Case study

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Giant cerebral aneurysm: 3D computed tomography angiography *vs.* rotational 3D digital subtraction angiography

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Abstract The purpose of writing this case study was to compare the accuracy of computed tomography angiography (CTA) and 3D rotational digital subtraction angiography (3D DSA) in demonstrating a giant cerebral aneurysm and its relationship to the parent artery. The patient was a 36-year-old female who presented to our department with a suspected cerebral aneurysm as seen on a non-contrast computerised tomography (CT) brain scan. The CTA and 3D DSA were performed on consecutive days and both demonstrated a giant aneurysm arising from the right posterior cerebral artery. A series of 3D images were produced from both modalities, with each possessing sub-millimeter spatial resolution. After comparison between the two 3D data sets, it was evident that the 3D DSA was superior in delineating the relationship between the aneurysm and its parent artery. The CTA suffered from partial voluming in this area and it seemed as though a connection was present between the aneurysm and posterior cerebral artery distal to the aneurysm neck. Based on the CTA alone, an incorrect report would have resulted. Surgery later confirmed the absence of this connection and, thereby, proved that 3D DSA was more accurate in the visualisation of this patient's aneurysm. Treatment for this patient could therefore be planned more confidently based on the 3D DSA findings.

Keywords: Aneurysm, CT angiography, rotational 3D digital subtraction angiography.

Introduction

This case study review is of a 36-year-old female with a large right posterior cerebral artery (PCA) aneurysm who presented for a computed tomography (CT) brain examination following facial nerve palsy-like symptoms. The CT scan demonstrated a large posterior circulation aneurysm, measuring approximately 3 cm in size. As a result of these findings, further investigations were performed, including a cerebral angiogram – together with 3D rotational digital subtraction angiography (3D DSA) – and a CT angiogram of the Circle of Willis (CTA COW). The purpose of writing this case study was to compare the accuracy of CTA and 3D DSA in demonstrating the aneurysm and the surrounding vasculature.

Digital subtraction angiography represents the gold standard for the evaluation of intracranial aneurysms[1] and, when combined with 3D DSA, is the criterion standard method for detecting aneurysms.[2] There are two other modalities that are widely used to detect cerebral aneurysms, CTA and magnetic resonance angiography (MRA). Both have similar diagnostic performance in detecting cerebral aneurysms,[3] but CTA is more appropriate in an emergency setting due its quicker scan time and lack of safety restrictions for patients (pacemaker, aneurysm clip, etc.)

The results of these examinations confirmed two things. First, the diagnosis of a giant aneurysm arising from the proximal portion of the right posterior cerebral artery (PCA) and second, that 3D DSA was superior to CTA in the depiction of the aneurysm and surrounding arterial vasculature. According to Rooij *et al.*,[4] cerebral aneurysms arising from the posterior cerebral arteries are rare, with an incidence of about 1–2% of all types of aneurysms. Clinical presentation is variable and can consist of a combination of sub-arachnoid haemorrhage, visual field deficit and occulomotor palsy.[4] No issues or complications arose from either procedure.

Method

CT Angiography of the Circle of Willis

The CTA COW was performed on a 16-slice Siemens Somatom Sensation (Germany). Non-contrast helical scans were first performed from the carotid bifurcation to 2 cm below the skull vertex. These scans were performed to obtain the correct level for the test bolus, to detect any calcification within the arteries and to enable subtraction to be performed once the dynamic run was completed. A baseline level was then chosen for the test bolus at the site of the basilar and middle cerebral arteries. The scanning parameters were: 100 kVp, effective mA 200, 0.75 mm collimation, 0.5 second gantry rotation time and 15 mm table feed per rotation. The reconstruction interval was set to 0.4 mm with a soft reconstruction kernel.

Although some centres use a set time delay (15–20 seconds) to achieve optimal arterial opacification,[2,3,5] other institutions[6,7] adopt a test bolus or timing run for each individual patient. Our department employs the latter technique, ensuring dynamic scanning during peak intraluminal contrast attenuation. Villablanca *et al.*[6] emphasised the importance of avoiding set delays and stated that timing runs and peak opacification-sensing software should always be used.

In order to achieve this, 10 mL of intravenous Ultravist® 370 (Iopromide 76.9%) was delivered at a rate of 5 mL per second

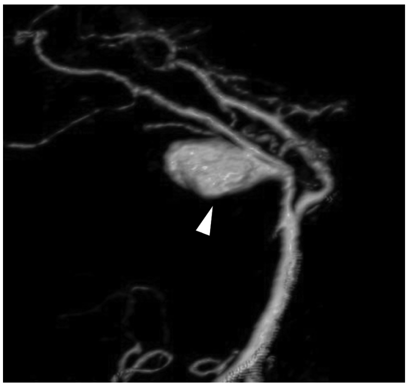

Figure 1 3D RAO image from the CTA COW demonstrating the large right PCA aneurysm (arrowhead).

