Performance analysis of 8-channel MDCT angiography in detection, localization, and sizing of intracranial aneurysms identified on DSA

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PURPOSE

To retrospectively analyze the performance of 8-channel multi-detector computed tomographic angiography (MDCTA) in detecting, localizing, and sizing intracranial aneurysms using conventional intraarterial digital subtraction angiography (DSA) as the gold standard.

MATERIALS AND METHODS

A retrospective search from November 2004 to August 2006 revealed subarachnoid hemorrhage (SAH) in 25 patients (13 females and 12 males, age range 21–73 years) who underwent both DSA and 8-channel MDCTA exams. Two independent reviewers compared both studies for the presence, location, and size of the aneurysm.

RESULTS

A total of 35 aneurysms in 25 patients were identified on DSA, and 33 on MDCTA. MDCTA missed two 4-mm posterior communicating artery (PcoA) aneurysms. There was a mismatch in the location of two aneurysms. One aneurysm at PcoA on DSA was reported as a supraclinoid internal carotid artery (ICA) aneurysm on MDCTA. The other on M2 bifurcation was reported as on M1. No size mismatch was noted. MDCTA had a 94% (33/35) aneurysm detection rate, 88% (31/35) aneurysm localization rate and 100% (33/33) sizing rate.

CONCLUSION

MDCTA correlated perfectly with DSA in the detection of intracranial aneurysms of anterior communicating artery and middle cerebral artery; however, slightly lower performance was noted in the PcoA and ICA supraclinoid segment aneurysms.

Key words: • multi-detector computed tomographic angiography • angiography, digital subtraction • intracranial aneurysm

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Digital subtraction angiography (DSA) is the gold standard in diagnosis of intracranial aneurysms; however, the technique is invasive, requires a skilled performer, and is relatively costly and time consuming (1, 2).

Among other alternative diagnostic tests, computed tomography (CT) angiography has attracted much attention as a substitute due to its high accuracy, noninvasive nature, availability, and favourable technical aspects such as three dimensional, multiplanar imaging, short acquisition time, and intravenous rather than intraarterial contrast (1, 3). Above all, accuracy of CT angiography has been the foremost consideration because early and definite detection of aneurysm is critical, given the fact that ruptured aneurysms are the main cause of subarachnoid hemorrhages (SAH), and have a high mortality rate (3).

Multidetector imaging is a recent development, has improved the efficiency of CT imaging especially with regard to resolution and acquisition time. Therefore, with multidetector row CT angiography (MDCTA), better yield is expected in aneurysm detection. A few studies have addressed this subject (1, 2, 4–7). Recognition of advantages, and better understanding the potential pitfalls and limitations of MDCTA will improve the quality of image interpretation and reporting, and will also guide the physician in correct decision making. The purpose of this study is to analyze retrospectively the performance of eight-channel MDCTA in detecting, localizing, and sizing intracranial aneurysms using conventional intraarterial DSA in the setting of non-traumatic acute SAH.

Materials and methods

From November 2004 to August 2006, a retrospective comprehensive search of the digital archives of our DSA unit was made, and cerebral angiograms of patients who were referred to our clinic with suspected intracranial aneurysms were examined. These patients were referred for a cerebral DSA exam on the basis of their clinical and radiologic findings suggestive of SAH and intracranial aneurysms, including SAH on nonenhanced cranial CT exam. Cases related to trauma were excluded.

