Original Article

Multi-detector Computer Tomography Angiography in the Initial Assessment of Patients Acutely Suspected of Having Intracranial Aneurysm Rupture

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Abstract

Introduction: Multi-detector computer tomography angiography (CTA) provides a fast non-invasive assessment of the cerebral vessels, is readily available in an acute setting and can potentially replace invasive digital subtraction angiography (DSA) for the diagnosis of intracranial vascular lesions in an emergency setting. We report our experience in the use of emergent cerebral CTA versus DSA in the assessment of patients presenting acutely with symptoms suspicious of brain aneurysm rupture. Materials and Methods: Thirty-seven consecutive patients presenting acutely with clinical suspicion of brain aneurysm rupture were evaluated over a 4-month period from January to April 2008. CTA with peripheral intravenous contrast injection was performed on a 32 slice helical scanner. DSA was performed within 48 hours for all cases when CTA was the initial assessment. Studies were assessed via radiology reports using DSA or surgery as the gold standard. Results: All except for 3 patients had CTA as the initial study. There were 26 cerebral aneurysms detected by CTA in these 37 patients, with 9 negative studies. There were 2 patients with arteriovenous malformations (AVM), 1 with AV fistula (AVF), 1 tumoral bleed, 2 vertebral dissections, and 1 missed sagittal sinus thrombosis (CVT) on CTA. Based solely on CTA assessment, 3 patients had direct surgical clipping of the aneurysm, while 4 proceeded to direct endovascular coiling. Conclusion: Emergent CTA is a non-invasive, reliable and viable alternative to emergent DSA for the assessment of the cerebral vessels in the acute assessment of patients presenting with symptoms suspicious of brain aneurysm rupture. Where positive, it can serve as a guide to therapeutic decisions. Review of CTA source data is essential, especially for small lesions and for post-clipping assessment.

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Key words: Digital subtraction angiography, Intracranial aneurysms, Multi-detector computer tomography angiography

Introduction

Digital subtraction angiography (DSA) has historically been considered the standard of reference in the diagnostic evaluation of patients acutely suspected of having intracranial aneurysm rupture.[1] However, DSA is an invasive, resource intensive and costly procedure, which may not be readily available on a 24-hour basis. It is also associated with a small but definite risk of complications such as stroke.[2-4] On the other hand, multi-detector computer tomography angiography (CTA) provides a fast non-invasive assessment of the cerebral vessels, is readily available in an acute setting and can be easily performed immediately after the initial diagnostic computed tomography (CT) scan. CTA allows for rapid diagnosis and treatment planning and can potentially replace invasive DSA in an emergency.[5-12] We report our experience in the use of emergent cerebral CTA versus DSA in the assessment of patients presenting acutely with symptoms suspicious of brain aneurysm rupture.

Materials and Methods

Patients

Between January and April 2008, 37 consecutive patients presenting acutely with clinical suspicion of brain aneurysm rupture were studied. There were 22 males and 15 females with ages ranging between 16 and 76 years (mean age, 60).

Clinical Presentation

Analysis of clinical data revealed that all patients presented acutely, and headache was the most common presenting

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symptom. Other presenting symptoms were giddiness, 3rd nerve palsy, drowsiness, sudden loss of consciousness or focal neurological deficits.

Multi-detector Computer Tomography Angiography (CTA)

CTA with peripheral intravenous (IV) contrast injection was performed on a 32 slice helical scanner (Lightspeed VCT 32, GE Healthcare, Milwaukee, Wis, USA). All CT images were diagnostic, and there were no technical failures or complications during scanning. Parameters for the CT angiographic acquisition were 0.625-mm section thickness, 0.3-mm section interval, 140 kVp and 400 mAs, 0.4 sec/rotation. Non-enhanced CT brain was performed first and was followed by contrast enhanced CT angiography, with a post-contrast CT brain scan. For CTA, 80 mL IV contrast (Omnipaque 350, Amersham Health, Oslo, Norway) was injected IV at a rate of 4 mL/sec followed by saline chase of 30mL at a rate of 2 mL/sec using a power injector (Stellant, Medrad Inc, Pa, USA) via an 18-gauge catheter positioned in the antecubital vein. A bolus tracking method (Smart Prep) was used to monitor the optimal contrast enhancement with the monitoring ROI placed within the pulmonary trunk, with the scan manually started when a 100 Hounsfield Unit (HU) density threshold is exceeded.

3-D Reconstruction and Post-processing

Volumetric CTA source data were post-processed on a workstation (GE Advantage Windows Version 4.2, Milwaukee, Wis, USA) with both volume-rendering technique (VR) and maximum intensity projections (MIP) after automatic segmentation of a pre-contrast dataset.

