64-Multidetector Row CT Angiography (64-MDCTA) in Diagnosis of Intracranial Aneurysms in Acute Subarachnoid Hemorrhage: Comparative Study with Digital Subtraction Angiography (DSA)

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Abstract

Objective: The aim of this study was to compare 64-multidetector row CT angiography (64-MDCTA) with digital subtraction angiography (DSA) in diagnosis of intracranial aneurysms in cases of acute subarachnoid hemorrhage.

Materials and Methods: Our study included 50 patients 33 women and 17 men who underwent imaging on a 64-MDCT scanner (Light Speed VCT; GE Healthcare). The CTA was done using the following parameters; collimation 64 x 0.625mm; rotation time 0.350ms; pitch 0.531 in a caudocranial scan direction; tube voltage 120 kVp, tube current 350 mA, matrix of 512x512, field of view 18-22 cm, section thickness 1.25mm and reconstruction interval 0.625mm (50% overlapping). For post-processing, the reconstructed images were used to produce; Maximum intensity projection (MIP) reformats in axial, sagittal and coronal planes, 3-D Maximum intensity projection (MIP), and 3D volume rendered (VR) model. Digital subtraction angiography (DSA) was done in all cases.

Results: Out of 50 patients included in our study, 12 (24%) patients had negative study on CTA and DSA. A total 40 aneurysms had been identified on DSA (two patients had two aneurysms) in 38 patients and 38 aneurysms (95%) had been detected on CTA with two missed aneurysms on CTA (5%). Most of CTA-identified aneurysms (28 aneurysms=70%) were located within the anterior cerebral circulation and the remaining 10 aneurysms (25%) were located in posterior cerebral circulation. The sensitivity of MDCTA in detection of aneurysms in our study was 95%, the specificity was 100% and the total accuracy of about 96.2%.

Conclusion: 64-MDCTA is an accurate method in the diagnosis of intracranial aneurysms in acute spontaneous subarachnoid hemorrhage and can be used as an alternative method to DSA.

Key Words: Row CT angiography — Digital subtraction angiography (DSA).

Introduction

ALTHOUGH there are several causes of acute spontaneous subarachnoid hemorrhage (SAH), aneurysms contribute to 85% and hold a high morbidity and mortality rate. Mortality is high in subarachnoid hemorrhages (SAH) due to rupture of aneurysms. Most deaths occur due to the first bleeding or repetitive bleeding. The fatality rate including pre-hospital deaths is quoted as high as 80% ill. For patients that survive the initial hemorrhage, there is increased rate of re-bleeding if the aneurysm is not treated. This is up to 2-4% for the first 24 hours, 15-20% within the first two weeks and up to 50% in the first six months. This contributes to the high mortality rate, and hence stresses the importance of quick and accurate diagnosis of cause of SAH [2].

For the time being, selective digital subtraction angiography (DSA) is used as the standard method in diagnosis and preoperative evaluation of cerebral aneurysms. Although the permanent neurologic complication risk is low (0.07%-0.5%) in DSA exams performed in cases with suspected cerebral aneurysms, this method is invasive, time consuming and expensive. DSA has high sensitivity and specificity values in diagnosis of cerebral aneurysms while false negative results ranging from 5% to 10% have been reported in the literature [3]. A number of studies have been carried out over the last decade to assess the effectiveness of CTA in the evaluation of intracranial aneurysms as compared to the gold standard DSA [4-7].

Prompt radiological evaluation of ruptured intracranial aneurysm is critical for determining appropriate treatment. Currently digital subtraction
angiography (DSA) is considered as gold standard for the detection and therapeutic decision making regarding internal carotid artery (ICA) [8,9]. However, DSA is invasive and costly with 0.5% risk of permanent neurological complications Rol.

Rapid evaluation of ICA by technically advanced and minimally invasive cross sectional imaging such as multi-detector computed tomography angiography (MDCTA) and magnetic resonance angiography (MRA) has changed diagnostic approach to ICA evaluation mi. CTA has relatively high sensitivity and high specificity due to ongoing development of the cross sectional imaging [12].