The internal neurosurgical management policy of intracranial aneurysms in our institution dictates that all patients with suspected intracranial aneurysms should first undergo a cerebral DSA exam, and if findings suggest an intracranial aneurysm, to further delineate soft tissue and bone anatomical relationships, patients are further scheduled to undergo a cerebral MDCTA exam. In some patients, due to rapid deterioration and unstable vital signs, despite the presence of an aneurysm, no MDCTA study was performed after the cerebral angiogram. For only 25 patients (13 females, and 12 males) in whom DSA exam was positive for an aneurysm, results of a comparative MDCTA exam were available. Those patients were enrolled in the study. In each of these patients, MD-
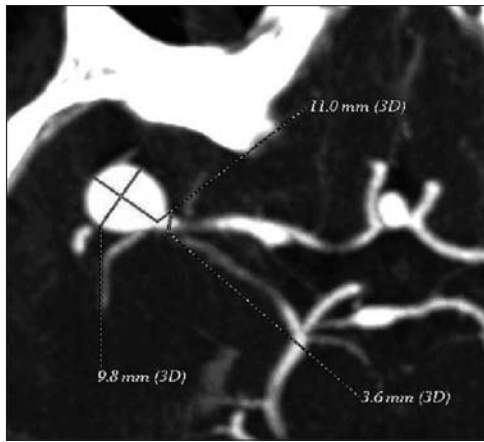
Figure 1. Maximum diameter of a middle cerebral artery aneurysm was measured on an MDCT angiography maximum intensity projection (MIP) image.
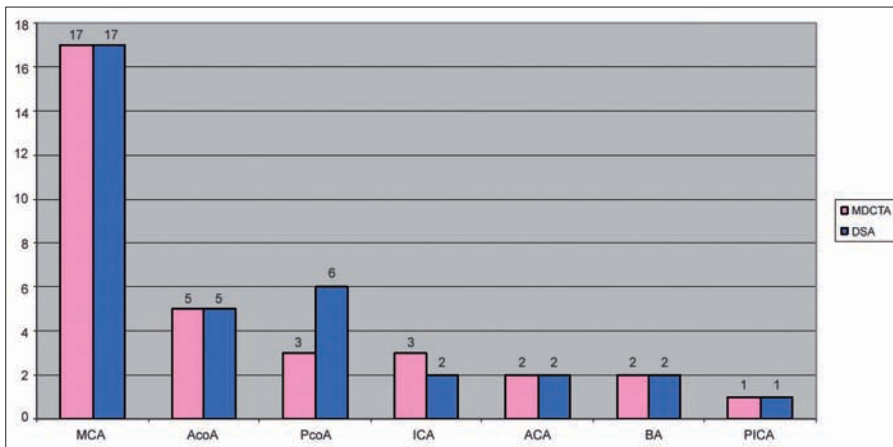

Figure 2. Sites of aneurysms detected at MDCT angiography and DSA (MCA, middle cerebral artery; AcoA, anterior communicating artery; PcoA, posterior communicating artery; ICA, internal carotid artery; ACA, anterior cerebral artery; PICA, posterior inferior cerebellar artery; BA, basilar artery).

CTA was performed either on the same day after the DSA exam, or on the following day. Each of these 25 patients had a SAH. None of the patients had prior aneurysm repair or coiling procedure. Mean patient age was 51.5 years (range, 21–73 years). Informed consent was obtained before the exams either from the patient or from the patient's legal representatives.

DSA (1024 x 1024 matrix, Multistar Plus/T.O.P., Siemens AG, Forchheim, Germany) was performed transfemorally using a single arm DSA unit. Field of view (FOV) was 20 cm and frame rate was 2F/s. Patients subsequently underwent selective common carotid and vertebral artery arteriography. Single vertebral artery views were used when one vertebral artery was too tortuous or hypoplastic and technically difficult to catheterize. In order to demonstrate the exact vascular anatomy, selective views were taken by injection of 6 ml of non-ionic contrast agent (Iomeron 400 mgI/mL, Bracco SpA, Milan, Italy) at an injection rate of 4–7 ml/s using a power injector. In addition to standard anteroposterior (AP) and lateral views, additional views were also obtained as necessary to clarify the anatomy of the aneurysm.