DSA Procedure

DSA was performed transfemorally in all patients, using a 4 F or 5 F H1 catheter (Cook Bloomington Inc, USA) and/or Sidewinder 2 catheter (Terumo Corporation, Japan), within 48 hours for all cases when CTA was the initial assessment, by using a bi-plane DSA unit (Advantx, GE Medical Systems, Milwaukee, Wis, USA), using an imaging matrix of 1024 X 1024 pixels. Bilateral selective internal carotid artery injections were acquired and either unilateral or bilateral vertebral artery or external carotid artery injections were also obtained, as necessary. For each vessel, 6 mL to 8 mL of nonionic contrast medium (Omnipaque 350, Amersham Health, Oslo, Norway) was injected at a rate of 4 mL/s to 6 mL/s using a power injector (Medrad Inc, Pa, USA). In all patents, standard anteroposterior and lateral projections were obtained for the carotid and vertebral injections. If an abnormality was suspected on the standard angiograms, additional oblique projections and/or 3 dimensional rotational angiography (20 mL of contrast at 5 mL/s) were also obtained. Subtracted rotational angiography data were post-processed on a workstation (GE Advantage Windows Version 4.2, Milwaukee, Wis, USA) with volume-rendering technique.

Image Interpretation

Studies were assessed via radiology reports using DSA or surgery as the gold standard. The CT angiogram images were further reviewed independently by 1 fellow neuroradiologist (SM) and 1 senior neuroradiologist (SYY), with disagreements resolved by consensus. DSA images were similarly interpreted by 2 neuroradiologists (SM and SYY).

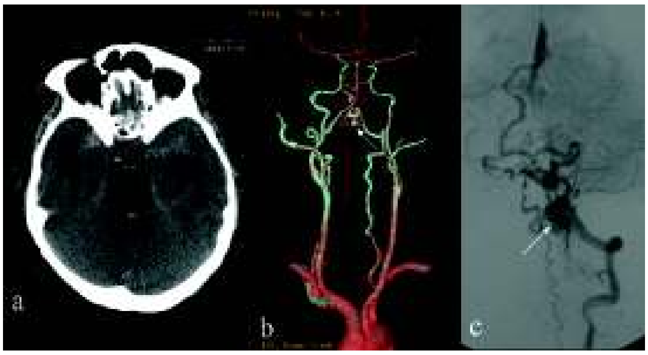
Results

Non-contrast CT scan showed acute sub-arachnoid haemorrhage in 32 patients and parenchymal haematoma was seen in 5 patients. All except for 3 patients had CTA as the initial study. There were 26 cerebral aneurysms detected by CTA in these 37 patients, with 9 negative studies. Other true positive cases were AVMs (n = 2), AV fistula (n = 1), hemangiopericytoma tumoral bleed (n = 1) and vertebral artery dissections (n = 2). All negative CTA studies were followed-up by DSA. There was no false positive CTA in this series, with 3 false negatives of a small PICA aneurysm, an inferior cerebellar micro-AVM with small intranidal aneurysm and a missed sagittal sinus thrombosis, respectively. All three of these were seen on careful retrospective review of the source data. Based solely on CTA assessment of the aneurysm morphology and subsequent treatment suitability, 3 patients had direct surgical clipping of the aneurysm, while 4 proceeded to direct endovascular coiling.

