA was reported to be approximately 50%,³ clinicians should also examine carefully including source imaging of TOF MRA to detect dAVF. We present a case of low-flow Borden type I occipital traumatic dAVF caused by intractable pulsatile tinnitus. Because of the low-flow fistula, this case extended more than 1 year without having a diagnosis of dAVF. The aetiology and the characteristic angiographic findings producing an intractable tinnitus were also discussed.

CASE PRESENTATION

A 69-year-old woman suffered a bruise at the back of her head. CT revealed contralateral haemorrhagic contusion (figure 1A) and linear fracture of the lateral occipital bone (figure 1B, arrow). As her

neurological condition was good, she immediately received medical treatment. After the accident, she began to suffer from intractable pulsatile tinnitus, causing a depressive state. Three-dimensional (3D) MIP imaging of TOF MRA revealed subtle opacification of the left sigmoid sinus (SS) adjacent to the left occipital artery (OA), but did not confirm the diagnosis (figure 1C). The TOF source image clearly revealed an abnormally high signal from the left OA to the SS, suggesting the presence of dAVF (figure 1D, arrowhead). Unfortunately, these findings were overlooked for almost 8 months, and she was referred to a psychiatrist. Finally, her previous doctor referred her to our hospital for further examination. Digital subtraction angiography (DSA) was performed, which revealed that the dAVF fed by multiple mastoid OA branches was draining into the SS, accompanying an arterial jet flow (figure 2A). A magnified OA angiogram identified the feeders (figure 2B, black arrows), the site of the shunted pouch (figure 2B, white arrowhead) and a jet flow directly into the SS (figure 2B, black arrowheads). Based on the DSA findings, the patient was diagnosed with dAVF (Borden type I). Because psychiatric problems could have been caused by the intractable tinnitus that flows to the SS, the lesion was treated with transarterial selective embolisation of the shunted pouch.

TREATMENT

Under local anaesthesia, a guide catheter was placed at the left common carotid artery, from which a microcatheter was advanced into the shunted pouch; six coils were inserted and complete obliteration of the dAVF was achieved (figure 2C,D) while preserving the sinus flow.

OUTCOME AND FOLLOW-UP

The patient's tinnitus immediately and completely disappeared after embolisation. After the 6-month follow-up, there is no apparent recurrence of the dAVF.

DISCUSSION

Pulsatile tinnitus caused by dAVF is uncommon; the relative frequency of patients with dAVF is 7%–8%.⁴ However, because dAVF with cortical venous reflux may produce aggressive symptoms,

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Figure 1 An axial head CT scan shows right temporal haemorrhagic contusion and thin acute subdural haematoma (A). An axial bone-window CT scan (B) shows linear occipital fracture (white arrow) around the area where the head was struck. Three-dimensional maximum-intensity projection imaging of time-of-flight (TOF) magnetic resonance angiography (MRA) in the coronal plane (C) shows the subtle opacification of the left sigmoid sinus adjacent to the left occipital artery (OA). In an axial source imaging of TOF MRA (D), abnormally high signals of the left sigmoid sinus and the mastoid branch of OA are clearly revealed (white arrowhead).

including convulsion, venous infarction and intracranial haemorrhage, the presence of dAVF should not be overlooked,⁵ and although dAVF without cortical reflux (Borden type I) has a benign clinical course, abrasive pulsatile tinnitus is occasionally intractable. In this situation, dAVF treatment also should be considered.^{5,6}

