Comparison of CTA with 6-row detector VS DSA and 3DRA in intracranial aneurism diagnosis

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Abstract

Aim: Four-section CT angiography (MSCTA) accurately detects aneurysms at (or more) than 4 mm, but is less accurate for those less than 4 mm. Our purpose was to determine the accuracy of 6-section MSCTA (6MSCTA) in aneurysm detection vs. combined digital subtraction angiography (DSA) and 3D rotational angiography (3DRA).
Methods: In a retrospective review of patients studied because of acute symptoms suspicious for arising from an intracranial aneurysm, 96 subjects were included who had undergone CT angiography (CTA). Of these, 40 patients underwent catheter DSA. The most common indication was subarachnoid hemorrhage (SAH; N=57). Two neuroradiologists independently viewed CTA, DSA and 3DRA.
Results: A total of 36 aneurysms were found in 25 patients. Reliability was excellent (κ=0.98) between the aneurysm size on 6MSCTA and DSA/3DRA. Ultimately, 36 aneurysms were detected by DSA/3DRA in 25 of the 40 patients who underwent conventional angiography. One 6MSCTA was false negative; one 1.5-mm aneurysm was missed by CTA. Also, in four patients, CTA detected only one aneurysm, but DSA/3DRA detected two aneurysms. The sensitivity of CTA for aneurysms less than 4 mm was 64%, whereas it was 100% for those 4-10 mm and more than 10 mm (overall: 84%).
Conclusions: This study suggests that 6MSCTA is appropriate in detecting aneurysms less than 4-mm. However, the combination of DSA with 3DRA is currently the most sensitive technique to detect untreated aneurysms and should be considered in suspicious cases of SAH where the aneurysm is not depicted by 6MSCTA, because 6MSCTA may occasionally miss aneurysms less than 3-4 mm of size. A consequence of this conclusion is the protocol of aneurysmal SAH diagnosis.

Keywords: CTA, DTA, 6-row detector, 3DRA, intracranial aneurism.

Introduction

Aneurysms are one of the most important causes of subarachnoid hemorrhage (SAH), with a fatality rate between 40% and 60%, whereas misdiagnosis is associated with further increased morbidity and mortality (1,2). Traditionally, catheter digital subtraction angiography (DSA) has been considered the "gold standard" for aneurysm detection; currently, 3D rotational DSA (3DRA; obtained via the catheter angiogram) may offer increased aneurysm detection, with improved visualization of an aneurysm's configuration and contour compared with DSA alone (3-6). However, the combination of DSA/3DRA is invasive, time consuming, and may involve neurologic complications in 1%-2% of the cases (7,8). Hence, an accurate, noninvasive test would be invaluable in the emergent screening for SAH.

In this regard, multisection CT angiography (MSCTA) has shown a good potential in the noninvasive detection of intracranial aneurysms.

Because there has been little literature comparing combined DSA/3DRA with 6-section MSCTA (6MSCTA), our purpose was to evaluate the accuracy of 6MSCTA in aneurysm detection with special attention to smaller (4 mm) aneurysms.

Methods

Patient recruitment

In a retrospective review of a 1-year period (January 2012 through December 2012), patients who had clinical histories requesting urgent evaluation for intracranial aneurysm via 6MSCTA (N=97) at the Neuroradiology Department of the University Hospital Center "Mother Teresa" and the "Medicare" diagnostic center, were identified via CT log. Forty of 96 patients who underwent CTA and DSA were included in this study.

Review of the cases

Patients underwent CTA after CT or after detecting SAH. The most common sign/symptom was a sudden thunderclap/worst headache of life.

6MSCTA and DSA/3DRA were interpreted by two different neuroradiologists. The neuroradiologist who interpreted CTA knew the clinical symptoms. DSA/3DRA examination was interpreted by a neuroradiologist who knew the clinical background and the findings of initial NECT/CTA. The CTA results were usually available at the time of DSA evaluation.

In addition, our intent was to make sure that questionable areas on the CTA were evaluated on the DSA/3DRA to include false-positives detected by CTA. DSA and 3DRA (when present) or surgical results were accepted as the "gold standard" for the presence of aneurysm. Also, the maximum size measurements of the aneurysms were obtained. Each CTA's quality was also graded as "good" (diagnostic quality with adequate arterial visualization on 3Dvolume rendered [3D-VR], maximum intensity projection [MIP], and multiplanar reformats [MPRs]); "fair" (mildly limited 3D reconstruction visualization of arterial structure due to contrast bolus or motion, though with adequate MPRs); "poor" (severely limited [but visible] arterial visualization with inadequate MPR images); or "failed" (complete lack of visible arteries).