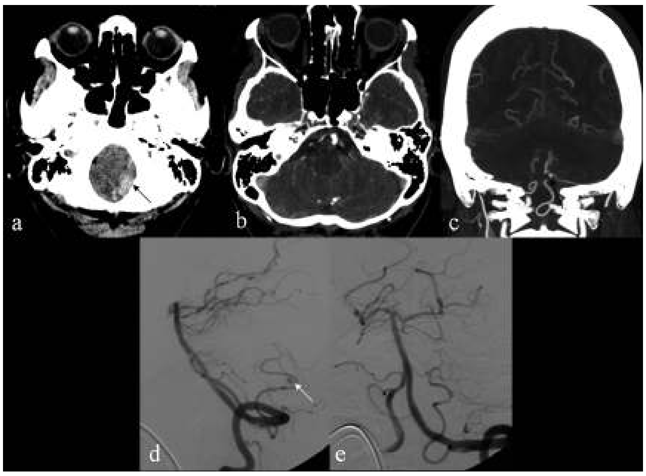
Discussion

Intracranial aneurysm rupture is an acute neuro-surgical emergency with a fatality rate of between 40% and 60%, whereas mis-diagnosis is associated with a further increased morbidity and mortality.[1,13,14] Thus, timely identification and adequate treatment of ruptured intracranial aneurysms is critical in the management of these patients. The ideal imaging examination for aneurysm detection and characterisation should not only be non-invasive, easy to perform, reproducible, readily available and accompanied by minimal complications, but should also depict aneurysms with a high degree of accuracy. Traditionally, DSA has been considered the standard of reference for the evaluation of patients acutely suspected of having intracranial aneurysm rupture, but it has several disadvantages, including its invasive nature, necessity for skilled procedurists, time and manpower resource consuming nature and relatively high costs. Furthermore, DSA reportedly has finite risk of vascular complications including haematoma, vascular

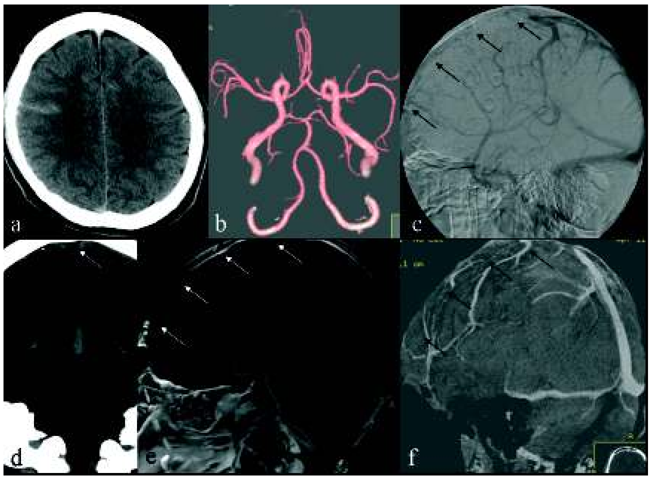
Figs. 1a-f. 52/Female with sudden onset severe headache. (a) Non-contrast CT shows sub-arachnoid haemorrhage in the pre-pontine cistern (white arrow); (b,c) Immediate CTA shows lobulated basilar top aneurysm (white arrows) amenable to coiling; (d,e,f) Pre and post-coiling DSA images showing direct endovascular aneurysm coiling.



Figs. 2a-c. 61/Male with headache and giddiness. (a) Non-contrast CT shows diffuse sub-arachnoid and intraventricular blood with hydrocephalus; (b) CTA shows foramen magnum DAVF, confirmed on DSA (white arrows) (c).



Figs. 3a-e. 58/Female with headache and vomiting. (a) Non-contrast CT shows sub-arachnoid blood in the left peri-medullary cistern (black arrow); (b, c) CTA source & coronal MIP images show small left PICA aneurysm, which was initially missed (black arrows); (d,e) DSA Left vertebral lateral & oblique AP views show 3 x 2 mm left PICA aneurysm, subsequently clipped (white arrow).



Figs. 4a-f. 26/Male with acute severe headache and giddiness with loss of consciousness; (a) Initial non-contrast CT showed acute sub-arachnoid haemorrhage in the right frontal/temporal sulci; (b) Immediate CTA was negative for aneurysm/AVM; (c) DSA showed thrombosed anterior superior sagittal sinus (SSS) (arrows); (d,e,f) Retrospective analysis of CTA source data-set showed thrombosis of SSS which was missed initially (arrows).

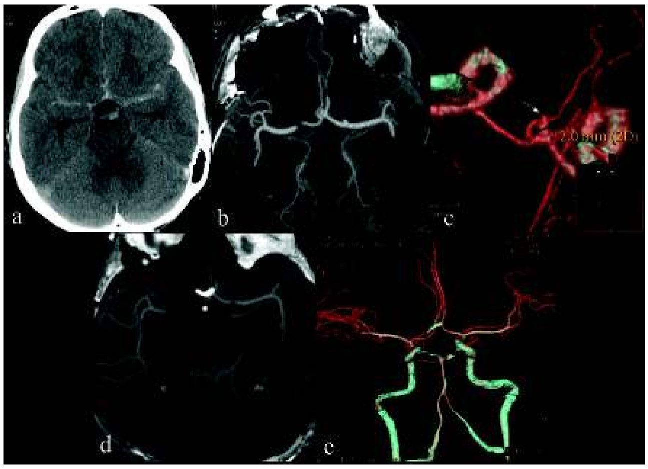


Fig. 5a-e. 32/Male with acute thunder-clap headache; (a) Initial non-contrast CT shows basal sub-arachnoid haemorrhage; (b,c) Immediate CTA shows small 2 mm ACOM aneurysm unsuitable for coiling (arrows); (d,e) post-clipping CTA shows no residual aneurysm. No DSA study was required.

