CASE REPORT

Novel use of 4D-CTA in imaging of intranidal aneurysms in an acutely ruptured arteriovenous malformation: is this the way forward?

Arun Chandran, Mark Radon, Shubhabrata Biswas, Kumar Das, Mani Puthuran, Hans Nahser

Department of Neuroradiology,
The Walton Centre NHS
Foundation Trust, Liverpool,
L9 7LJ, UK

Correspondence to

Dr Arun Chandran, The Walton
Centre NHS Foundation Trust,
Liverpool L97LJ, UK; Arun.
Chandran@thewaltoncentre.
nhs.uk

Accepted 16 June 2015

SUMMARY

Ruptured arteriovenous malformation (AVM) is a frequent cause of intracranial hemorrhage. The presence of associated aneurysms, especially intranidal aneurysms, is considered to increase the risk of re-hemorrhage. We present two cases where an intranidal aneurysm was demonstrated on four-dimensional CT angiography (time-resolved CT angiography) (4D-CTA). These features were confirmed by digital subtraction angiography (catheter arterial angiogram). This is the first report of an intranidal aneurysm demonstrated by 4D-CTA. 4D-CTA can offer a comprehensive evaluation of the angioarchitecture and flow dynamics of an AVM for appropriate classification and management.

BACKGROUND

Spontaneous intracranial hemorrhage (ICH) is a serious complication of brain arteriovenous malformations (AVMs).¹ Particular AVM features increase the risk of hemorrhage, including small AVM size, posterior fossa location, associated aneurysms, and deep venous drainage.^{2,3} In particular, the presence of intranidal aneurysms correlates with a high risk of hemorrhage at presentation and during the follow-up period.⁴

Currently, three-dimensional CT angiography (3D-CTA) is used for planning and management as a primary non-invasive modality to image patients with spontaneous ICH with the suspicion of an underlying AVM.⁵ However, 3D-CTA examines only a single time point and therefore provides little information about flow dynamics, which is necessary to further assess and determine the characteristics of the AVM.

In the recent literature, 4D-CTA (time-resolved CT angiography) has been described as a new non-invasive tool in the diagnosis and follow-up of untreated AVMs with comparable results to digital subtraction angiography (DSA).^{6,7} We report two cases in whom intranidal aneurysms were demonstrated on 4D-CTA in an acutely ruptured AVM. The aim of this report is to illustrate the use of this non-invasive tool (4D-CTA) as a potential alternative to DSA in a ruptured AVM where timing of intervention is critical.

CASE PRESENTATIONS

Case 1

A 40+-year-old woman presented with sudden onset headache. On examination there was no focal

neurological deficit and the Glasgow coma scale (GCS) was 15. A non-contrast CT head examination demonstrated left ganglionic hemorrhage with intraventricular extension.

Case 2

A 30+-year-old man presented with sudden onset headache and confusion. The GCS was 14 with no other focal neurological deficits identified. A non-contrast CT head examination demonstrated left temporal intraparenchymal hemorrhage.

INVESTIGATIONS

The 4D-CTA examinations were performed on a 320-detector CT (Aquilion One, Toshiba Medical System, Japan) using a time-density curve to calculate the timing and duration of the scan. The catheter DSA was performed in a biplane angiography system (Inova, GE Healthcare, Milwaukee, Minnesota, USA).

Case 1

The left ganglionic AVM (very small nidus) with two intranidal aneurysms were identified on both 4D-CTA and DSA ([figure 1](#)). Early venous filling ([figure 1C, D](#)) was found on both modalities; however, the pattern of drainage (whether superficial or deep venous location) was difficult to delineate on 4D-CTA, which failed to grade the AVM. Deep venous drainage via the basal vein with arterial feeders from the medial thalamostriate perforators was demonstrated on DSA.

Case 2

The left temporal plexiform AVM with middle cerebral and posterior cerebral arterial feeders and deep venous drainage via the basal vein into the internal cerebral vein was demonstrated on both 4D-CTA and DSA. There were three intranidal aneurysms ([figure 2](#)), but 4D-CTA could only demonstrate two ([figure 2A, B](#)), one in the anterior and the other in the central part of the nidus. DSA additionally revealed a third nidus aneurysm ([figure 2E](#)) in the posterior aspect. This could only be identified retrospectively with low confidence on the 4D-CTA ([figure 2D](#)).

Thus, a total of four intranidal aneurysms were demonstrated on 4D-CTA on prospective review as opposed to five on DSA. 4D-CTA therefore potentially missed an intranidal aneurysm during prospective review although it could be seen retrospectively ([figure 2D](#)).