CTA technique

CTAs were obtained by a 6-channel multidetector CT scanner (Simens Emotion 6). An 18 or 20 gauge needle was placed in the antecubital vein. The CTAs were initiated via "triggering" off of the aortic arch at an HU threshold of 140 HU after the intravenous contrast bolus was initiated; this delay varied, but typically ranged from 10-25 seconds. Contrast material (Ultravis 300 Bayer) was injected at a rate of 3.5-4 mL/s via power injection for a total volume of 80 mL in each study. The scanning parameters included 120 kV, effective milliamps of 300 per section, collimation of 1 mm, a reconstruction interval of 0.9 mm with a 0.45 mm overlap, and a table speed of approximately 0.85 mm/s. The section revolution time was 0.6 seconds. Data for the CTA were obtained in a caudal-cranial direction from the level of approximately C1–2 up through the vertex of the skull, for a scan time of 10.09 seconds.

Neuroradiologists measured the aneurysm's maximum size on each positive CTA in a similar projection as that of the 3DRA to obtain a correlation of the maximum size between modalities. The largest diameter of each aneurysm was measured in millimeters and graded as large (>10 mm), medium (4-10 mm), or small (<4 mm), in accordance with previous reports (10).

DSA and 3DRA techniques

DSA (Siemens Axiom Artis Workstation Leonardo) was performed with femoral catheterization by the Seldinger technique with a monoplane DSA unit that has rotational capabilities. Typically, 6-9 mL of nonionic contrast (Ultravis 300 Bayer) was used per run, usually consisting of one anteroposterior (AP), 1 lateral, and 1-2 oblique views. The runs consisted of a 38-cm FOV (AP), 30 cm FOV (lateral and oblique), and a 1024 x 1024 matrix. The spatial resolution was 0.32 x 0.32 mm.

While the catheter was within each of the three major arteries (bilateral internal carotid and ≥1 vertebral artery), standard AP, lateral and oblique DSA runs were obtained; a single rotational 3DRA acquisition was typically obtained before removing the catheter from each vessel; if the contralateral vertebral artery was not visualized on 3DRA, then a single contralateral vertebral artery DSA run was performed to clear the posterior inferior cerebellar artery. The 3DRA acquisition typically involved a 1- to 3-second delay, followed by a 4-mL/s injection for a total of 16-20 mL; the tube rotation arc was 240° (only 1 rotation used) with a rotation time of approximately 4.0-4.5 seconds. These were reconstructed in a 256 x 256 matrix.

The 3DRA runs were sent immediately on completion of the procedure to an adjacent 3D workstation (Siemens Axiom Artis Workstation Leonardo). The size of each aneurysm was calculated on the DSA run after magnification correction. A neuroradiologist measured each aneurysm's maximum size on 3DRA (if available) in a similar projection as that measured on the CTA to obtain a correlation of the maximum size between modalities. Again, the largest diameter of each aneurysm was measured in millimeters graded as large (>10 mm), medium (4-10 mm), or small (<4 mm), in a similar fashion to the CTA measurements.

Statistical analysis

For statistical analysis, tables were constructed, with the sensitivity, specificity, positive/negative predictive values, and accuracy calculated both on a per-aneurysm and per-patient basis via comparison of MSCTA to 3DRA/DSA.

Values of the reliability coefficients (weighted "κ") were calculated to assess the extent of the agreement between the two modalities regarding the maximum size measurement. A "κ" value of 0.8 or above indicates excellent agreement; a range of 0.6-0.8 indicates good agreement; values from 0.4-0.6 indicate moderate agreement; a range of 0.4-0.2 indicates mild agreement, and; values less than 0.2 indicate no agreement.

Results

A total of 96 patients (55 women and 41 men; age range: 23-81 years) clinically requiring emergent CTA for intracranial aneurysms showed up during a 1-year period; 57 of these exhibited SAH. Of the 96 patients, 40 individuals underwent conventional angiography, whereas 36 aneurysms (25 patients) were confirmed by DSA.