In the case of pulsatile tinnitus that developed after head trauma, the occurrence of dAVF would be very high on the list of differentials in such a clinical scenario. When the presence of dAVF is suspected, TOF MRA is recommended to detect as a first-line non-invasive evaluation. According to the recently published guidelines for intracranial dAVF,³ the diagnostic sensitivity and specificity of CT angiography has improved from 15.4% to 93% with the advancement of imaging techniques such as the introduction of multidetector CT. TOF MRA is commonly used as a non-invasive tool because of the lack of ionising radiation. TOF MRA's reported sensitivity and specificity are about 50%, which can be increased to 93% using contrast-enhanced MRA by high-field scanner.³ However, we believe that careful reviewing of non-contrast TOF MRA including source images could detect the abnormal flow-related enhancement of the affected dural sinuses and that it should be a part of a protocol in clinical practice. Even if the TOF MRA were to be normal in a situation in which dAVF is strongly suspected, we should closely follow-up and evaluate both the clinical symptom and TOF MRA. In our case, as 3D MIP imaging of TOF MRA showed only a subtle abnormal appearance, clinicians failed to diagnose the patient's dAVF; finally, the patient was driven to depression. If the source imaging of TOF MRA was more carefully checked in addition to

Figure 2 A lateral angiogram view of the left external carotid artery (A) shows a dural arteriovenous fistula (dAVF) between the mastoid branch of the occipital artery (OA) (black arrows) and sigmoid sinus (black arrowheads). A magnified lateral view of (B) shows a network of multiple arterial feeders (black arrows) draining into the shunted pouch (white arrowhead) and the sigmoid sinus associated with arterial jet flow (black arrowheads). A non-subtracted lateral view of a skull image (C) obtained just after transarterial embolisation shows placed coils in the shunted pouch. A lateral view of selective OA angiography obtained after embolisation (D) shows complete obliteration of the dAVF.

3D MIP imaging at initial MRI after head trauma, the patient's dAVF might have been diagnosed earlier.

This was a Borden type I case, with no cortical reflux; therefore, it might not be easily detected using 3D MIP of MRA imaging only. Furthermore, because the pulsatile tinnitus was intractable and caused psychiatric distress, we decided to treat the dAVF. To treat dAVF, it is important to obliterate the shunted point completely by a transvenous or transarterial approach. Although transvenous embolisation for totally packing the affected sinus was safe and effective for patients with dAVF, especially with multiple shunted points, simple sinus packing could not be performed in patients with Borden type I dAVF to preserve normal venous flow. Transarterial embolisation using various embolic materials was chosen for treating these patients; however, the curative rate was low, and additional treatment options were required.³ In our case, as the selective OA angiogram clearly indicated a sole shunted pouch, which is accessible from one of the OA branches, we considered treating with a transarterial approach only by simple packing of the shunted pouch. Thus, the microcatheter was advanced into the shunted pouch that was embolised using several coils while preserving the sinus flow.

The intensity of her tinnitus was believed to be a result of the fistulous jet flow. Although some reports have discussed the occurrence of dAVF after a head trauma,⁷ the underlying pathophysiology remains unclear. While many cases were located in the middle fossa, a few cases were located in the posterior fossa, such as in our case. Generally, non-traumatic dAVF was reportedly associated with venous sinus thrombosis.⁶ However, in our case, no apparent thrombosis within the SS

Learning points

- ▶ Dural arteriovenous fistula (dAVF) should be considered when pulsatile tinnitus appears after a head trauma.
- ▶ The importance of evaluating source imaging of time-of-flight (TOF) magnetic resonance angiography (MRA) should be emphasised, even when three-dimensional maximum-intensity projection imaging of TOF MRA does not demonstrate apparent abnormal findings.
- ▶ Transarterial embolisation of the shunted pouch while preserving the normal sinus flow may be a treatment option for dAVF causing intractable tinnitus.

and TS was observed. The pathophysiology of our case was inferred as follows: referring to the source imaging of TOF MRA and DSA, the shunted pouch was believed to exist within the occipital dura layers, and the feeders fed from the mastoid OA branch passed through the fracture line. Thus, during the repair process of the torn dura matter, the arterial network from the OA to the occipital dura was developed, and a blood pouch within the dura matter was formed. Finally, as the penetration between the blood pouch and SS through a small fistulous point occurred, the dAVF accompanying the jet fistulous flow was configured. The fact that the fistulous flow was rapid but small might make visualising dAVF in 3D MIP imaging of TOF MRA difficult.

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