CT angiography and its role in the investigation of intracranial haemorrhage

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Introduction

Spontaneous intracranial haemorrhage constitutes only 15% of acute stroke but remains the most devastating form, with a death and severe disability rate of more than 75%. Prompt identification of a structural vascular abnormality, or lack of it, is a major factor in improving the clinical management of these patients and ultimately their outcomes.

Digital subtraction angiography (DSA) has been the gold standard imaging technique allowing for a detailed assessment of the circle of Willis. However, it is an invasive examination carrying significant risks (1% stroke rate) to the patient, is time consuming and requires a certain level of experience limiting its availability. The wide availability of CT angiography, on the other hand, coupled with the introduction of multi-detector row CT angiography (MDCTA) and the improved post-processing techniques, has resulted in an increased use of CTA as an imaging tool for the assessment of the intracranial vascular structure.

CT angiography techniques and role

CT angiography is proving to be a suitable alternative method of assessing the cerebral vessels. This is due to its non-invasive nature, lower radiation dose, wide availability and the ability to perform the examination in conjunction with non-contrast CT. The introduction of multi-detector row CT angiography has revolutionised the CTA technique with its quicker acquisition times and improved post-processing image quality.

Following image acquisition, the volumetric data is transferred to a working station for further processing. In our institution this includes multi-planar reformation (MPR) with 1mm thickness in multiple planes, thin slab maximum intensity projections (MIP) and volume rendered technique (VRT) algorithm. A systematic and thorough approach is adopted in reviewing all the images.

The main role of CTA is to identify the culprit vascular lesion and assess treatment options. With respect to aneurysms, this is achieved by examining the following features: size, shape, location in relation to the haemorrhage, calcification, number of vessels involved and the presence of any other lesions or anatomical variants.

Subarachnoid haemorrhage

In our institution, once an unenhanced CT has demonstrated subarachnoid haemorrhage (SAH), a CTA is usually acquired in the same setting, saving the patient and the medical team an extra visit to the radiology department. Intracranial aneurysms are responsible for most cases of SAH, approaching 90%. In addition to identifying the aneurysm, the radiologist should look for certain features including location of the aneurysm in relation to the blood (figure 1), neck size, number of vessels incorporated within the aneurysm and the presence of vasospasm. Occasionally, in the presence of multiple aneurysms, it might not be possible to identify the culprit lesion and the neuro-interventionist will need to treat more than one lesion (figure 2).

Many authors have published data indicating the high sensitivity and specificity of CTA in detecting acutely ruptured intracranial aneurysms. Using MDCTA, Agid et al quote a 98% sensitivity and 100% specificity for the detection of aneurysm. Similar results are also published by Sideman, Lourence and Byyny. A meta-analysis by Westerlaan et al showed a specificity of 99% for ruptured aneurysms and a sensitivity of 92%. Despite these impressive rates, CTA lags slightly behind conventional DSA and can occasionally yield false negatives, especially in cases of tiny aneurysms measuring less than 2mm and ones that are close to bony structures.

In late SAH presentation, the accuracy of unenhanced CT and lumbar puncture sensitivity and accuracy drop significantly. CTA is a very powerful tool in assessment of this subgroup of patients. A negative unenhanced CT and CTA can exclude aneurysmal SAH with a post-test probability of 99%.

As interpretation is user dependent, technological advances coupled with increased familiarity with the investigation should yield greater detection rates. A systematic approach to assessing the arterial tree, its branches and Table 1

CT angiography to aneurysm therapy chart.

CT confirms SAH

Examination reviewed by neuroradiologist assessing for: presence of aneurysm and the treatment options

Endovascular Embolisation
Or surgical clipping

•Proceed to CTA directly

•If CT +ve but CTA –ve, consider DSA

Table 1

CT angiography to aneurysm therapy chart.
MIPs in three orthogonal planes with different post-processing techniques should be implemented to ensure aneurysm detection.

**Arteriovenous vascular malformation**

AVM are another well-recognised cause of SAH and intracerebral haemorrhage. The main modality for imaging these abnormalities is DSA as it allows for dynamic assessment. However, when an AVM is encountered on CTA, certain radiological features should be actively assessed to try and stratify the risk of recurrent haemorrhage. Venous pouches or intra-nidal aneurysms (figure 3) confer a higher risk for AVM rupture and can cause a diagnostic dilemma due to their wide range and locations; hence identification of these lesions is essential.

Sanelli et al. demonstrated that, while DSA remains the gold standard, CTA has an important role to play in the initial diagnostic vascular assessment. CTA can assess both arterial supply of the nidus as well as its venous drainage, and is also useful in stereotactic localisation. A recent study showed that CTA was more sensitive (87%) than MRI and MRA (83% and 87% respectively) at identifying ruptured AVMs, and that sensitivity was 100% for AVMs larger than 3cm. They also showed that associated aneurysms were best detected with CTA, compared to these other imaging modalities.

Although conventional cerebral angiography remains the modality of choice for the diagnosis of dural arteriovenous fistula, CTA can be useful with certain imaging features suggestive of the diagnosis. For example, tortuous feeding vessels with a basal ganglionic haemorrhage, the yield of further investigation values of the spot sign. It is important to remember that the spot sign is mainly used in primary intracranial haemorrhage where an underlying structural abnormality is not identified. In addition to the obvious exclusion of grafting, wide availability and lower dose when compared with DSA. In addition, when reviewed by an experienced operator (figure 5), CTA is a highly sensitive and specific investigation and should be used as a gatekeeper limiting the need for DSA.

**References**

Figures 1A and 1B
(A) Unenhanced CT brain showing predominantly posterior fossa haemorrhage suggesting a posterior circulation aneurysm. (B) CTA confirms a tiny left posterior inferior cerebellar artery aneurysm (2mm).

Figures 2A and 2B
Axial (A) and coronal (B) CT angiography images demonstrating multiple vascular abnormalities.
1. AVM in the left temporal region.
2. Left middle cerebral artery aneurysm, this is the culprit abnormality given the surrounding hematoma (red arrow).
Figures 3A, 3B, 3C and 3D
(A) Unenhanced CT brain demonstrating large intraventricular haemorrhage and a small adjacent left corona radiata haemorrhage. (B) CTA reveals a large left frontal AVM. (C) CTA also show a tiny aneurysm intimately related to the parenchymal haemorrhage. (D) 3D reconstructed images of a conventional angiogram showing the aneurysmal lesion within the AVM.

Figures 4A and 4B
(A) CTA showing a right cerebellar tortuous vessels and, interestingly, the right temporal artery is enlarged raising concerns for a dural fistula. (B) Conventional cerebral angiogram confirming a dural arteriovenous fistula.
Figures 5A-D
CT and initially CTA was interpreted as negative.

**Figure 5E**
Conventional cerebral angiogram showing aneurysm in the right distal internal carotid artery.

**Figure 5F**
On retrospective review of CTA, the lesion was present but difficult to see.