Objective: The aim of our study was to compare 64-multidetector row CT angiography (64—MDCTA) with digital subtraction angiography (DSA) in diagnosis of intracranial aneurysms in cases of acute subarachnoid hemorrhage.

Material and Methods

Our study included 50 patients who had undergone imaging on a 64-MDCT scanner (LightSpeed VCT; GE Healthcare) and digital subtraction angiography (DSA) between June 2008 and October 2011. Our study included 33 women and 17 men (age range 38-67 years; mean age 58.4 years).

CTA protocol:

CT scan was done using 64-row MDCT scanner (Light Speed VCT; GE Healthcare). Patients were examined in a supine position with their arms alongside the body and their heads tilted slightly forward.

At first, the test bolus technique was performed just below the level of skull base to obtain accurate information about the circulation time of the patient. After 18 or 20-gauge canula was placed in the antecubital vein, 15ml of contrast media was injected followed by 20ml of saline flush at a flow rate of 5.0ml per second using a double head injector. Single-level dynamic CT scans were performed with the gantry tilted parallel to the skull base. Dynamic CT scans (5mm section thickness) were acquired every 2s, starting 5s after intravenous administration of the test bolus. Scans were continued until contrast media appeared in the neck arteries and veins. The time intensity curves at the internal carotid artery and internal jugular vein were done by placing small circular regions of interest (ROIs) at sites. Then the delayed time was calculated for arterial and venous phases of the study.

The CTA was done using the following parameters; collimation 64x0.625mm; rotation time 0.350ms; pitch 0.531 in a caudocranial scan direction; tube voltage 120 kVp, tube current 350 mA, matrix of 512x512, field of view 18-22cm, section thickness 1.25mm and reconstruction interval 0.625mm (50% overlapping).

The cerebral vascular anatomy and pathology were analyzed by loading the source images (slice thickness of 0.625mm) on a separate workstation (Advantage 4.3; GE Healthcare). For post-processing, the reconstructed images were used to produce 1. Multi-planar reformatted images 2.2-D Maximum intensity projection (MIP) reformats in axial, sagittal and coronal planes with a sliding thin slab (5mm slab thickness with 2 5mm increment) was used for analysis of the intracranial vascular systems (arterial and venous system), 3. 3-D Maximum intensity projection (MIP), and 4. 3D volume rendered (VR) model.

DSA protocol:

All cases were done in Angio Suite (Siemens Axiom Artis). Our standard imaging protocol was to examine both internal carotid arteries (ICA) and the vertebrobasilar system in a posterior-anterior (PA) and lateral projection using the following technical factors; FOV 22cm, frame rate ranging from 4 frames per second to 1 frame per second in arterial and venous phases respectively and 5 ML of diluted contrast using hand injection. If no aneurysm was seen on the PA and Lateral ICA projections, a transorbital oblique projection was performed to demonstrate the middle cerebral artery (MCA) bifurcation/trifurcation and also provide a second look at the anterior communicating (ACOM) artery region. If an aneurysm was suspected or seen oblique views were done to identify the aneurysmal neck.

Results

Our study included 50 patients 33 women and 17 men, their age range between 38-67 years; mean age 58.4 years. Out of 50 patients included in our study, 12 (24%) patients had negative study on MDCTA and DSA (no detected aneurysms). 38 (76%) patients had positive studies on DSA. Two (4%) patients had false negative (no aneurysms identified) MDCTA with small aneurysms confirmed on DSA.

A total 40 aneurysms had been identified on DSA (two patients had two aneurysms) and 38 aneurysms (95%) had been detected on MDCTA with two missed aneurysms on MDCTA (5%).
Most of MDCTA-identified aneurysms (28 aneurysms=70%) were located within the anterior cerebral circulation and the remaining 10 aneurysms (25%) were located in posterior cerebral circulation. Out of aneurysms in our study, 12 (30%) were anterior communicating (ACOM) artery aneurysms, 7 (17.5%) were distal ICA aneurysms, 4 (10%) were posterior communicating (PCOM) artery aneurysms, 4 (10%) were middle cerebral artery aneurysms, 5 aneurysms (12.5%) were in posterior cerebral artery, 3 aneurysms (7.5%) were in posterior inferior cerebellar artery and 2 (5%) aneurysms were in superior cerebellar artery.