MDCTA studies of all 25 patients were performed on an eight-row CT scanner (Light Speed Ultra, General Electric, Milwaukee, Wisconsin, USA). Scanning was performed in the caudocranial direction starting at the level of the foramen magnum, and ending 1 cm above the lateral ventricles, covering both the anterior and posterior circulation. Scanning parameters were as follows: 120 kV, 300 mA, 8×1.25 mm collimation, 0.875 mm/s table speed, 1.25 mm slice thickness, 0.6 mm reconstruction interval and 0.5 s tube rotation period, 18 cm FOV, and 512 x 512 matrix. Intravenous contrast material was injected using an automatic injector, containing 350 mg of iodine per ml via an antecubital vein with a total volume of 2 mL/kg of patient's weight at an injection rate of 4–6 mL/s. Scanning was started as soon as the maximum carotid enhancement was reached at the carotid bifurcation level, as detected by the automatic bolus-tracking program (SmartPRep®, GE Medical Systems, Milwaukee, Wisconsin, USA). No technical failures or complications were encountered. The studies were not hindered by patient movement or venous contamination.

On a separate workstation (Advantage Windows 4.0, GE Healthcare, Milwaukee, Wisconsin, USA), axial source images were evaluated, and three-dimensional (3D) images with maximum intensity projection (MIP) and volume rendering (VR) techniques were reconstructed from thin axial images. Reformation and evaluation of CT images took about 10–15 minutes. Analyses of DSA and MDCTA studies were performed by two independent radiologists. The maximum diameter of the aneurysm sac was measured on CT angiographic MIP images (Fig. 1), while it was predicted roughly by comparing the aneurysm with adjacent vessel diameters at archived DSA images by using the sizing catheter. MDCTA and DSA studies were correlated according to four criteria: presence or absence of an aneurysm, number of aneurysms, size of aneurysm(s), and location of aneurysm(s). For purposes of this study, the diameter of each aneurysm was graded as large (>13 mm), medium (5–12 mm) or small (<4 mm) according to the measurements by DSA and MDCTA. Seven arterial aneurysm locations evaluated for comparison were the middle cerebral artery (MCA), anterior communicating artery (AcoA), posterior communicating artery (PcoA), internal carotid artery (ICA), anterior cerebral artery (ACA), posterior inferior cerebellar artery (PICA), and basilar artery (BA).

Results

A total of 35 aneurysms were identified on DSA in 25 patients. Of these 25 patients, 17 patients had one, seven patients had two, and one patient had four aneurysms. Thirty-three aneurysms were identified on MDCTA in 25 patients. The two aneurysms missed on MDCTA were located at PcoA and were smaller than 4 mm on the DSA exam. The locations of the
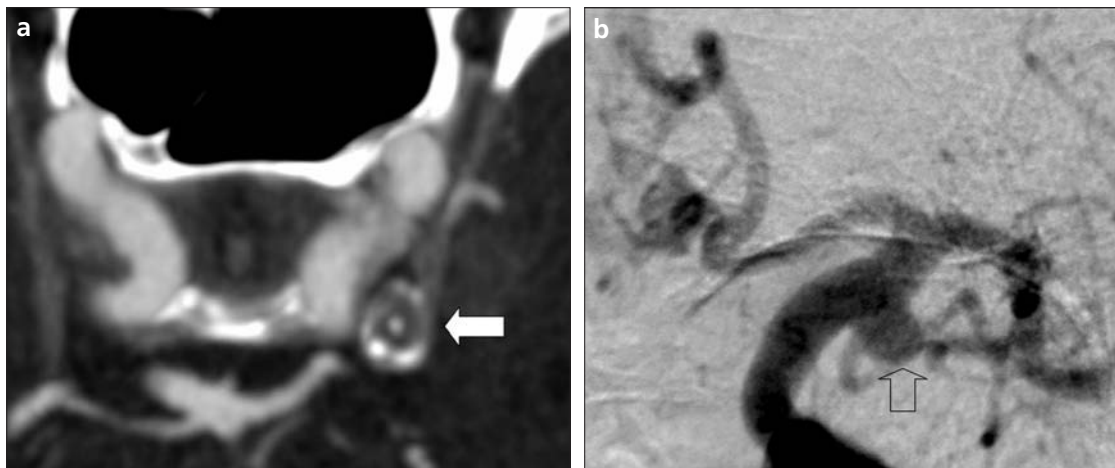
Figure 3. a, b. Axial plane MDCT angiography **(a)** and DSA **(b)** images. This aneurysm (*arrow,* **a**) was presumed to be located at the supraclinoid segment of the left internal carotid artery on MDCT angiography, but DSA revealed the location at the left posterior communicating artery (*open arrow,* **b**).
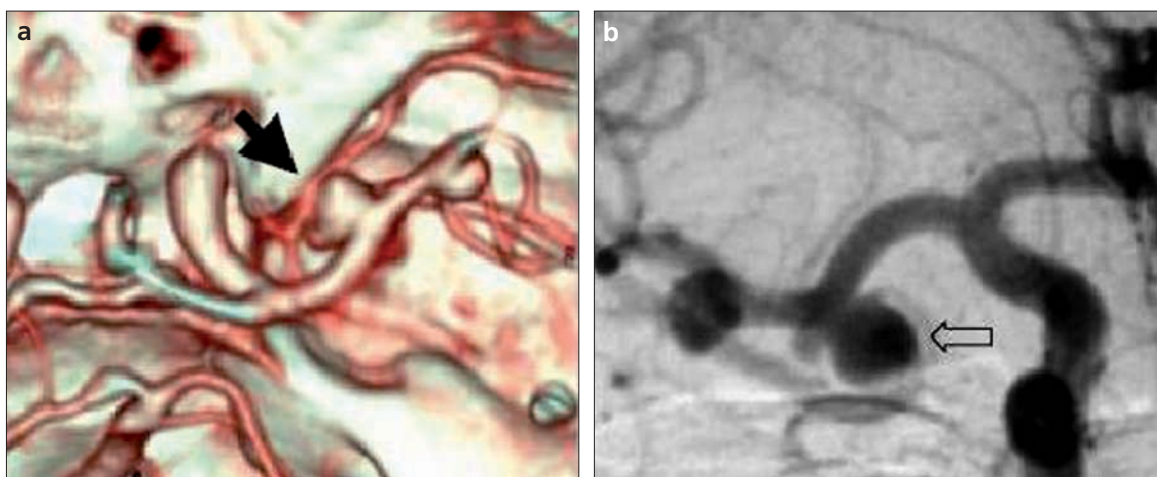

