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PICTORIAL ESSAY

Computed Tomographic Angiography Findings in Spontaneous Intracranial Haemorrhage: Correlation with Digital Subtraction Angiography

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ABSTRACT

In this pictorial essay, computed tomographic angiography findings in various cerebrovascular diseases that lead to spontaneous intracranial haemorrhage are illustrated. They include aneurysm, intracranial dissection, brain arteriovenous malformation, dural arteriovenous fistula, Moyamoya disease, and developmental venous anomalies. Correlation with digital subtraction angiography is provided for each computed tomographic angiography illustration.

Key Words: *Cerebral angiography; Intracranial arteriovenous malformations; Intracranial hemorrhages; Moyamoya disease; Vertebral artery dissection*

中文摘要

自發性顱內出血的電腦斷層血管造影結果與數字減影血管造影的相關性

梁錦榮、馮啟雄

本圖片回顧展示引致自發性顱內出血的各種心血管疾病的電腦斷層血管造影術結果。這些心血管疾病包括動脈瘤、顱內血管夾層、腦動靜脈畸形、硬腦膜動靜脈瘻、煙霧病、及腦發育性靜脈異常。本文內每個電腦斷層血管造影圖都附有相關的數字減影血管造影圖以作參考。

INTRODUCTION

Digital subtraction angiography (DSA) has been the gold standard for evaluating patients presenting with spontaneous intracranial haemorrhage. With the advances in non-invasive imaging, around the world computed tomographic angiography (CTA) and magnetic resonance angiography (MRA) are increasingly used as first-line investigations for these patients.

The advantages of CTA over DSA are that it is non-invasive, widely available, much quicker to perform, capable of three-dimensional (3D) reconstruction, and is suitable for use in critically ill patients. However, CTA lacks the ability to selectively assess individual vessels (required for endovascular treatment of certain cerebrovascular disease, such as early venous shunting in dural arteriovenous fistula [DAVF] or cross shunting). By contrast, DSA is an invasive procedure that has a

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0.5% risk of incurring permanent neurological deficit.[1] Due to the inherent risks of DSA, it should be reserved for cases with equivocal findings after CTA/MRA or for evaluating the angioarchitecture of cerebrovascular