The sensitivity of MDCTA in detection of aneurysms in our study was 95%, the specificity was 100% and the total accuracy of about 96.2%.

MDCTA was able to delineate the size of the aneurysms, most of aneurysms in our study were medium sized aneurysms in 33 aneurysms, followed by small aneurysms in 3 cases and large aneurysms in 2 cases. CTA was also able to delineate the aneurysmal necks in most of cases (32 aneurysms) and unclear neck in 6 aneurysms. 24 of the aneurysms detected in our series were narrow-necked (i.e. measuring 3mm and less) and 8 aneurysms detected in our study were wide neck (more than 3mm).

Fig. (1 A,B,C): Sagittal 2D-MIP (a) & coronal 3D VRT (b) reveal 9 mm sized anterior communicating artery aneurysm with antero-superior orientation (white arrows) and DSA (c) confirms the same location & orientation of the aneurysm (white arrow).

Fig. (2 A,B,C): Coronal 2D-MIP (a) & axial oblique 3D VRT (b) reveal 8 mm sized supra-clinoid left internal carotid artery aneurysm with superior orientation (white arrows) and DSA (c) reveals this aneurysm to be in the same location & orientation (white arrow).

Fig. (3 A,B): 3D MIP (a) reveals 6mm sized posterior communicating artery aneurysm with posterior orientation (white arrow) and DSA (b) confirms the same location of the aneurysm (white arrow). NB: Failed selective catheterization of right common carotid artery, so we did arch aortogram.
Fig. (4 A,B,C): Axial 2D-MIP (a) & coronal 3D VRT (b) reveal 9.5mm sized left middle cerebral artery aneurysm with postero-inferior orientation (white arrows) and DSA (c) confirms MDCTA findings (white arrow).

Fig. (5 A,B,C,D): Sagittal 2D-MIP (a) & coronal 3D VRT (b) reveal 3mm sized left anterior cerebral artery aneurysm with postero-lateral orientation (white arrows) and DSA (c & d) confirm the location & orientation of the aneurysm (white arrow).

Fig. (6 A,B,C,D): Coronal 2D-MIP (a), coronal 3D VRT (b) & targeted coronal 3D VRT of posterior circulation (c) reveal 4mm sized right posterior cerebral artery aneurysm with superior orientation (white arrows) and DSA (d) confirms the location & orientation of the aneurysm (white arrow) with no identified neck.

Fig. (7A,B): Coronal oblique 3D VRT (a) reveals 7.5mm sized left posterior inferior cerebellar artery aneurysm with inferior orientation (white arrow) and DSA (b) confirms MDCTA findings (white arrow).
Table (1): Distribution of cerebral aneurysms included our study on MDCTA.

<table>
<thead>
<tr>
<th>Anatomical Location</th>
<th>No of aneurysms</th>
<th>Total aneurysms</th>
<th>on DSA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Distal ICA</td>
<td>6</td>
<td>1</td>
<td>7</td>
</tr>
<tr>
<td>ACOM</td>
<td>12</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>PCOM</td>
<td>4</td>
<td>1</td>
<td>5</td>
</tr>
<tr>
<td>MCA</td>
<td>4</td>
<td>-</td>
<td>4</td>
</tr>
<tr>
<td>ACA</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td>PCA</td>
<td>5</td>
<td>-</td>
<td>5</td>
</tr>
<tr>
<td>PICA</td>
<td>3</td>
<td>-</td>
<td>3</td>
</tr>
<tr>
<td>SCA</td>
<td>2</td>
<td>-</td>
<td>2</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38</strong></td>
<td><strong>2</strong></td>
<td><strong>40</strong></td>
</tr>
</tbody>
</table>


Table (2): Size of aneurysms and aneurysmal necks included our study on MDCTA.