Figure 4. a, b. Volume rendering MDCT angiography **(a)** and DSA **(b)** images. On MDCT angiography **(a)**, the location of the aneurysm (*arrow,* **a**) was noted to be the right M1 bifurcation, whereas it was located at M2 bifurcation on DSA (*open arrow,* **b**).
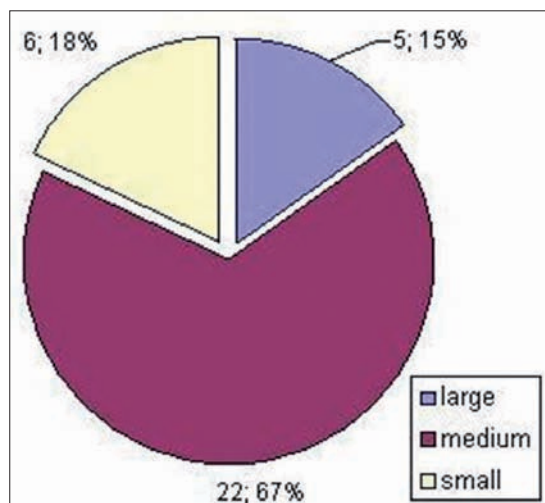

Figure 5. Size of the aneurysms detected on MDCT angiography.

located at the supraclinoid segment of ICA on MDCTA (Fig. 3). The location of the other aneurysm was noted at the M1 bifurcation on MDCTA, but was at the M2 bifurcation on DSA (Fig. 4). Six aneurysms were small, five aneurysms were large and 22 aneurysms were medium size on MDCTA (Fig. 5). The observers concurred about the vessel size for all 33 aneurysms on both imaging modalities. Given that two aneurysms were missed and two were mislocated, MDCTA had detected 33 of 35 aneurysms (94%), localized 31 of 35 aneurysms (88%), and had accurately assessed size in 33 of 33 (100% of those detected).