The average age of the 40 patients ultimately included in the study was 53.2±8.72 years (range: 33-70 years). Fourteen (35%) of these patients were males. Table 1 presents the distribution of SAH among patients included in the study.

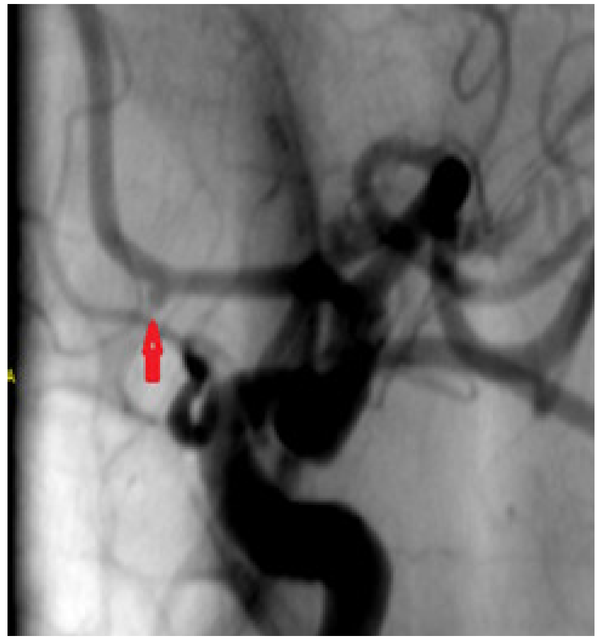
Table 1. SAH percentage

SAH	Number	Percentage
No	3	7.5
Yes	37	92.5
Total	40	100

One patient underwent conventional angiography after a negative CTA; conventional angiography depicted an aneurysm on DSA that was missed on CTA. This false-negative CTA occurred in a patient with SAH and the subsequent DSA/3DRA identified a 1.5-mm ACoA (ACoA: anterior communicating artery) (Figure 1).

Figure 1. False negative CTA: ***A 60-year-old woman suspected for intracranial aneurysm, underwent CTA. CTA showed blood in prepontin, suprasellar, sylvien bilateral, interhemispheric region, right lateral ventricul, but no aneurysm was detected. Then DSA depicted a 1.5mm aneurysm of McA. A the arrow shows the location of the aneurysm not detected by CTA B arrow point the aneurysm.***

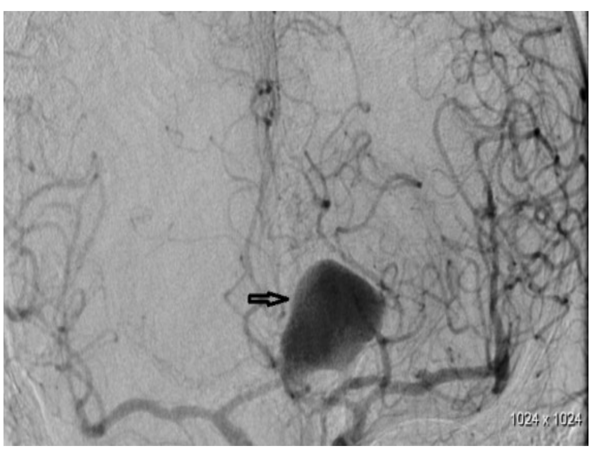
A DSA



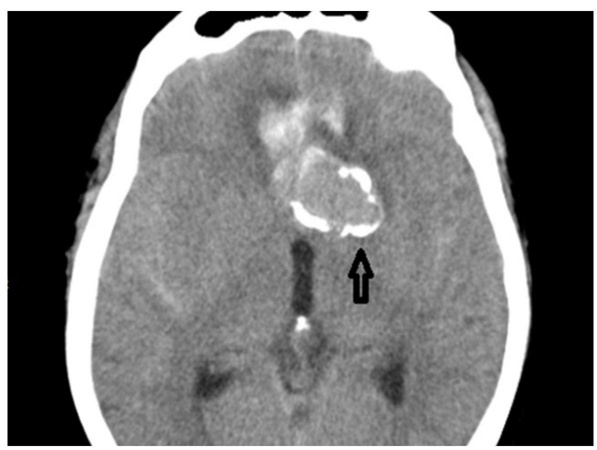
B CT

Figure 2 displays a case with SAH from a large aneurism (23 mm in A1-A2 dex.), whereas figure 3 exhibits a SAH case with multiple aneurisms.