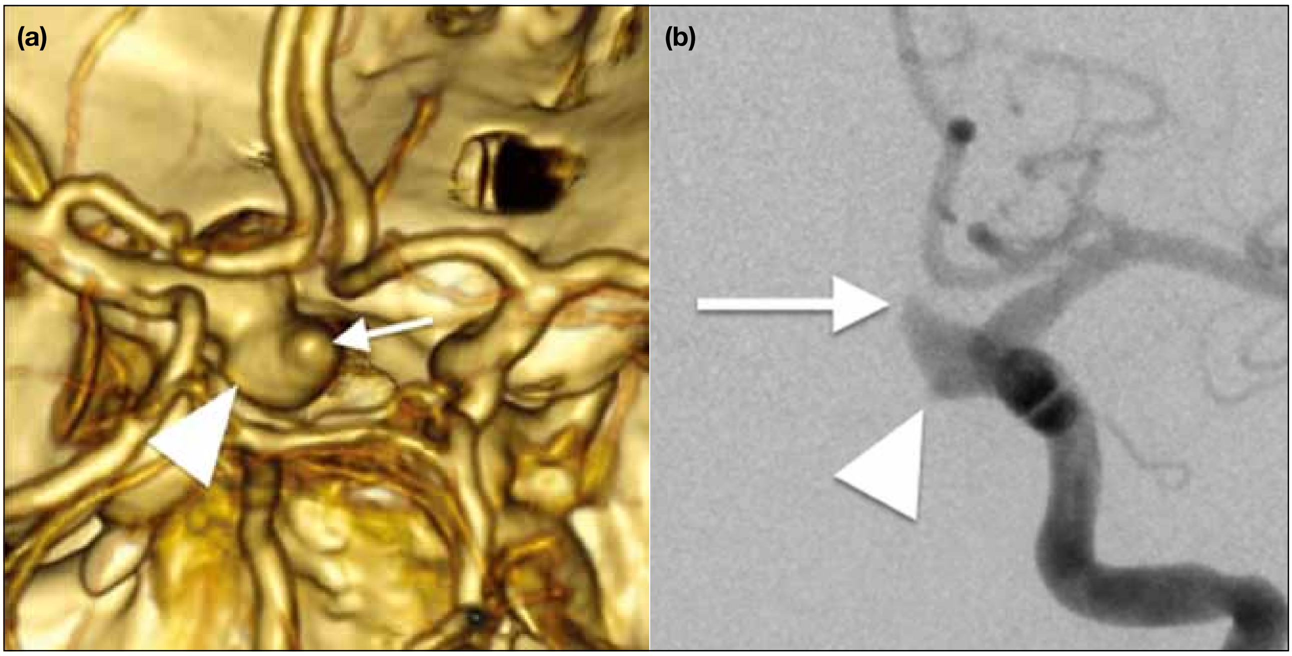

Figure 1. Left supraclinoid internal carotid artery aneurysm with daughter aneurysm is shown. (a) 3D reconstruction of computed tomographic (CT) angiography images viewed from above shows a medial pointing aneurysm (arrowhead) at the left supraclinoid internal carotid artery. A superior and medial pointing daughter aneurysm (arrow) suggestive of a ruptured point is evident. (b) Frontal projection of the left internal carotid artery digital subtraction angiography shows the corresponding aneurysm (arrowhead) and daughter aneurysm (arrow). A diffuse subarachnoid haemorrhage is seen at the basal cisterns in the non-contrast CT brain image (not shown).

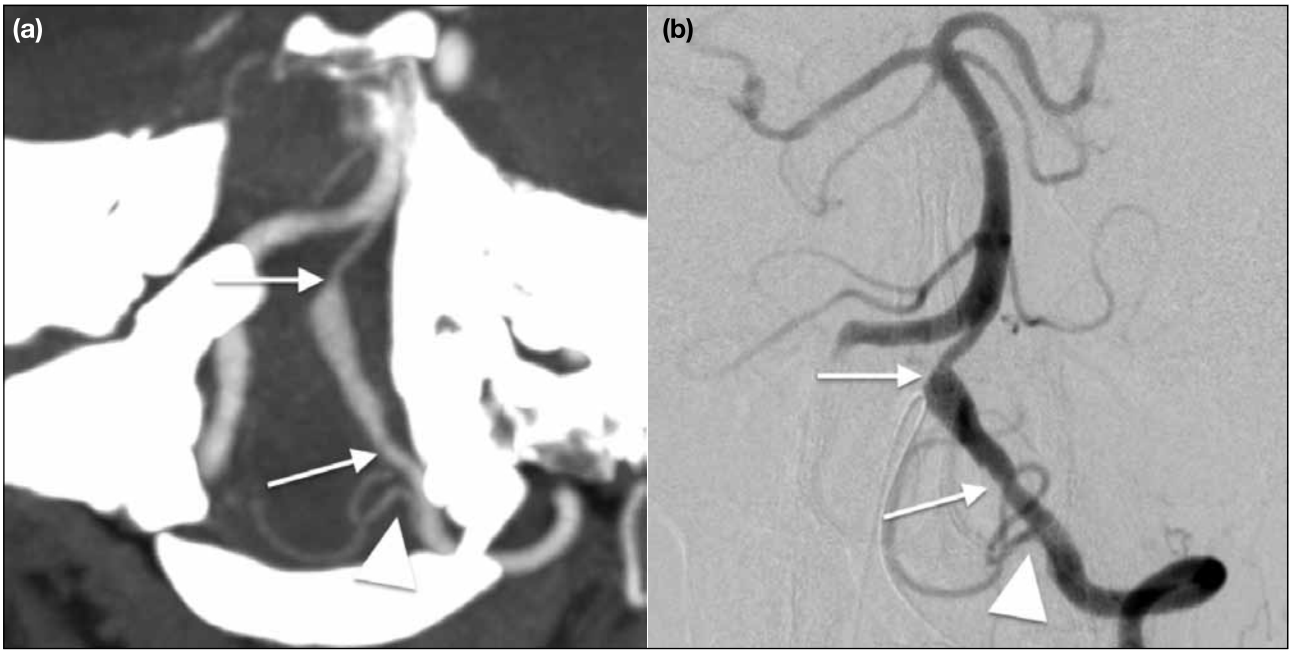

Figure 2. Left intracranial vertebral artery dissection is shown. (a) A coronal oblique reformatted image in maximum intensity projection reveals a segment of aneurysmal dilatation (arrows) at the left intracranial vertebral artery distal to the origin of posterior inferior cerebellar artery (arrowhead) and proximal to the basilar artery, suggestive of dissection. (b) The corresponding digital subtraction angiography image shows the same segment of aneurysmal dilatation (arrows) at the left intracranial vertebral artery. Diffuse subarachnoid haemorrhage was seen in the posterior cranial fossa (not shown).