Discussion

The ideal examination for the detection and characterization of intracrani-

aneurysms detected on MDCTA and DSA are listed in Fig. 2. There was a mismatch in the location of two aneurysms on DSA and MDCTA. One of these aneurysms, which was located at PcoA on DSA, was presumed to be

al aneurysms should not only be non-invasive, easy to perform, readily available, and associated with only minor complications, but it also should depict aneurysms with high accuracy for successful surgical or endovascular treatment (5). Also important are demonstration of arterial origin, surrounding vascular anatomy, orientation of the sac with regard to the skull base, and the presence of possible intraluminal thrombus or peripheral calcifications, as well as accurate measurement, and display of aneurysm sac and neck (8).

Familiarization with strengths and limitations of CTA would allow better detection of aneurysms in CT angiograms of the intracranial circulation, and evaluation of the aforementioned properties. Many studies performed with single-slice helical CT reported the sensitivity of CTA in detecting intracranial aneurysms ranging from 67% to 100% and specificity from 50% to 100% (3, 8–11) with limited sensitivity for aneurysms smaller than 3 mm, as compared to aneurysms greater or equal to 3 mm (25–64% and 92–100%, respectively) (4). In other words, low spatial resolution of CTA (compared with DSA) led to difficulty in identifying aneurysms smaller than 3 mm. This is the main limitation of CTA (8). Recent improvements in CT technology, especially MDCTA, in which many parallel rows of X-ray detectors work simultaneously, increasing scan speed, volumetric coverage, and spatial resolution, may not only resolve this limitation, but also promote characterization of aneurysms (1).

With 4-channel MDCT scanners, better sensitivity and specificity results are reported, ranging from 85% to 96% for sensitivity and from 83% to 97% for specificity (1, 2, 4, 5, 12). With an increase in CT channel number, the sensitivity and specificity increase as well. With 16-channel MDCT, overall sensitivity and specificity were 96% and 100%, respectively, in the study by Tipper et al. (13), and 92.5% and 93.3% in the study by Yoon et al. (1). Also, detection of aneurysms smaller than 3 mm improved with MDCTA, with sensitivities ranging from 74% to 91% (1, 2, 12, 13). Our study design did not allow us to calculate the sensitivity and specificity results; however, only two aneurysms out of 35 were missed on the MDCTA examination using an 8-channel CT scanner, with an aneurysm detection rate of 94%. The two aneurysms that were missed were

less than 4 mm in size. Fortunately, small aneurysms often remain unruptured, or have low risk of rupture (1).

In this study, as in the previous relevant studies, CTA was able to detect all aneurysms located at the AcoA and MCA regardless of their size. Some authors have suggested that it is safe to rely on CTA findings alone for surgery in patients having aneurysms in the aforementioned locations (8, 14–16). However, two aneurysms were mislocated in our study in MCA and ICA territories. Care should be taken because aneurysms that arise from the intracavernous or supraclinoid segments of ICAs may be obscured by bone or venous blood on CTA studies (17–20). Aneurysms of intracavernous or supraclinoid arteries, which have close proximity to bony structures of the skull base, may be overlooked or may have their location misinterpreted on MDCTA, as in our series (2, 4, 9, 17).

Results of our study indicate a relatively poor detection rate for PcoA aneurysms, which is consistent with what is reported in the literature (1, 8, 15, 16). This may be due to small size (<4 mm), lobulated shape, and location adjacent to the posterior clinoid processes, which makes their discrimination difficult because of density values similar to those of bone (8). Also, it is difficult to differentiate a small aneurysm from an infundibulum, a pyramidal dilatation at the origin of a vessel with an artery arising from the apex. Infundibula are especially common in PcoAs (1).

No size mismatch was noted in aneurysms detected both by MDCTA and DSA in our study. MDCTA is more accurate for measurement of aneurysms because it utilizes digital measurements by calipers in any chosen plane. With DSA, precise measurements are more difficult due to magnification and the lack of size references (1, 4). However, recent studies have demonstrated that although CTA may allow better demonstration of the orientation of an aneurysm, calcification and intraaneurysmal thrombi, as well as the neck, shape, and important adjacent bony structures (18), it has a tendency to overestimate the neck/dome ratio, which may affect the selection of treatment options (1).