spasm and a 1% risk of disabling neurologic deficits and a 0.1% risk of mortality.[4,8] Hence, an accurate, non-invasive test would be invaluable in the emergent screening of such patients. In this regard, CTA has shown potential in the non-invasive detection of intracranial aneurysms. Recent literature has demonstrated a high accuracy in detecting aneurysms using multi-detector CTA ranging from 92% to 100%.[15-19]

CTA has many advantages over DSA including decreased cost, non-invasiveness, rapid time to diagnosis and it can be easily performed after the initial diagnostic CT scan.

CTA also allows the display of adjacent bony landmarks in 3 dimensions which is useful for neurosurgical planning. Even after CTA, if DSA is required to answer specific queries, it can be tailored to enable more precise, rapid and thorough evaluation of the lesion in question.

Although in our series CTA correlated well with DSA images (Figs. 1 & 2), there were 3 false negatives. A case of a small (2.5mm) left PICA aneurysm was initially missed on CTA (Fig. 3), which was subsequently visualised on the DSA examination and was also seen on careful retrospective analysis of the CTA data. In our view, this missed initial mis-diagnosis on CTA resulted from a failure to review the axial source images before the reconstruction dataset. Pedersen et al[20] have reported that experience plays a critical role in the interpretation of images acquired with this technique and we support their suggestion that radiologist experience both with the CTA technique and with image review at the workstation plays a crucial role in image interpretation. Lacking such experience, radiologists may miss not only small aneurysms but also small adjacent branch vessels – an oversight that could negatively affect treatment planning.

The other false-negative case deserves elaboration as such a scenario may lead to mis-diagnosis (Fig. 4). This patient was referred from the emergency department with a sudden onset of severe headache with clinical suspicion of acute sub-arachnoid haemorrhage. The initial non-contrast CT scan showed acute sub-arachnoid haemorrhage, but the CTA was negative for any aneurysm or vascular malformation. DSA was done subsequently which showed a thrombosed superior sagittal sinus. On retrospective review of the non-contrast CT and CTA source dataset, the thrombosed superior sagittal sinus was visible.

In agreement with Alberico et al,[8] the addition of a post-CT angiography contrast CT brain as part of the screening protocol may increase the detection of incidental dural sinus thrombosis. This information is important because dural sinus thrombosis may present with the same clinical symptoms as sub-arachnoid haemorrhage from aneurysm rupture.

The third false negative case had an inferior cerebellar micro-AVM with a small intranidal aneurysm, which was initially missed on CTA. It was also subsequently seen on a careful retrospective review of the CTA source data, again emphasising the importance of carefully reviewing the axial source images before looking at the reconstruction dataset.

However, CTA is not without limitations as the 3-D reconstruction process is operator dependent. Improper thresholding can markedly alter the appearance of the vessels and could potentially result in the elimination of vascular branches or aneurysms.[21] Visual thresholding individualised to each case in conjunction with MIP reconstruction can resolve these potential problems relatively easily. With increased training and experience, CT technologists are able to independently perform multi-detector row CTA with relative ease. In our experience, the CTA examinations were completed safely and quickly, even in patients whose ability to cooperate was impaired by sub-arachnoid haemorrhage.

The anatomic localisation and spatial resolution obtained with multi-detector row CT angiography in our study were excellent. The use of CT angiography for treatment planning has been compared favourably with that of DSA for the same purpose,[22] and our study results confirm this notion that CTA can provide valuable information for treatment planning (Fig. 5). Seven patients in our study proceeded to definitive treatment based solely on CTA assessment. Three patients had direct surgical clipping of the aneurysm, while 4 proceeded to direct endovascular coiling.

Further improvements in CT technology may decrease acquisition time, improve spatial resolution, and increase the accuracy and specificity of CT angiography for aneurysm detection.

Conclusion

Emergent CTA is a promising tool for the accurate detection of aneurysms in intracranial vessels. It is non-invasive, reliable and is a viable alternative to emergent DSA for the assessment of the cerebral vessels in the acute assessment of patients presenting with symptoms suspicious of brain aneurysm rupture. It has the ability to accurately characterise aneurysms, delineate anatomic landmarks and can serve as a guide to therapeutic decisions. Review of CTA source data is essential, especially for small lesions and for post-clipping assessment. Subsequent DSA is warranted for initial CTA negative cases.

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