CASE REPORT

Angiographic detection of cerebral cavernous malformations with C-arm cone beam CT imaging in three patients

Martin G Radvany,¹ Daniele Rigamonti,² Philippe Gailloud¹

¹Division of Interventional Neuroradiology, The Johns Hopkins University School of Medicine, Baltimore, Maryland, USA

²Department of Neurosurgery, The Johns Hopkins University School of Medicine, Baltimore, Maryland, USA

Correspondence to
Dr Martin G Radvany,
mradvan2@jhmi.edu

SUMMARY

Cerebral cavernous malformations (CMs) are typically not seen during conventional digital subtraction angiography (DSA) and are therefore classically referred to as angiographically occult malformations. We present three cases in which DSA with selective intra-arterial contrast injection in the common carotid artery and C-arm cone beam CT imaging was able to demonstrate a CM. In addition, an associated developmental venous anomaly (DVA) was present in all three cases, although detected by MRI in only one of them. In light of this finding, we suspect that the incidence of DVA associated with CM is probably higher than previously reported.

BACKGROUND

Cavernous malformations (CMs), also known as cavernomas or cryptic vascular malformations, are the second most common type of cerebral vascular malformation with an incidence of 0.4–0.8% in the general population.^{1–2} CMs are divided into a sporadic non-hereditary form and a hereditary form.³ They typically present with seizures or neurological deficits secondary to intracranial hemorrhage. Developmental venous anomalies (DVAs), formerly known as venous angiomas, are often found in association with CMs.^{4–5} Based on MRI studies, this association has been documented in approximately 25% of cases.^{6–8} While older studies used to link intracranial hemorrhage with DVAs, it is now accepted that a coexistent CM is in most cases the cause of the bleed.⁷ CMs tend to bleed more frequently when they are associated with a DVA than when they are isolated.⁶

CMs are slow-flowing lesions that are only exceptionally detected by conventional digital subtraction angiography (DSA).⁹ They have therefore classically been defined as cryptic or angiographically occult vascular malformations. Recent technological developments in flat panel technology have allowed the combination of DSA and cone beam CT (CBCT) imaging to produce high-resolution CT-like reconstructions of data sets obtained by conventional angiography techniques. In the three patients reported here, this new angiographic technique was able to document a CM and its associated DVA.

CASE PRESENTATIONS

Case 1

A 50-year-old man presented with a syncopal episode and seizure activity documented by EEG. MRI suggested the diagnosis of cerebral arteriovenous malformation (figure 1A). He was referred to

Figure 1 Case 1. A 50-year-old man presented with syncopal episode and seizure activity documented by EEG. (A) Post-contrast T1-weighted MRI demonstrates a 7 mm enhancing mass in the cortical and subcortical white matter of the right cingulate gyrus. (B) Cone beam CT demonstrates a 7 mm mass with mild enhancement with an associated developmental venous anomaly.

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our institution for further evaluation, which included DSA with CBCT (figure 1B). A standard 20 s CBCT acquisition was performed using a flat-panel angiography system (Artis zee VC13D; Siemens AG Healthcare Sector, Forchheim, Germany) while injecting the contrast agent through a 5F JB-1 diagnostic catheter selectively placed in the right common carotid artery. A mixture of 25% contrast agent (Iohexol-300, GE Healthcare, Milwaukee, Wisconsin, USA) and 75% normal saline was administered with a power injector using the following parameters: rate rise 0.5 s; flow rate 2 ml/s; total injection volume 50 ml; total volume of contrast 12.5 ml; injection duration 25 s; x-ray delay 5 s. The dataset reconstruction was performed on a

dedicated workstation (Syngo DynaCT, Siemens AG). The reconstructed dataset included 394 slices through the acquired volume, with a 512×512 matrix and isotropic voxel size of 0.46 mm^3 . High-resolution secondary reconstructions of the area of interest were then obtained with a voxel size of 0.10 mm^3 .

Case 2

A 50-year-old man presented with a generalized tonic-clonic seizure. Outside studies demonstrated a hemorrhagic lesion in the left anterior temporal region (figure 2A). A partial angiogram performed as part of this initial evaluation was unremarkable. The patient was referred for further investigation, at which time DSA was repeated along with CBCT imaging. CBCT was performed using the previously described protocol (figure 2B).

Figure 2 Case 2. A 50-year-old man presented with a generalized tonic-clonic seizure. (A) MRI demonstrates a heterogeneous mass with T1 shortening, patchy enhancement and a peripheral rim of hemosiderin staining in the left temporal lobe. (B) Cone beam CT demonstrates a mass in the left temporal region with large pockets of contrast accumulation and an associated developmental venous anomaly.

Figure 3 Case 3. A 9-year-old girl had complained of headaches since age 5. (A) T1-weighted MRI after contrast administration demonstrates a 1 cm enhancing mass in the left cingulate gyrus with an adjacent developmental venous anomaly (DVA). (B) Cone beam CT demonstrates a weakly enhancing mass with an associated DVA.

Case 3

A 9-year-old girl had complained of headaches since the age of 5. At age 7 she underwent CT, MRI/MRA and DSA at an outside institution, leading to the diagnosis of anterior cerebral artery arteriovenous fistula for which follow-up with MRI/MRA and DSA was recommended (figure 3A). She came to our institution for a second opinion at age 9, where she underwent DSA with CBCT as part of her evaluation. CBCT was performed using the previously described protocol (figure 3B).

DISCUSSION

The recent introduction of enhanced angiography techniques using CBCT imaging has significantly expanded the diagnostic capabilities of catheter-based angiography. In our three patients cerebral CMs, which are typically considered as angiographically occult lesions, were demonstrated during conventional angiography supplemented by CBCT. It is interesting to note that, in our preliminary experience, increased x-ray delay (ie, longer contrast injection) seems to enhance the conspicuity of the CMs. This finding is consistent with previous reports of venous pooling observed in CMs during angiography,⁹ and with the technique of prolonged contrast injection recommended by Rosenbaum *et al* to image lesions in the calvarium.¹⁰

In addition, CBCT demonstrated associated DVAs that were not demonstrated by MRI in two of our three cases, even when the studies were reviewed retrospectively. This finding suggests that the association between DVAs and CMs might be more common than previously thought, a notion already suggested by surgical observation.¹¹

It should be noted that this technique provides the angiographer with an additional tool for the diagnosis of CMs and does not replace MRI or conventional angiography. It does require an extra contrast injection, although the total additional contrast volume is only 12.5 ml. The added radiation dose to the patient is at this time 60 mGy, approximately that of a conventional head CT, and should be recognized and taken into account, especially in pediatric cases. Technical refinements allowing for lower dose exposure are currently in development.

Contributors MGR drafted the manuscript and participated in radiographic image analysis. DR participated in radiographic image analysis and manuscript editing. PG conceived the technique and participated in radiographic image analysis and manuscript editing.

Competing interests None.

Ethics approval The institutional IRB does not require IRB review/approval for case reports in which three or fewer cases are reported.

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Learning points

- Digital subtraction angiography (DSA) with cone beam CT (CBCT) imaging is able to detect cavernous malformations, vascular lesions that have classically been considered as angiographically occult.
- This technique also shows a high sensitivity for the detection of associated developmental venous anomalies compared with both MRI and DSA.
- DSA with CBCT imaging appears to be a useful new addition to the angiographic armamentarium for the detailed evaluation of intracranial vascular malformations.

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