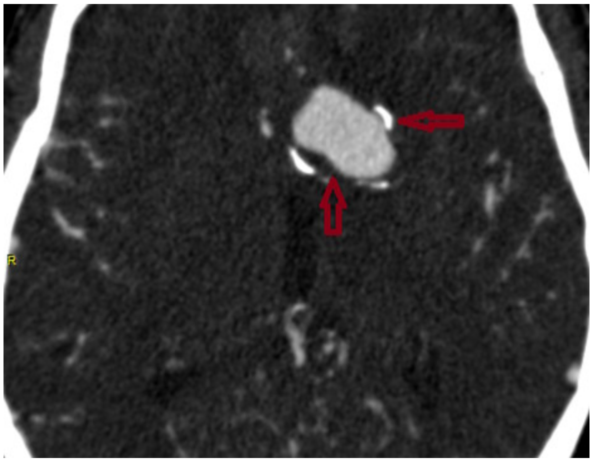
Figure 2: ***A 45 year-old woman with SAH from a large aneurysm, 23mm in size, in A1-A2 dex. CTA and DSA detected the aneurysm. CTA depicts an aneurysm partially thrombosed and with calcified walls.(B,C). D measurements made in 3D DSA. Results yield are smaller than in CTA because the thromb and calcification are not showed in DSA.***