CrossMark

To cite: Chandran A,
Radon M, Biswas S, et al.
BMJ Case Rep Published
online: [please include Day
Month Year] doi:10.1136/
bcr-2015-011784

Figure 1 Coronal (A) and sagittal oblique (B) whole-brain subtracted maximum intensity projection (MIP) reconstructions showing two intranidal aneurysms (white arrows). Mid-arterial phase 10 mm unsubtracted sagittal MIP reconstruction showing aneurysms (white arrows) and early venous filling (black arrow). Mid-arterial phase frame from intra-arterial digital subtraction angiography showing aneurysms (white arrows) and venous shunting (black arrow).

OUTCOME AND FOLLOW-UP

Case 1

The nidal aneurysms showed spontaneous resolution during the planning stereotactic radiosurgery (SRS) DSA at 4-month intervals. The SRS was therefore abandoned as there was no

definable nidus for target localization except for subtle early venous filling. Complete spontaneous resolution of the early venous filling and the AVM was seen at the 12-month follow-up DSA. In view of the spontaneous resolution of the aneurysms, they were considered to be pseudoaneurysms.

Figure 2 Coronal (A) and sagittal oblique (B) whole-brain subtracted maximum intensity projection (MIP) reconstructions showing two intranidal aneurysms (white arrows). (C) Mid-arterial phase 10 mm unsubtracted sagittal MIP reconstruction showing aneurysms (white arrows) and early venous filling (black arrow). (D) Mid-arterial phase frame from intra-arterial digital subtraction angiography showing aneurysms (white arrows) and venous shunting (black arrow). (E) Lateral projection of vertebral artery injection at intra-arterial DSA showing posterior aneurysm (arrow).

Figure 3 (A) Lateral projection of internal carotid artery injection at follow-up intra-arterial digital subtraction angiography (DSA) showing resolution of the previously detected anterior aneurysm, but the presumed middle aneurysm remains visible (arrow). (B) Lateral projection of vertebral artery injection at intra-arterial DSA showing resolution of the posterior aneurysm (arrow, representing previous location). (C) Superselective angiogram at follow-up showing that the middle aneurysm was a foot of a draining vein (arrow).

Case 2

During the follow-up DSA at 4 months, the previously diagnosed nidal aneurysms could be characterized on the appearance

and flow pattern. The anterior and posterior intranidal aneurysms were considered to be pseudoaneurysms secondary to hemorrhage as these were not shown on subsequent angiography (figure 3A, B). At the same time, the centrally located aneurysm was found not to be a true aneurysm, but misinterpretation of the foot of a draining vein confirmed on superselective angiography (figure 3C).

In both of our cases the intranidal aneurysms were not amenable to endovascular treatment secondary to perforator and en passage supply to the nidus, so conservative management was adopted.

DISCUSSION

4D-CTA has gained increasing use in cerebrovascular imaging in recent years.^{6 7} DSA remains the gold standard for the evaluation of cerebral vasculature due to its high temporal and spatial resolution compared with other modalities. However, its invasive nature, time and resource requirements are disadvantages.⁸

Following rupture of an AVM, the presence of intranidal aneurysms is believed to increase the risk of re-hemorrhage.^{9 10} Angiographically detected intranidal aneurysms following hemorrhage may represent two distinct pathologies: a true aneurysm (arterial/venous), present prior to the hemorrhage, which has proven histological confirmation of thin-walled vascular architecture on resection specimens;⁹ or a pseudoaneurysm secondary to rupture of thin-walled vessels.¹⁰

The diagnosis of pseudoaneurysm was considered based on angiographic progression (disappearance) of the previously identified intranidal aneurysms without histologic confirmation.¹⁰

Table 1 Spetzler–Martin classification and re-hemorrhage risk factors

AVM variables for classification	Response	4D-CTA	DSA
Early venous filling (AV shunt)	Yes/No	2	2
Brain AVM diagnosed	Yes/No	2	2
Spetzler–Martin grade			
Size			
<3 cm		1	1
3–6 cm		1	1
>6 cm		0	0
Eloquence			
Non-eloquent		0	0
Eloquent		2	2
Drainage			
Superficial		0	0
Deep		1*	2
Major arterial feeders identified	Yes/No	2	2
Re-hemorrhage risk factors			
Intranidal aneurysms	Yes/No	4	5
Venous stenosis	Yes/No	0	0
Flow-related aneurysms	Yes/No	0	0
High flow shunts	Yes/No	0	0

*In the ganglionic AVM the drainage pattern was difficult to interpret due to low temporal resolution compared with DSA and crowding of the vasculature due to non-selective opacification.

