Usefulness of multislice computerized tomography angiography in preoperative diagnosis of ruptured cerebral aneurysms

Apport de l’angioscanner cérébral multicoupe pour le diagnostic préopératoire des anévrismes rompus intracrâniens

E. Gerardin\textsuperscript{a,\ast},\textsuperscript{b}, B. Daumas-Duport\textsuperscript{c}, E. Tollard\textsuperscript{a}, O. Langlois\textsuperscript{d}, J.-N. Dacher\textsuperscript{a, b}, E. Clavier\textsuperscript{a}, F. Proust\textsuperscript{d}

\textsuperscript{a} Department of Neuradiology, Hôpital Charles Nicolle, University of Rouen, France
\textsuperscript{b} LITIS, EA 1108, University of Rouen, France
\textsuperscript{c} Department of Neuradiology, Hôpital G et R Laennec, University of Nantes, France
\textsuperscript{d} Department of Neurosurgery, Hôpital Charles Nicolle, University of Rouen, France

Available online 25 September 2009

KEYWORDS
Cerebral aneurysm; Multislice computed tomographic angiography; Digital subtraction angiography; Subarachnoid hemorrhage

Summary
Objective. — Non-invasive imaging methods have become primordial in subarachnoid hemorrhage. The aim of our study was to evaluate the sensitivity and specificity of multislice computed tomographic angiography (MSCTA) for the diagnosis of cerebral aneurysm.

Methods. — The 28 included consecutive patients with SAH underwent both MSCTA and digital subtraction angiography (DSA). The MSCTA studies were interpreted by two independent readers (A and B) for the presence, the location and size of the aneurysm comparatively to the DSA as reference examination.

Results. — In 20 patients, 38 aneurysms were diagnosed and in eight no aneurysm was found. Per patient basis, the diagnostic sensitivity and specificity were excellent. Per aneurysm basis, the diagnostic sensitivity and specificity of MSCTA were, respectively, 97.4 and 100\% for reader A, 100 and 100\% for reader B. For aneurysms less than 3 mm, sensitivity was 100\% for both readers. Interobserver agreement was excellent for the detection of aneurysm (κ = 0.98, 95\% CI [0.96–1]). Intertechnique and interobserver agreements were excellent for the measurement of aneurysms (slope = 0.86, r = 0.91 p = 3.1 \times 10^{-7} and slope = 1.04, r = 0.99, p < 10^{-6}, respectively).

Conclusion. — MSCTA was an accurate and reproducible non-invasive imaging technique for preoperative diagnosis of ruptured cerebral aneurysm. The MSCTA may be proposed in first intention after the diagnosis of SAH was established, with special care regarding injection procedure and a strict reading method using native images and thin MPR.

© 2009 Elsevier Masson SAS. All rights reserved.

\ast Corresponding author.
E-mail address: emmanuel.gerardin@chu-rouen.fr (E. Gerardin).

0150-9861/ - see front matter © 2009 Elsevier Masson SAS. All rights reserved.
doi:10.1016/j.neurad.2009.07.004
Introduction

The ruptured cerebral aneurysm is the cause of 85% of subarachnoid hemorrhage (SAH), with 50% mortality rate [1] from the population-based studies. The digital subtraction angiography (DSA) is considered as the gold standard examination to detect cerebral aneurysm. Nevertheless, this invasive, time consuming, may be responsible of neurological complications in 2.63% [2]. Hence, an efficient non-invasive examination, consuming few time, would be suitable in the emergency investigation of SAH.

The multislice computed tomography angiography (MSCTA) is playing an increasing role in the exploration of patients with SAH. Over the past 9 to 10 years, the sensitivity of CTA in detection intracranial aneurysms has progressively improved from single section CTA to four MSCTA to the current routine use of 16 and 64 MSCTA. The first studies with single section CTA showed sensitivity widely ranging from 73 to 100% [3—5], with a constant disability to detect small aneurysms smaller than 3 mm in diameter. The use of new generation MSCTA (16 and 64 detectors) allowed infra-millimeter acquisition, and, recent studies reported a diagnostic sensitivity per aneurysm ranging from 95.5 to 100% [6—9]. Nevertheless, the efficiency in the detection of small aneurysm remained mild because the diagnostic sensitivity varied between 77.8 and 92.3% [6—9].