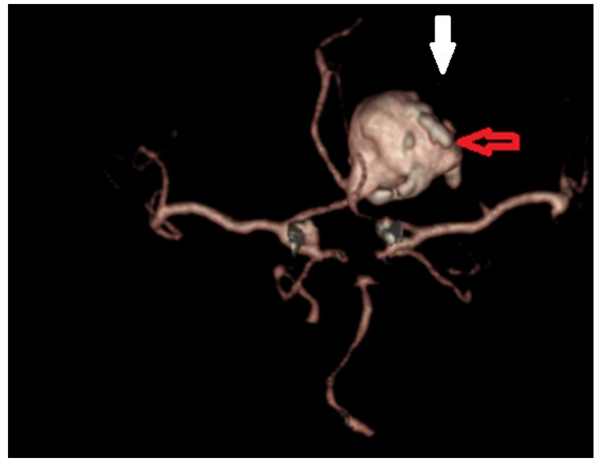
A CTA



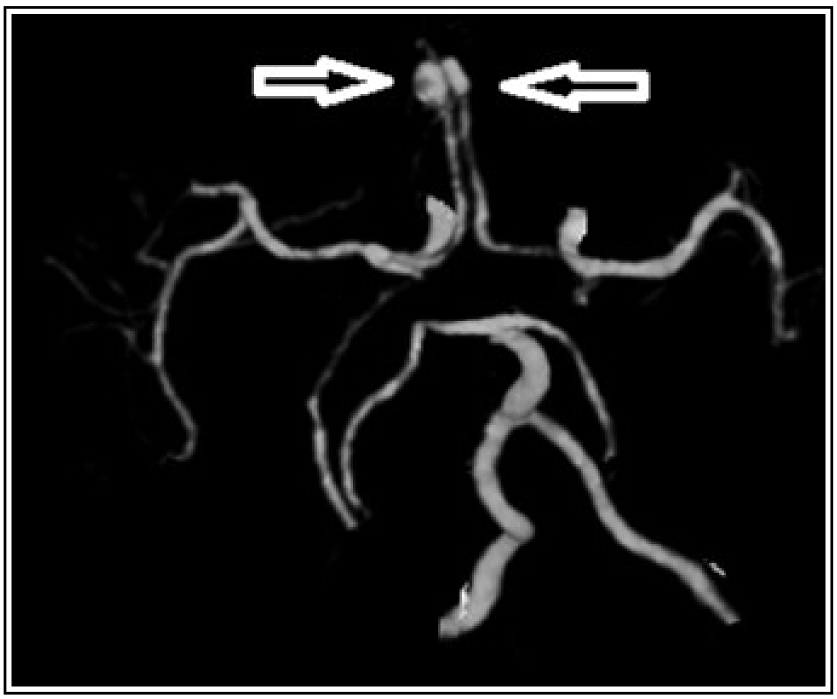
B DSA



C CT MPR

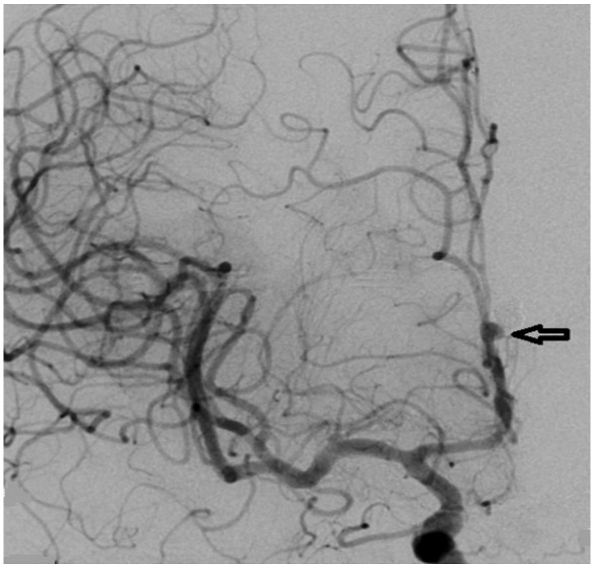


D CTA riconstruction.

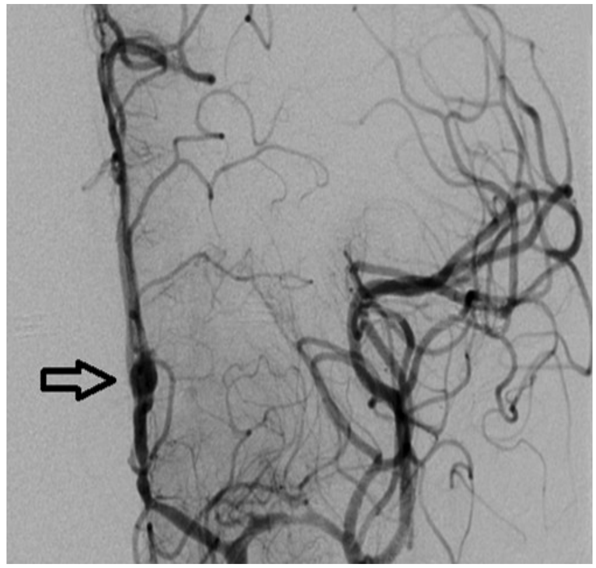


E 3D DSA

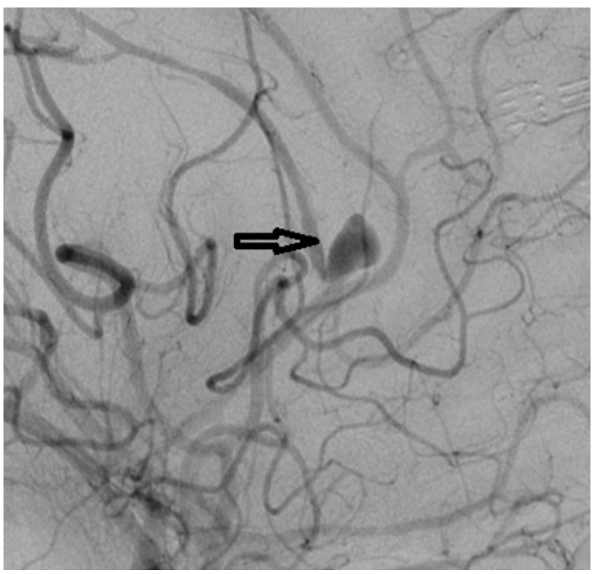
Figure 3. CTA, DSA: ***A 48 year-old male have SAH and multiple aneurysms, two pericallosal aneurysms 6mm dhe 4mm.***