disease before endovascular intervention. Increasing use of non-invasive imaging modalities should ultimately improve patient safety.

ANEURYSM

Aneurysm is seen as an outpouching of vessel wall on CTA and DSA. In a recent meta-analysis, the pooled sensitivity and specificity of CTA for detecting ruptured cerebral aneurysm were 98% and 100%, respectively.[2] CTA has the advantage of 3D reconstruction which is best for assessing the relationship of aneurysms to their parent vessels. In most instances, the treatment decision can be based on the 3D reconstruction of CTA, without resorting to DSA.[3] Aneurysm blebs or 'daughter aneurysms' are classical indicators of rupture (Figure 1).[3] Extravasation of contrast is rare, but is sometimes seen.[4]

INTRACRANIAL DISSECTION

Intracranial dissections cause about 0.4 to 2.5% of all strokes in the general population but cause 5 to 20% of strokes among young patients.[5] The sensitivity and specificity of CTA in diagnosing vertebral artery dissection was reported as 100% and 98%, respectively.[6] The angiographic patterns of dissection can be categorised as aneurysmal or steno-occlusive.[7] Subarachnoid haemorrhage can occur with an

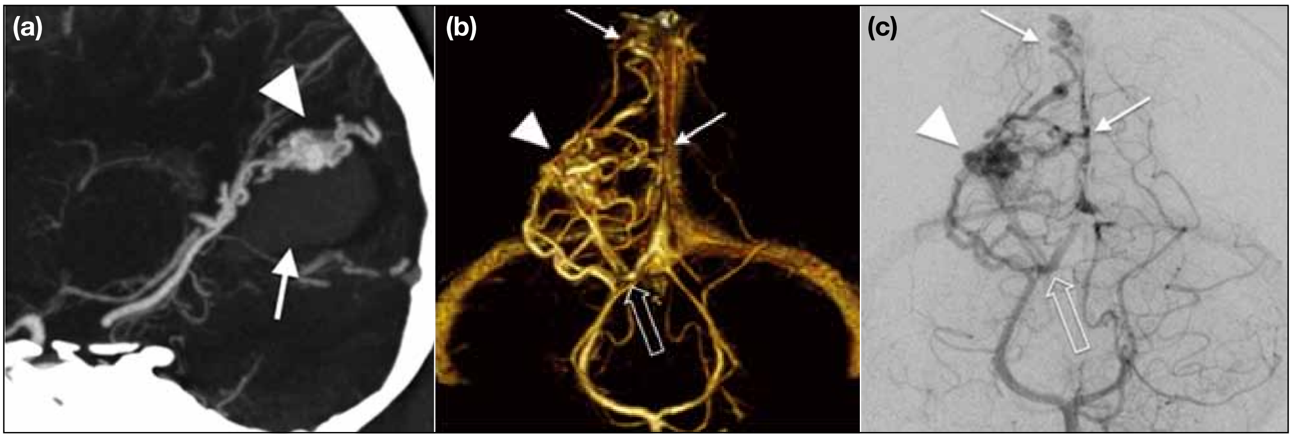

Figure 3. Right occipital lobe brain arteriovenous malformation is shown. (a) A sagittal reformatted computed tomographic angiography (CTA) image in maximum intensity projection shows an arteriovenous malformation (AVM) nidus (arrowhead) at the superior border of the haematoma (arrow). (b) 3D reconstruction of CTA images viewed from the front and above shows the AVM nidus (arrowhead) together with its draining veins; drainage is into the superior sagittal sinus (arrows) and the right basal vein of Rosenthal (open arrow). (c) Towne's projection of the right vertebral artery digital subtraction angiography confirms the presence of a brain AVM at the right occipital lobe (arrowhead) with venous drainage towards the superior sagittal sinus (arrows) and right basal vein of Rosenthal (open arrow).