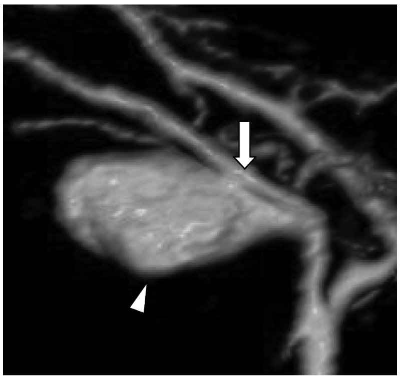

Figure 2 Magnified view of Figure 1 showing the apparent connection (arrow) between the aneurysm (arrowhead) and right PCA.

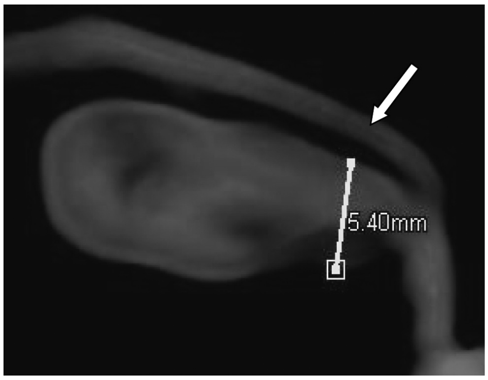

Figure 3 Lateral projection from the 3D DSA indicating the absence of any connection between the aneurysm and the right PCA (arrow). Measurement gives an indication as to the large size of the aneurysm.

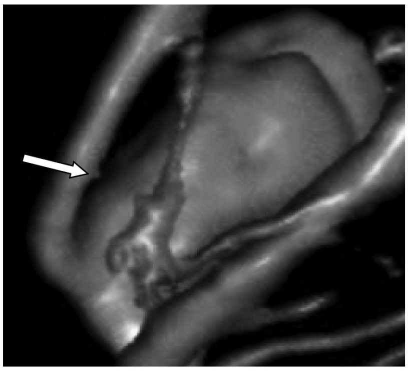

Figure 4 Lateral projection from the 3D DSA again demonstrating the absence of any connection (arrow) between the posterior cerebral artery and the aneurysm.

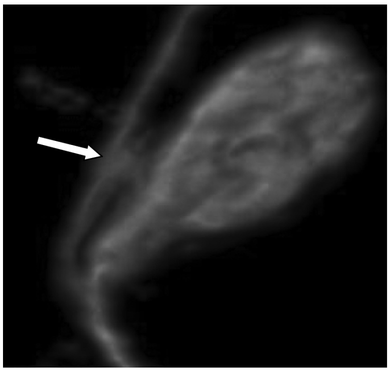

Figure 5 CTA COW in the same projection as Figure 4. Apparent connection between posterior cerebral artery and aneurysm (arrow).

followed by a 50 mL saline flush, also at 5 mL per second. The baseline level was then scanned at a rate of one image per second for 25 seconds. These images were then loaded into a software program known as Dynamic Evaluation that generated a time-intensity curve to give the optimum delay for the dynamic run.

The dynamic contrast-enhanced sequence was then performed using the delay calculated from the time-intensity curve and 0.75 mm slices were acquired from 2 cm below the vertex to below the carotid bifurcation (same scanning parameters as pre-contrast images). 50 mL of Ultravist® 370 (Iopromide 76.9%) at a rate of 5 mL per second was used for the dynamic injection, followed by 50 mL of saline, also at 5 mL per second. The field-of-view (FOV) for the scan included the entire brain and anterior neck. Excellent opacification of the cerebral arterial circulation occurred. This protocol is in keeping with standard cerebral CTA examinations.[6,7]

3D Rotational Angiography

Prior to the 3D rotational sequence, bilateral common carotid and vertebral artery angiography was performed to confirm the presence of the aneurysm as well as to check for any others within the cerebral circulation. None were found. Following this, the 3D rotational acquisition was performed. Images were acquired with the C-arm rotating 200° around the patient's head with a rotation speed of 40° per second (five second rotation time).

Firstly, a set of mask images was acquired, followed by a series of live, contrast-enhanced images. For the 3D acquisition, 12 mL of Ultravist® 240 (Iopromide 49%) was administered at 2 mL per second via a power injector. Following subtraction of the two data sets, the resultant images were then sent to a Siemens Syngo workstation, where a 3D model of the left vertebral artery, basilar artery and aneurysm was obtained. Excellent opacification of the basilar artery and aneurysm was achieved.