4D-CTA, four-dimensional CT angiography; AVM, arteriovenous malformation; DSA, digital subtraction angiography.

There is no current robust literature evidence to suggest whether pseudoaneurysms have a lower risk of re-hemorrhage than a true intranidal aneurysm.

In our cases, four of the five intranidal aneurysms were considered to be pseudoaneurysms and one was a misinterpretation of a draining vein, evident on follow-up superselective angiography.

We were able to demonstrate the application of a non-invasive modality that can be a potential alternative to DSA in evaluating an acutely ruptured AVM (table 1). We believe that the ability to select the optimal phase of contrast from the dynamic 4D-CTA dataset is advantageous in diagnosing intranidal aneurysms because the phase can be selected for the optimal balance of arterial and nidus filling. A further prospective study is needed to validate our findings for wider application.

Learning points

- Four-dimensional CT angiography (4D-CTA) is a novel non-invasive tool in the evaluation of an acutely ruptured AVM.
- 4D-CTA could be a potential alternative in an unstable patient where digital subtraction angiography (DSA) is not readily available.
- 4D-CTA could expedite the management of an acutely ruptured AVM by bypassing a diagnostic DSA prior to intervention.

Contributors AC wrote and reviewed the manuscript. SB, MR, KD, MP and HN reviewed the manuscript and helped in the preparation of the manuscript.

Competing interests None declared.

Patient consent Obtained.

Ethics approval Ethics approval was obtained from the Institutional Review Board.

Provenance and peer review Not commissioned; externally peer reviewed.

REFERENCES

- 1 Al-Shahi R, Warlow C. A systematic review of the frequency and prognosis of arteriovenous malformations of the brain in adults. *Brain* 2001;124(Pt10):1900–26.
- 2 Meisel HJ, Mansmann U, Alvarez H, et al. Cerebral arteriovenous malformations and associated aneurysms: analysis of 305 cases from a series of 662 patients. *Neurosurgery* 2000;46:793–800.
- 3 Langer DJ, Lasner TM, Hurst RW, et al. Hypertension, small size, and deep venous drainage are associated with risk of hemorrhagic presentation of cerebral arteriovenous malformations. *Neurosurgery* 1998;42:481–6.
- 4 Redekop G, TerBrugge K, Montanera W, et al. Arterial aneurysms associated with cerebral arteriovenous malformations: classification, incidence, and risk of hemorrhage. *J Neurosurg* 1998;89:539–46.
- 5 Gross BA, Frerichs KU, Du R. Sensitivity of CT angiography, T2-weighted MRI, and magnetic resonance angiography in detecting cerebral arteriovenous malformations and associated aneurysms. *J Clin Neurosci* 2012;19:1093–5.
- 6 Willems PW, Taeshineetanakul P, Schenk B, et al. The use of 4D-CTA in the diagnostic work-up of brain arteriovenous malformations. *Neuroradiology* 2012;54:123–31.
- 7 Wang H, Ye X, Gao X, et al. The diagnosis of arteriovenous malformations by 4D-CTA: a clinical study. *J Neuroradiol* 2014;41:117–23.
- 8 Kaufmann TJ, Huston J III, Mandrekar JN, et al. Complications of diagnostic cerebral angiography: evaluation of 19,826 consecutive patients. *Radiology* 2007;243:812–19.
- 9 Marks MP, Lane B, Steinberg GK, et al. Intranidal aneurysms in cerebral arteriovenous malformations: evaluation and endovascular treatment. *Radiology* 1992;183:355–60.
- 10 Garcia-Monaco R, Rodesch G, Alvarez H, et al. Pseudoaneurysms within ruptured intracranial arteriovenous malformations: diagnosis and early endovascular management. *AJNR Am J Neuroradiol* 1993;14:315–21.

Copyright 2015 BMJ Publishing Group. All rights reserved. For permission to reuse any of this content visit <http://group.bmj.com/group/rights-licensing/permissions>.
BMJ Case Report Fellows may re-use this article for personal use and teaching without any further permission.

Become a Fellow of BMJ Case Reports today and you can:

- Submit as many cases as you like
- Enjoy fast sympathetic peer review and rapid publication of accepted articles
- Access all the published articles
- Re-use any of the published material for personal use and teaching without further permission

For information on Institutional Fellowships contact consortiasales@bmjgroup.com

Visit casereports.bmj.com for more articles like this and to become a Fellow