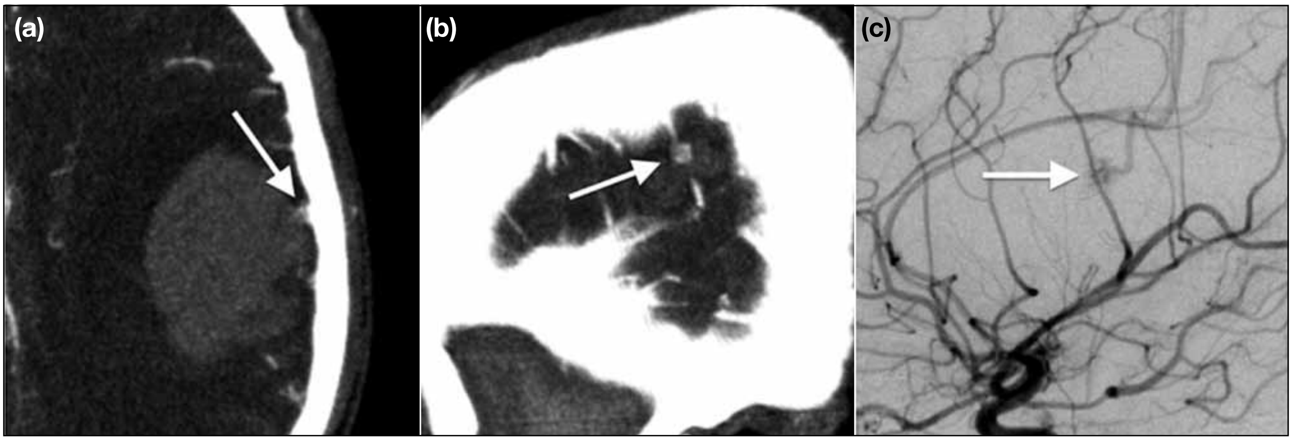

Figure 4. Small left fronto-parietal brain arteriovenous malformation is shown. (a) Axial and (b) sagittal oblique computed tomographic angiography images in maximum intensity projection show a small arteriovenous malformation (AVM) nidus (arrows) adjacent to the haematoma subjacent to the skull vault. The AVM nidus is inconspicuous in the axial plane, but is unequivocally seen in the sagittal oblique plane. (c) Digital subtraction angiography of the left internal carotid artery injection confirms the small left fronto-parietal brain AVM (arrow) with en passage arterial supply from a cortical branch of the left middle cerebral artery.

aneurysmal pattern of an intracranial dissection.[7] The most common angiographic finding is focal dilatation with or without proximal or distal stenosis (Figure 2).[7] The presence of an intimal flap at the proximal margin of the dissection is a specific finding, which is seen in less than 10% of patients.[5]

BRAIN ARTERIOVENOUS MALFORMATION

Brain arteriovenous malformation (AVM), or more specifically a pial AVM, is an abnormal connection between arteries that would normally supply the brain tissue and veins that normally drain the brain;