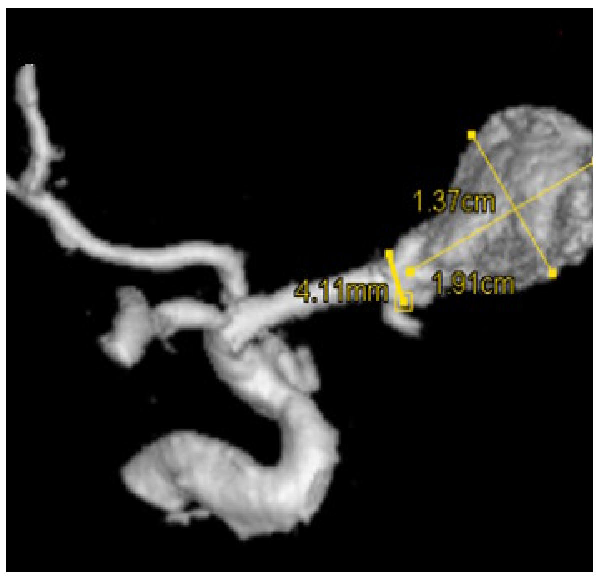
A DSA



B DSA



C DSA



D CTA

Table 2 presents DSA parameters among study participants.

Table 2. DSA parameters

Aneurysm size	Sensitivity	Specificity	PPV	NPV	Accuracy
Small	100%	100%	100%	100%	100%
Medium	100%	100%	100%	100%	100%
Large	100%	100%	100%	100%	100%

The sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and accuracy of MSCTA in detecting each aneurysm size on a per-aneurysm basis are shown in Table 3.

Table 3. 6MSCTA parameters

Aneurysm size	Sensitivity	Specificity	PPV	NPV	Accuracy
Total	84%	100%	100%	79%	90%
Small	64%	100%	100%	79%	84.60%
Medium	100%	100%	100%	100%	100%
Large	100%	100%	100%	100%	100%

On the basis of size, the sensitivity of 64MSCTA was 100% for "large" aneurysms more than 10 mm, 100% for aneurysms 4-10 mm, and 64% for aneurysms less than 4 mm (overall sensitivity was 84%). Regarding the maximum size of each aneurysm, there was excellent correlation between the maximum size on CTA and 3DRA. The reliability coefficient was $\kappa=0.98$, indicating excellent correlation between the maximum aneurysm size measured via both modalities.

Among patients with aneurysms on CTA confirmed by conventional angiography (N=25), there were: 13 aneurysms less than 4 mm in size; 18 aneurysms ranging from 4 to 10 mm, and 5 aneurysms at more than 10 mm by using the DSA/ 3DRA size as the standard. Eleven (27.5%) of the 40 patients had more than 1 aneurysm (Table 4).

Table 4. Aneurysms percentage

Aneurysm	Number	Percentage
No	15	37.5
Yes	14	35.0
Multiple	11	27.5
Total	40	100.0

Table 5 presents the distribution of aneurisms by location among patients included in the study.

Table 5. Aneurysms locations

Size	Aneurysms locations
Small	MCA bifurcation : n=3; AcoA: n=3; AcoP: n=4; Carotido-ophtalmic: n=0; Basilar tip: n=0; Pericallosal: n=3
Medium	MCA bifurcation: n=2; AcoA: n=2; AcoP: n=4; Carotido-ophtalmic: n=2; Basilar tip: n=4; Pericallosal: n=4
Large	MCA bifurcation: n=1; AcoA: n=1; AcoP: n=1; Carotido-ophtalmic: n=2; Basilar tip: n=0; Pericallosal: n=0
Total	MCA bifurcation: n=6; AcoA: n=6; AcoP: n=9; Carotido-ophtalmic: n=4; Basilar tip: n=4; Pericallosal: n=7

Discussion

CT is the optimal method for SAH diagnosis (95% positive in the first 24 hours). CTA, a non-invasive method, is utilized to decide whether to perform surgery or embolization.

Optimally, the work-up of SAH would include the use of noninvasive testing to efficiently guide therapy of intracranial aneurysms before embolization or surgery. The need for an initial noninvasive work-up by CTA cannot be understated; the current 6-section scanners can yield an evaluation of the cervical and cranial vasculature in the same sitting and can potentially decrease the amount of time necessary to perform conventional angiography, embolization, or even surgery by depiction of the vasculature and adjacent structures. Benefits of an initial, noninvasive work-up include knowledge of the anatomy before endovascular therapy, the ability to avoid the inherent risks of invasive conventional angiography, the ability to decide that a patient should immediately undergo surgery when endovascular therapy is not feasible, and the ability to detect other, less common causes of SAH (9-17). In addition, there is a significant potential for MSCTA in cases where aneurysms are of low likelihood, such as SAH in patients after significant trauma, or in patients without hemorrhage but with severe headaches and a positive family history of aneurysm. Hence, with the increasing speed, coverage, and resolution of MSCTAs, it has been increasingly accepted for screening of the craniocervical arteries (9-17).