The objective of our study was to evaluate the diagnostic value of MSCTA in an emergency department, with special emphasis on the smaller aneurysms.

Patients and method

Study design

This retrospective study analyzed the diagnostic value of MSCTA in SAH using DSA as reference examination. The primary objective was to calculate diagnostic sensitivity and specificity of MSCTA in detecting the ruptured and associated aneurysms. The secondary objectives were to calculate these values to depict small aneurysms (< 3 mm) and to determine the interobserver agreement for the diagnostic values and for the aneurysm measurement.

Patient population

The inclusion criteria to compose this consecutive population were:

- patients with SAH confirmed by CT scan or lumbar puncture on a period of 10 months;
- MSCTA carried out at admission;
- diagnostic confirmation established by pre procedural angiography, with at least a four axis acquisition.

The exclusion criteria were:

- death of the patient before performing MSCTA or DSA;
- patients without preprocedural four axis DSA.

At admission, the initial neurological status was classified according to the WFNS classification [10] and the severity of bleeding on CT-scan was graded according to the Fisher’s classification [11]. For treatment assignment when the SAH cause was an aneurysm, the neurovascular interdisciplinary team consisting of interventional neuroradiologist (EC) and vascular neurosurgeons (FP, OL) jointly discussed the obliteration procedure for each aneurysm using both MSCTA and DSA. The choice of optimal method of an early aneurysm treatment on a per patient basis was based on the evaluation of the clinical grade, the patient age, the presence of hematoma, the location of aneurysm and the morphologic features of aneurysm (size and branches arising from the aneurysmal sac and neck).

Reference examination

The DSA was performed via a transfemoral approach after induction of analgesia or under general anesthesia for the uncooperative patients with a DSA unit Multistar TOP (Siemens AG, Erlangen, Germany). Four vessel angiograms were obtained in anteroposterior and lateral projections for vertebral artery, completed by bilateral oblique projections (+45° and −45°) for carotid artery only. Additional focused views in the region of interest were performed on demand of the neuroradiologist. DSA was performed with a 1024 x 1024 matrix and a field of view (FOV) of 20 cm and 28 cm for anteroposterior and lateral view of carotid artery and 14 cm for the vertebrabasilar examination. If aneurysm was present, the neuroradiologist takes the measurement of maximal diameter after magnification correction. This measurement was made on the workstation after choosing the more useful view. All images were recorded on hard copy films. Conventional angiograms results were used as the standard reference.

The presence of aneurysms was evaluated on hard copy film and locations were recorded. The maximal diameter was reported if it was calculated initially.

Multislice computed tomographic angiography

All CT examinations were performed using a 16 detector row CT unit (Lightspeed, General Electric HealthCare, Milwaukee, WI, USA) with the following acquisition protocol and reconstruction parameters: axial plane scanning extending from the body of the C2 vertebra to the vertex, 0.5 s gantry rotation time, 16 x 0.625 mm collimation, 0.625 pitch, 0.625 mm slice thickness, 0.4 mm reconstruction interval and 140 kV/300 mA. The contrast agent (350—370 mgI/ml) was injected into an antecubital vein using a power injector (Medrad®; Pittsburg, PA, USA). The injection rate was 3.5 mL/s. Eighty millimetre of contrast agent was pulsed by 80 mL of saline. Bolus tracking was used to detect contrast bolus with a region of interest situated at the pulmonary artery. The data consisted of about 140 identical 0.625-mm-thick slices. Images were processed on a GE Advantage Workstation 4.2 (General Electric HealthCare, Milwaukee, WI, USA). Images processing consisted of axial, coronal, sagittal multplanar volume-reformatted (MPVR) and 3D volume-rendering (VR) reconstructions. All native data were made anonymous and burned on CD.
Reading methods

There were two neuroradiologists (EG and BDD) who interpreted first the MSCTA blinded to DSA. The analysis of MSCTA data was performed using a workstation to allow interactive reconstruction and interpretation. The MSCTA examinations were analyzed following several stages according to a written protocol:

- axial, coronal and sagittal 0.4 mm thick multiplanar reconstruction (MPR);
- multiplanar 3 to 5 mm thick maximal intensity projection (MIP);
- VR reconstructions.