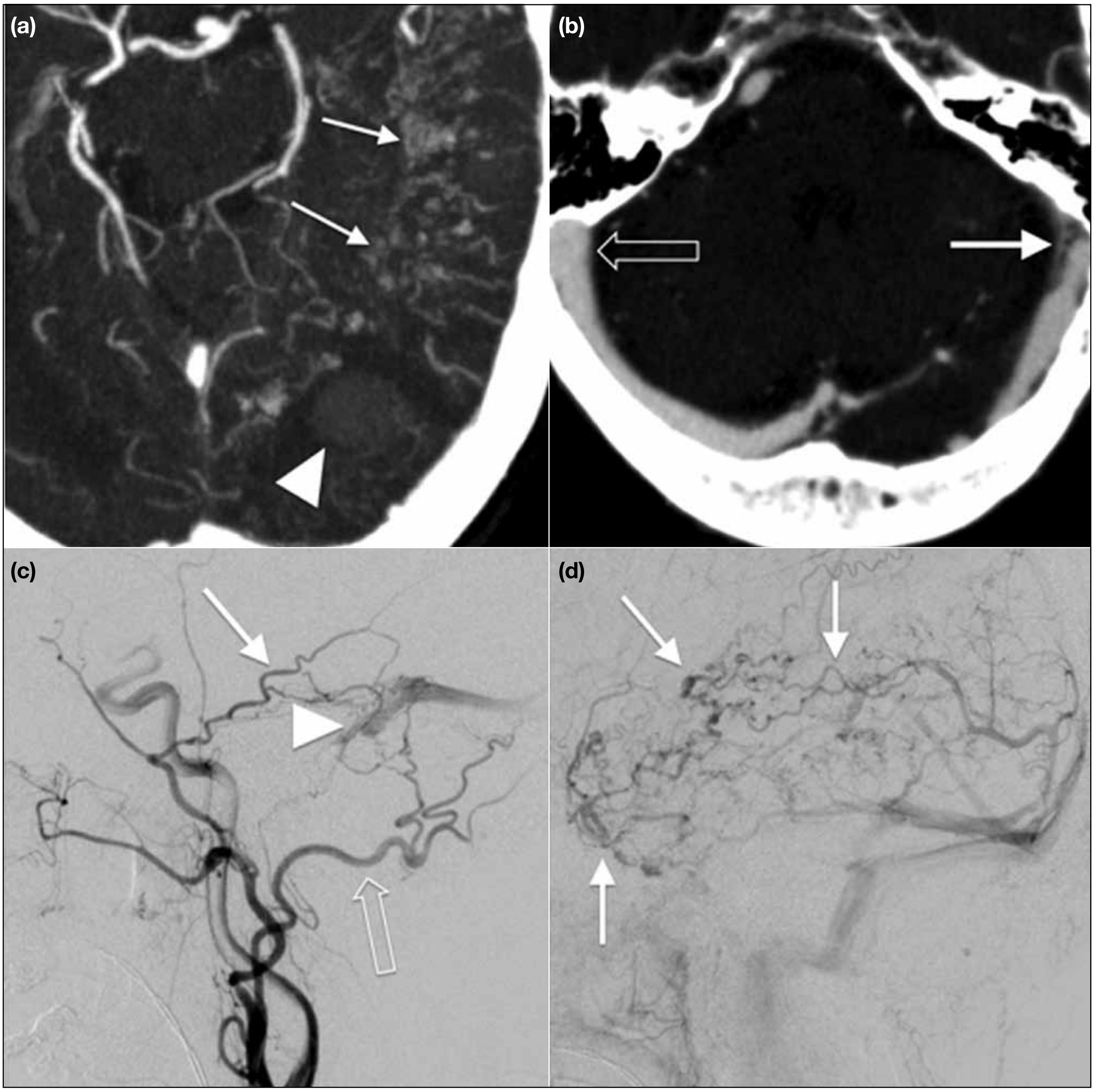

Figure 5. Dural arteriovenous fistula to the left sigmoid sinus is shown. (a) An axial computed tomographic angiography (CTA) image in maximum intensity projection shows a small intraparenchymal haematoma at the left occipital lobe (arrowhead). Multiple dilated cortical veins (arrows) are seen at the left occipito-temporal lobe, and suggest venous hypertension with cortical venous reflux. (b) An axial CTA image in maximum intensity projection shows a shaggy appearance of the left sigmoid sinus (arrow) as compared to the smooth border of the right sigmoid sinus (open arrow). (c) Arterial phase of the left external carotid artery digital subtraction angiography (DSA) in lateral projection shows a dural arteriovenous fistula to the left sigmoid sinus (arrowhead) and is supplied by branches of the left middle meningeal artery (arrow) and left occipital artery (open arrow). (d) Venous phase of the left external carotid artery DSA shows cortical venous reflux (arrows).

the resulting arteriovenous shunting (and intervening network of vessels) within the brain parenchyma lacks a true capillary bed.[8] Brain AVM is seen in CTA and DSA as an abnormal tangle of vessels in the parenchyma (Figure 3). Dilated vessels may be seen in the subarachnoid space, and represent the dilated arterial feeders or draining veins. The adjacent skull bones sometimes obscure small brain AVMs in CTA images, especially when a large haematoma is present. It is best avoided by using multiplanar assessment during interpretation (Figure 4). Although CTA lacks the ability to selectively assess each feeding vessel by super-selective injection, its ability to provide global assessment about the supplying arterial and venous drainage makes it a valuable tool for brain AVM diagnosis and pre-treatment planning (Figure 3).