<table>
<thead>
<tr>
<th>Size of aneurysms</th>
<th>No of aneurysms</th>
<th>Size of neck of aneurysms</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Narrow neck</td>
</tr>
<tr>
<td>Small (&lt;5mm)</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>Medium (5 to &lt;13mm)</td>
<td>33</td>
<td>23</td>
</tr>
<tr>
<td>Large (13 to &lt;25mm)</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>38</strong></td>
<td><strong>25</strong></td>
</tr>
</tbody>
</table>

Discussion

Mortality is high in subarachnoid hemorrhages (SAH) due to rupture of aneurysms. Most deaths occur due to the first bleeding or repetitive bleeding. For this reason, fast and accurate evaluation of the patients is of great importance in planning the therapeutic interventions. For the time being, selective digital subtraction angiography (DSA) is used as the standard method in diagnosis and preoperative evaluation of cerebral aneurysms [13].

MDCTA is a fast thin-section volumetric spiral CT examination performed with a time-optimised bolus of contrast medium in order to enhance the cerebral arteries. Post-processing tools including 2-D maximum intensity projection (MIP), 3-D MIP, and volume rendering technique (VRT) are employed complementarily in the precise detection of intracranial aneurysms. The former provides two dimensional images obtained from voxels within a defined volume at a single plane, with resultant loss of depth perception. Unlike both 3- D MIP and DVR offered three dimensional images [13,14]. In our study we use all previous mentioned post-processing techniques beside multi-planar reformatted images which leading to increase the sensitivity, specificity and accuracy of the MDCTA in detection of cerebral aneurysms.

In a systematic review of studies published between 1988 and 1998, the average sensitivity of CTA for the detection of intracranial aneurysms was about 90%. Others reported sensitivity ranged from 80-97% depending on the size and location of aneurysm. With the improvisation of imaging technology since the 21st century, the overall pickup rate of confirmed intracranial aneurysms had scored above 90% consistently [4,15,16]. Chang et al series [17] yielded high sensitivity and specificity (94.4% and 97.2% respectively).

A review of previous literature indicates that 64 slice MDCTA on a patient basis has a sensitivity of between 77 and 98 with specificity between 90 and 100 and reported negative predictive values of between 70 and 99.4% [2,18-20].

Our series is in agreement with the result of previous studies with slightly high sensitivity, specificity and accuracy (95%, 100% and 96.2%) respectively. Two (5%) aneurysms were missed on MDCTA reporting. In our study, despite the high overall sensitivity of MDCTA in the detection of intracranial aneurysms (95%), the main limiting factor which reduces the sensitivity significantly is the size of the aneurysm. In our study, MDCTA failed to detect two small aneurysms which were diagnosed on DSA study. This phenomenon was reported in various previous studies. The smaller the size of the aneurysm, the lower the detection rate will be. Teksem et al reported a corresponding decline in the mean sensitivity of CTA depending on the size of the aneurysms, i.e. 64% for aneurysms <3mm, 83% for 3-4mm, 95% for 5-12mm, and 100% for aneurysms greater than 13mm [21].

In our study, the anterior cerebral circulation aneurysms remained the predominant location of all aneurysm detected by MDCTA constituting about 75% with ACOM artery aneurysms was the most common location (30%) while the posterior cerebral circulation aneurysms constituted about 25%. Uysal et al demonstrated a similar result with ACOM artery aneurysms as being the commonest (38%) followed by MCA aneurysm (32%) & posterior circulation aneurysms only constituted 9% while anterior circulation aneurysms constituted 91% [13].
Besides high sensitivity and specificity, MDCTA provides additional diagnostic information like dimensional reconstructions at different planes and angles that allows better delineation of aneurysmal neck, its orientation and spatial relationship. In our study; MDCTA was able to detected aneurysmal neck in 32 cases (84.2%) out of 38 aneurysms and unclear neck in 6 aneurysms (15.8%). In our series; 25 detected aneurysms had narrowneck and 7 aneurysms had wide neck. Detection of orientations of aneurysms on MDCTA helped the surgeon in determining surgical approaches and predetermination of aneurysmal neck is important in proper selection of clips.

Conclusion: 64-MDCTA is an accurate method in the diagnosis of intracranial aneurysms in acute spontaneous subarachnoid hemorrhage and can be used as an alternative method to DSA.

References