MSCTA were independently reinterpreted by the same physicians (EG and BDD) from the hard copy films. In cases of discrepancies between these two observers, consensus was obtained from an additional expert in the field (FD).

At the analysis of MSCTA, the following criteria were evaluated:

- the quality of injection graded as following: 0: no peripheral venous enhancement; 1: weak venous enhancement; 2: moderate venous enhancement; 3: strong venous enhancement;
- the presence or not of cerebral aneurysm. The diagnosis was based on the axial, MPVR and VR images together. Only findings that could be confirmed on the native images were rated as aneurysm;
- the neck and maximal diameter was measured on thin oblique view (0.4 mm; MPR) parallel to the great axis of the lesion and the parent vessel. The aneurysm size, based on previously published series [3,4,7–9], was classified into three groups: < 3 mm, 3–5 mm and > 5 mm. Its location was recorded. If present, the branches arising from the aneurysm were reported;
- in cases of multiple aneurysms, the signs of rupture (e.g.: blebs, daughter sac or location of SAH) were searched and reported when positive.

Statistical analysis

The two-by-two tables were constructed from true positive, false positive, true negative and false negative results from MSCTA compared with the results of the gold standard method (DSA). The sensitivity, specificity, positive and negative predictive values were calculated on both a per-patient and per-aneurysm basis. The purpose of per-patient statistics was to test the capacity of MSCTA to diagnose at least one aneurysm in each patient. Since all patients underwent DSA examination, missing one aneurysm among several ones in a given patient (false negative for the aneurysm, but true positive for the patient) has less consequences than missing all aneurysms in the same patient (false negative for patient). Finally, the two readers retrospectively reviewed lesions that were considered as false negative or false positive at the blinded review of MSCTA. A consensual opinion was obtained as the cause of misinterpretation.

Interobserver agreement between readers for MSCTA was determined by calculating κ statistic: excellent agreement, κ = 0.81–1.00. Finally, Blant-Altmann’s graph and linear regression analysis, with calculation of Pearson’s linear correlation coefficient, were used to assess the level of intermodality and interobserver agreement regarding the measurement of the aneurysm (maximal diameter). Statistical significance was set at 0.001.

Results

Population

The population, composed of 28 patients (sex ratio M/F: 0.64, mean age: 49.9 years, [SD = 14.4], was distributed into WFNS II in 18 patients [64%], into WFNS III in five [18%], into WFNS IV in four [14%] and into WFNS V in one [4%]). The severity of bleeding on CT-scan was classified as type 1 in five patients (18%), type 2 in eight (29%), type 3 in 10 (36%) and type 4 in five (18%). Etiology of the SAH was a ruptured aneurysm in 20 patients (71%) and 18 associated aneurysms were detected. These 38 aneurysms were distributed as follows: single in 12 patients, double in five, quadruple in one and sextuple in two. They were located as follows: 11 on the anterior communicating artery (AComA), six on the middle cerebral artery (MCA), five on the top of internal carotid artery (ICA), four posterior communicating artery (PCoA), three on the posterio inferior cerebellar artery (PICA), three on the pericallosal artery, two on the tip of basilar artery (BA), two on the posterior cerebral artery (PCA), and two on the cavernous segment of ICA. No aneurysm was diagnosed in eight patients (29%). The final diagnosis was perimesencephalic SAH (n = 2), vertebral dissection (n = 1), traumatic SAH (n = 1), intra-axial haematoma with subarachnoid contamination (n = 2) and no etiology was founded for two patients.

All aneurysms were saccular, except one fusiform aneurysm of PICA. Only 17 measurements (45% of diagnosed aneurysm) were available on DSA. The average maximal diameter measured 5.4 mm (SD = 3.3).

Branches arising from aneurysm sac or neck were described on five malformations in four patients.

Sensitivity and specificity of MSCTA

The quality of injection was evaluated as grade 0 in 16 cases (57%), grade 1 and 2 in nine (32%) and grade 3 in three (11%).

MSCTA allowed diagnosis in all cases, even in the three cases with strong venous enhancement.