DURAL ARTERIOVENOUS FISTULA

A DAVF is an abnormal connection between a dural venous sinus or a leptomeningeal vein and arteries that usually feed the meninges, bone, or muscles.[3] CTA is generally considered an insensitive imaging modality for detecting DAVFs due to the lack of the temporal resolution necessary to visualise arteriovenous shunts or venous drainage patterns.[9,10] In the literature, however, a few CTA imaging signs to identify DAVFs have been described. They are asymmetric arterial feeding vessels, shaggy appearance of a dural venous sinus, transcalvarial venous channels, and abnormal sizes and numbers of cortical veins (Figure 5).[11] Newer generation of multidetector CT scanners are capable of performing time-resolved CTA (i.e. 4D-CTA), which appears to be a valuable new adjunct in the non-invasive diagnostic work-up, treatment planning, and follow-up of patients with cranial DAVFs.[9]

MOYAMOYA DISEASE

Moyamoya disease is a chronic, occlusive cerebrovascular disease involving bilateral stenoses or occlusions of the terminal portion of the internal carotid arteries and / or the proximal portions of the anterior cerebral and middle cerebral arteries.[12] Irregular perforating vascular networks, called Moyamoya vessels, near the occluded or stenotic regions correspond to the lenticulostriate and thalamoperforate arteries that are responsible for the hazy 'puff of smoke' appearance in radiological images.[12] CTA can demonstrate Moyamoya vessels similar to those seen in DSA (Figure 6).

DEVELOPMENTAL VENOUS ANOMALY

Developmental venous anomaly (DVA), previously called venous angioma, is generally considered extreme