Over the past 10-12 years, the sensitivity and accuracy of CTA in detecting intracranial aneurysms has progressively improved during the evolution from single-section CTA (SS-CTA) to the 64-MSCTA. The sensitivities in initial studies of SSCTA has varied widely, ranging from 67% to 100%, with significant difficulty noted in detecting aneurysms less than 4 mm (17-22). In two reports, the sensitivity of 6MSCTA was 92%–98% and the specificity 100%, with an NPV of 82%-99% in aneurysm detection compared with DSA. In our study, the overall sensitivity of 6MSCTA was 84%, 64% for aneurysms<4mm, and 100% for aneurysms≥4mm. Thus, 6MSCTA is more sensitive than 6MSCTA. With the advent of newer, faster multidetector CT scanners, there can be thinner collimation, improved z-axis resolution, and contrast bolus timing, potentially leading to improved detection of these smaller aneurysms.

3DRA via conventional angiography has been increasingly used over the past ten years in evaluating aneurysms, because the combination of 3DRA with DSA demonstrates more aneurysms than DSA alone (3-6). However, a 3DRA examination is still dependent on conventional angiography, which is invasive with inherent risks, involves a significant amount of time and patient preparation, and is potentially long when vasculature is tortuous and difficult to catheterize. CTA can potentially avoid many of these limitations; one such example is evaluating the anterior communicating artery in SAH, where the artery can be difficult to visualize after various manipulations. Similarly, the uncommon PICA aneurysm can be excluded in SAH cases via CTA, avoiding catheterization when a small or hypoplastic vertebral artery is present. Therefore, although 3DRA may currently be slightly more sensitive for aneurysm detection than 6MSCTA, CTA is invaluable in SAH and other scenarios of acute intracranial hemorrhage.

Regarding aneurysm size, in our study there was excellent intermodality agreement in measuring the maximum aneurysm size on CTA versus 3DRA as noted by the reliability coefficient (the weighted "κ"). The question may arise as to whether CTA can accurately measure aneurysms less than 4 mm in size. The way to directly address that question would be to compare CTA with surgical findings for a large number of cases of small aneurysms less than 4 mm in size. To our knowledge, this direct comparison for small aneurysms has not been performed between CTA and surgery, though some previous studies may offer some insight into this subject. First, an experimental model obtained via postmortem reconstruction (by using resin) of true aneurysms demonstrated that the volumes (though the actual aneurysms sizes are not reported) measured by 3DRA are minimally more accurate than CTA, though both slightly overestimate the volume, from 7% to 11%, without a statistically significant difference between CTA and 3DRA (23), as also noted in our study.

In a study by Tanoue et al (5) comparing 3DRA with surgery, there is a table comparing the 3DRA neck size to surgery, noting that the neck size was usually underestimated by 3DRA, even for the 2- to 3-mm necks. Villablanca et al (23) describe CTA's accuracy in smaller aneurysms (<3-4 mm) compared with surgery or DSA, which they considered accurate in small aneurysm characterization, but they do not provide a correlation of size measurements between modalities or with surgery. Hence, it may be that CTA and/ or 3DRA may slightly overestimate or underestimate the maximum aneurysm size based on the scant data available, but overall these are considered to be generally adequate for the aneurysm size and the neck size measurements to clinically decide whether to perform surgery or embolization (5,9,12,17). The determination as to whether 6MSCTA or 3DRA can accurately measure the size of smaller (<3-4 mm) aneurysms may necessitate a study directly comparing these modalities with surgically clipped tiny aneurysms, or at least an experimental model reconstructed from cadavers.

In addition, because most of the patients showed up with SAH, expectation bias could lead to a falsely elevated sensitivity of 6MSCTA. Furthermore, there is no absolute evidence that an aneurysm was not present in the 6MSCTA patients deemed negative for aneurysm who did not undergo catheter DSA; however, there was 100% NPV in those who did undergo conventional angiography.