Results

Following review of the 3D images from both modalities, the 3D DSA was found to be more accurate than the CTA COW with regard to the relationship of the aneurysm to the surrounding arterial circulation. In particular, it was not entirely clear on the 3D CTA COW if the right PCA was connected to the antero-lateral margin of the aneurysm (Figures 1 and 2) distal to the aneurysm neck. On thin-section maximum-intensity projection (MIP) images (0.75 mm thick), it was also difficult to assess a possible connection between these two structures. These results made it difficult for the radiologist to give an accurate report and, based on these findings alone, would have lead to an inaccurate assessment.

On the 3D DSA however, it was clearly evident that there was no connection between these two structures (Figures 3 and 4) and this was later confirmed at surgery. The rotational sequence thereby provided a more exact assessment of the relationship between the aneurysm neck and the proximal right PCA. Treatment for this patient could therefore be accurately planned knowing the exact anatomic layout.

After discussion between the neuroradiologist and neurosurgeon and reviewing of the relevant images, the patient went to surgery to have the aneurysm clipped. The clipping was successful and the patient was subsequently discharged 11 days later.

For the CTA COW, the 0.75 mm helical slices were used to create the 3D model for viewing on the workstation. For the 3D DSA sequence, the voxel size was 0.535 mm, clearly superior to the CTA. Although both modalities had sub-millimeter spatial resolution, only the 3D DSA could resolve the small distance (~1–1.5 mm) between the right PCA and the aneurysm (Figures 4 and 5).

Discussion

3D rotational angiography is the latest development in the neurovascular imaging field. It combines the 3D visualisation capabilities previously offered only by CT and magnetic resonance imaging (MRI) with the anatomic resolution of DSA.[8] The findings in this case reflect current literature. Studies have shown that both CTA and 3D rotational angiography are highly sensitive in detecting cerebral aneurysms.[2,5,9,10] In a study of 100 patients who underwent cerebral CTA followed by either DSA or surgery, Teksam *et al*.[2] concluded that although cerebral CTA had a high sensitivity for detecting aneurysms, it was not sensitive enough to replace DSA, particularly for smaller (< 3 mm) aneurysms.

Advantages of DSA over CTA include its higher spatial resolution and temporal imaging capabilities.[10] However, there are other advantages, such as the lack of venous contamination and the ability to proceed to endovascular treatment (e.g. coiling) under certain circumstances. The disadvantages of DSA are also well documented. They include: high degree of invasiveness, relatively high cost and skill level to perform and risk of permanent neurologic deficit.[3]

The advantages of CTA over DSA include: reduced invasiveness, faster scan time, and, since subarachnoid haemorrhage is usually diagnosed on CT, the CTA acquisition can be performed without a large penalty in examination time.[1]

In a study by Karamessini *et al.*,[10] the authors found that cerebral CT angiography was equally sensitive to DSA in the detection of intracranial aneurysms > 3 mm. It also exhibited a 100% detection rate in anterior communicating and middle cerebral artery bifurcation artery aneurysms. This study, however, did not include a comparison with rotational angiography and the authors did comment on the fact of lower sensitivity of CTA in detecting aneurysms < 3 mm.

It is interesting to note that this case study compared 3D DSA and CTA with a large (~ 3 cm) aneurysm. Studies often include the ability of each modality to detect small aneurysms (≤ 3 mm), with spatial resolution being a major factor. In this study, obviously neither modality missed the aneurysm, but only 3D DSA could resolve the small gap between the aneurysm wall and the proximal PCA. A theory put forward by one of our radiologists was that because of the large size of the aneurysm, flow artifact could have caused the apparent connection seen in Figures 2 and 5.

Conclusion

Undeniably, 3D rotational angiography has proved to be an extremely helpful addition to the neuroimaging field, particularly in assessing cerebral aneurysms. It assists both neuroradiologists and neurosurgeons in viewing the anatomic layout prior to intervention in detail previously unseen with any other imaging technique. As a result of this, decisions can be made regarding endovascular or surgical treatment with a degree of accuracy never achieved before.

Computed tomography angiography has also proved very sensitive in the detection of cerebral aneurysms. It is a fast, non-invasive method of visualising the cerebral arterial circulation, with multi-planar reconstructions and 3D data sets available in a short space of time. Although both modalities offer sub-millimeter spatial resolution, the case study presented here demonstrates the superior clarity and accuracy of 3D DSA over cerebral CTA.

Further comparison between CTA and 3D DSA, particularly on a larger patient cohort, would be useful to more accurately determine the ability of each modality in depicting cerebral aneurysms.

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