Technique is extremely important in MDCTA studies. The volume and concentration of contrast material, the rate and type of injection, patient-related

factors such as body weight, timely delivery of contrast material, and proper timing of scanning, all affect the quality of images (4, 16, 18). In addition, in case of a technical failure, CT angiography cannot be repeated within a short time, due to venous contamination (8, 21). Fortunately we did not experience any technical failure, and image quality was satisfactory for diagnosis in all studies. In this study, MDCTA exams were performed either on the same day as the DSA exam, or on the following day. This approach exposes the patient to a large load of contrast medium, but bleeding aneurysms in our study had to be treated on an emergency basis, and diagnostic work-up was completed as soon as possible. In deciding when to perform the MDCTA study, factors such as kidney function and clinical condition should also be taken into consideration. ALARA (as low as reasonably achievable radiation dose) principles should be followed.

Although DSA is the method of choice for preoperative evaluation of intracranial aneurysms, it may not always provide sufficient information prior to surgery. Superimposition of vessel loops, tortuosity of vessels, small aneurysm size, and complicated aneurysm shape could lead to erroneous interpretations of DSA images. To avoid problems with DSA, multiple projections and high-frame-rate acquisition are needed, and additional time and volume of contrast medium are absolutely necessary (18). In addition, the resultant subtracted images may sometimes fail to delineate the aneurysm neck, vessels arising from the sac, mural calcifications, intraluminal thrombus, and relationship to bony structures of the skull base and to the brain parenchyma, which are important features of the aneurysm for the neurosurgeon to perform a safe operation. Several factors such as the rotational limitations of the C-arm fluoroscopy and inadequate projections due to lack of patient cooperation may contribute to ambiguous results at DSA due to its inability to project the aneurysm adequately. These limitations reduce the diagnostic accuracy of DSA, but recent studies have shown that it can be improved when DSA is performed in conjunction with rotational angiography (3, 8).

The failure to identify a very small aneurysm on DSA may simply be due to the inability to project the aneurysm adequately; additionally angiography

does not reveal the aneurysm in approximately 10–20% of patients with acute SAH (18, 22–25). Although DSA presents advantages such as large FOV, high spatial resolution, and temporal imaging capabilities, the importance of the invasiveness of this method cannot be underestimated. Also, when diagnosing patients suffering from SAH, the long examination time may negatively affect the quality of the images (8). Not only is DSA a time-consuming and operator-dependent method, permanent and transient neurologic complication rates of 0.3% and 0.6%, respectively, have been reported (26).

MDCTA is easy to perform and is less time-consuming than DSA. The evaluation of cerebral vasculature with CTA requires a high quality examination that is more dependent on technical parameters than on factors related to the patient, because the real scanning time is less than 1 minute, and is easily tolerated by the majority of patients with acute SAH (8). MDCTA can be performed immediately following non-enhanced cranial CT that demonstrates a SAH. If the result is positive, early diagnosis improves the prognosis of the patient. With the results of MDCTA, endovascular treatment or surgery can be planned in selected cases. Both MD-CTA and DSA are imaging techniques utilizing ionizing radiation. The radiation dose of CTA is greater than that of conventional CT, but is less than that of DSA (27). However, one of the disadvantages of CTA is its inability to demonstrate time-related characteristics of artery and aneurysm filling. For example, this feature may be important in determining which ACA preferentially fills an AcoA aneurysm and on which side the craniotomy should be performed for the aneurysm repair. But in the case of AcoA aneurysms, the anatomic information provided by CTA, including relative precommunicating ACA size and the direction of aneurysm growth, may help predict the side from which the aneurysm is preferentially filled (14).

In conclusion, in this study, cerebral MDCTA correlated perfectly with DSA in the detection of intracranial aneurysms of the AcoA and MCA; however, slightly lower detection was noted in PcoA and ICA supraclinoid segment aneurysms as compared with other locations. This should be kept in mind when interpreting MDCTA at these locations.

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