Also, there is debate regarding the optimal technique for contrast bolus and area of coverage on MSCTA. For example, a "triggering" function can be used to time the optimal contrast bolus (as in our study) versus a standard delay time. In addition, although we typically scanned only the head on MSCTA, some may consider a combined head and neck MSCTA essential to evaluate the entire cervical vasculature before catheter DSA; however, this probably would cause increased interpretation time and radiation dosage and could lead to misinterpretation if bolus timing is optimized for the cervical rather than the cranial vasculature.

In reality, if a CTA has been performed, the angiographer does not perform the catheter angiogram unbiased and tailors the examination accordingly. Actually, conventional angiography is usually not performed in cases that have a high likelihood to be negative, such as in the setting of a negative CTA. Hence, the mere presence of a DSA/3DRA examination creates expectation bias. In addition, our use of the combination of DSA/3DRA as a comparison with MSCTA, rather than solely DSA (as in most previous studies) may be seen as a bias against MSCTA (9-13). However, we feel that using the DSA/3DRA as a comparison standard is more appropriate since this combination is more accurate in detecting and characterizing aneurysms than DSA alone, as suggested by previous studies reported in the international literature (3-6). Potential biases of our study in favor of CTA could include the 4-mm cutoff size for small aneurysms. The reason that 4 mm (and not 3 mm) was used as a cutoff for small aneurysms was based on previous works in an attempt to use a similar system for comparisons with the literature, because previous works by Wintermark et al. (9) and Teksam et al. (10) have established that the sensitivity for aneurysms at (or more than) 4 mm was 97%-100% with 4MSCTA (11). Hence, our intent was to follow these works to focus the debate on the smaller aneurysms less than 4 mm in size, for which MSCTA has previously shown a lower sensitivity in aneurysm detection. Other authors have reported the use of 3 mm as a cutoff, which is also valid, and potentially future studies could use this threshold to focus on even smaller aneurysms (12,13).

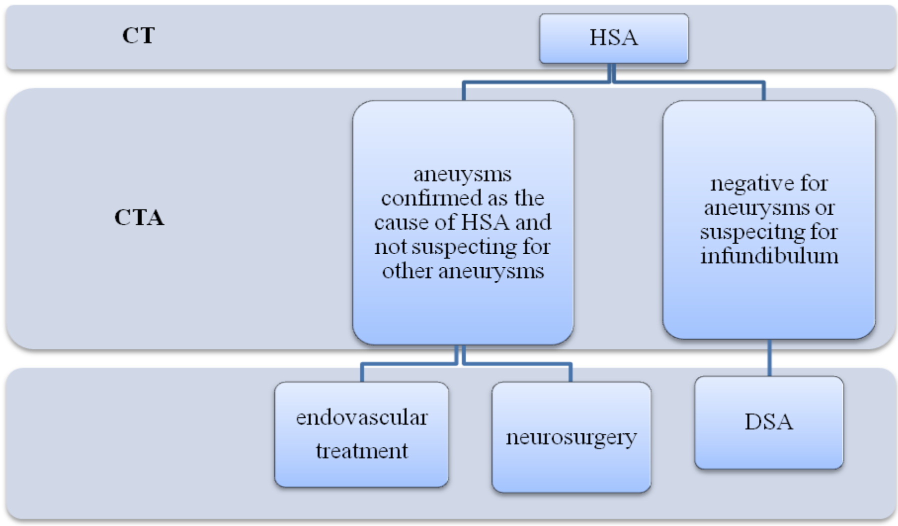
Conclusion

This study suggests that 6MSCTA is appropriate in the detection and delineation of intracranial aneurysms; however, this is still not quite as sensitive as the combination of DSA/3DRA.

Subsequently, if it is imperative to know whether there is an aneurysm, such as in the setting of SAH, and CTA does not reveal it, then DSA in combination with 3DRA is indicated, because 6MSCTA may still miss aneurysms less than 3-4 mm of size in particular locations.

In conclusion, the protocol of aneurysmal SAH diagnosis is displayed in the algorithm below (Figure 4). When HSA is suspected, CT is performed, which confirms HSA. Subsequntly, CTA is performed. When the culprit aneurysm is confirmed and there is no suspect for other aneurysms, the patient undergoes endovascular treatment or surgery. The patient undergoes DSA when CTA negative and SAH is present, or when there are suspects for aneurysms or infudibulum.

Figure 4. Protocol of aneurysmal SAH diagnosis



Conflicts of interest: None declared.

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