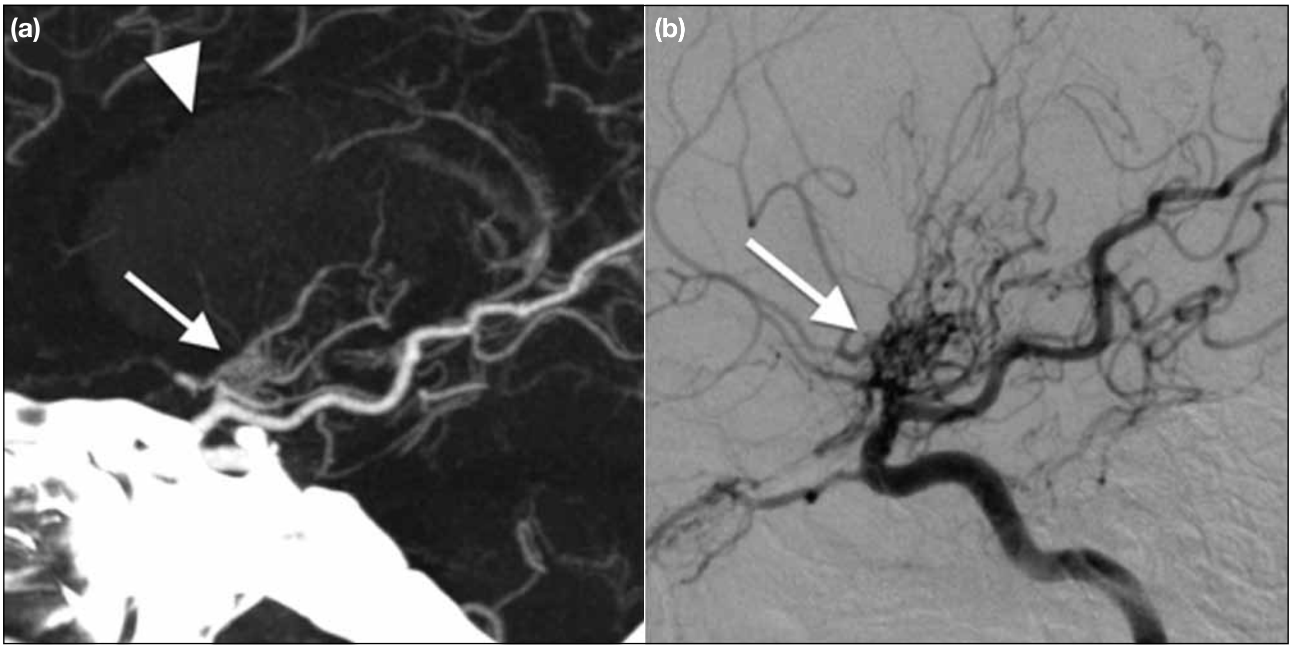

Figure 6. Features of Moyamoya disease are shown. (a) An oblique sagittal computed tomographic angiography (CTA) image in maximum intensity projection shows a 'puff of smoke' (arrow) in the basal cistern, suggestive of Moyamoya disease. A large haematoma is seen at the right basal ganglia (arrowhead). (b) Lateral projection of the right internal carotid artery confirms the diagnosis of Moyamoya disease with a similar 'puff of smoke' (arrow) at the basal cistern.

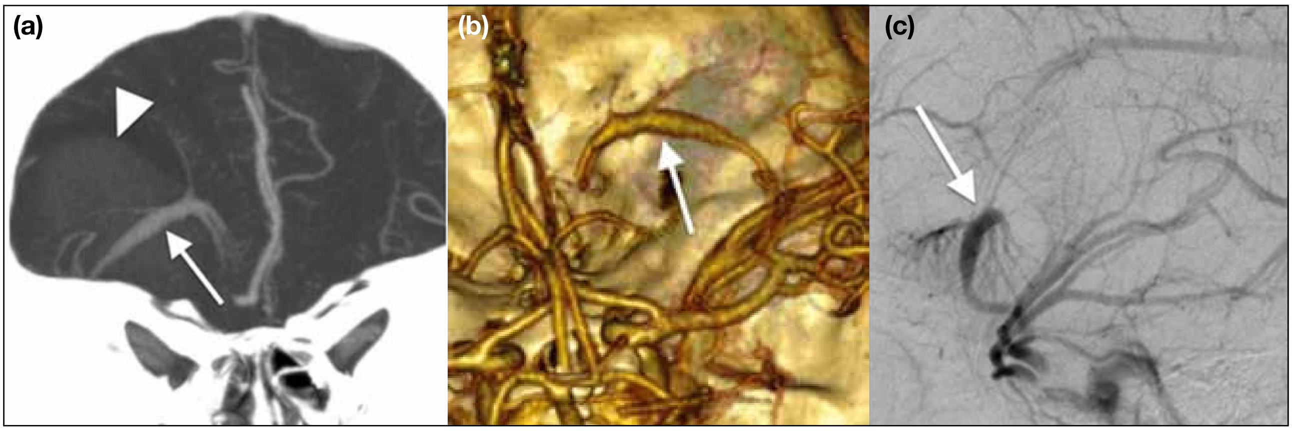

Figure 7. Right frontal lobe developmental venous anomaly is shown. (a) A coronal computed tomographic angiography (CTA) image in maximum intensity projection reveals a branching enhancing vascular structure at the right frontal lobe in the deep white matter converging on a dilated transcortical draining vein (arrow) with a typical 'medusa head' appearance compatible with a developmental venous anomaly (DVA) adjacent to an intraparenchymal haematoma (arrowhead). (b) 3D reconstruction of the CTA images viewed from above shows the developmental venous anomaly (arrow). (c) Venous phase of the right internal carotid artery digital subtraction angiography in lateral projection confirms the presence of a DVA (arrow) at the right frontal lobe.

anatomical variation of the cerebral vasculature.[13] Using CTA, it is seen as small vascular structure deep in the white matter that converges on a more dilated transcortical draining vein (Figure 7).[14] If haemorrhage is seen in DVA, there may be an associated cavernous malformation, which occurs in 13 to 40% of affected patients.[8,13] In some patients, haemorrhage can also be caused by thrombosis of the collector vein.[13]

CONCLUSION

As CTA is becoming the first line of investigation in spontaneous intracranial haemorrhage, radiologists should be familiar with the typical findings in various cerebrovascular diseases. Invasive DSA investigations should be reserved for equivocal cases or to evaluate the angioarchitecture of cerebrovascular disease before endovascular interventions.

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