On a per patient basis, MSCTA revealed sensitivity and specificity of, respectively 100% (20/20) and 100% (8/8) for both readers.

Reader A described 37 aneurysms in 20 patients. These aneurysms were 37 true positive cases. Sensitivity, specificity, positive and negative predictive values were 97.4, 100, 100 and 88.9%, respectively. The reader B diagnosed 38 aneurysms in 20 patients, which turned out to be all true positives cases. Sensitivity, specificity, positive and negative predictive values were all 100% (Table 1).

In spite of these results, reader A failed to depict one aneurysm on MSCTA. The missed aneurysm was an associated cavernous aneurysm (6.8 mm diameter), only shown on coronal MPR and MIP views (Fig. 1).
Computerized tomography angiography in cerebral aneurysms

Table 1 Diagnostic values of MSCTA according to the size of aneurysm.

<table>
<thead>
<tr>
<th>Aneurysm size</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Positive predictive value (%)</th>
<th>Negative predictive value (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reader A</td>
<td>97.4 (37/38)</td>
<td>100 (8/8)</td>
<td>100 (37/37)</td>
<td>88.9 (8/9)</td>
</tr>
<tr>
<td>Reader B</td>
<td>100 (38/38)</td>
<td>100 (8/8)</td>
<td>100 (38/38)</td>
<td>100 (8/8)</td>
</tr>
<tr>
<td>&lt; 3 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reader A</td>
<td>100 (10/10)</td>
<td>100 (8/8)</td>
<td>100 (10/10)</td>
<td>100 (8/8)</td>
</tr>
<tr>
<td>Reader B</td>
<td>100 (10/10)</td>
<td>100 (8/8)</td>
<td>100 (10/10)</td>
<td>100 (8/8)</td>
</tr>
<tr>
<td>3–5 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reader A</td>
<td>100 (10/10)</td>
<td>100 (8/8)</td>
<td>100 (10/10)</td>
<td>100 (8/8)</td>
</tr>
<tr>
<td>Reader B</td>
<td>100 (10/10)</td>
<td>100 (8/8)</td>
<td>100 (10/10)</td>
<td>100 (8/8)</td>
</tr>
<tr>
<td>&gt; 5 mm</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reader A</td>
<td>94.4 (17/18)</td>
<td>100 (8/8)</td>
<td>100 (17/17)</td>
<td>88.9 (8/9)</td>
</tr>
<tr>
<td>Reader B</td>
<td>100 (18/18)</td>
<td>100 (8/8)</td>
<td>100 (18/18)</td>
<td>100 (8/8)</td>
</tr>
</tbody>
</table>

MSCTA: multislice computed tomographic angiography; ASMD: angiographie par scanner multidétecteurs.

Moreover, one tiny ‘‘blister-like’’ deformation less than 1 mm was noticed in one case by one reader on MSCTA but not visualized initially on DSA. This was not reported as aneurysm. In this case, MSCTA and DSA had described at least one aneurysm consistent with the site of haemorrhage.

In the cases of multiple aneurysms (n = 8/20, 40%), ruptured malformation was always diagnosed (location of SAH, n = 6; daughter sac, n = 3 and blebs, n = 3). Daughter sac and blebs were diagnosed the same way with DSA.

MSCTA described in four patients (20%, five aneurysms) a branch arise from the aneurysm and no branch in 13 patients (65%). In the last three cases (15%), the two readers were unable to confirm the lack of branches due to strong venous enhancement (grade 3). In these three cases, the review of DSA confirmed that no branch arose from the malformation.

Finally, appropriate therapeutic orientation could be made with MSCTA in 85% of patients (17/20) and DSA was required for three patients 15% (3/20) with ineffective enhancement.

Small aneurysms

The mean of aneurysms maximal diameters was 5.5 mm (SD = 3.6) with an aneurysm neck of 2.7 mm (SD = 0.99). According to MSCTA measurement (the average of two independent measurements), 10 aneurysms (26%) were inferior to 3 mm, 10 (26%) were 3 to 5 mm and 18 (47%) were superior to 5 mm. MSCTA allowed the detection of all the small aneurysms (< 3 mm) (Fig. 2) described by DSA, with a sensitivity of 100% for both readers; for 3 to 5 mm, it was 100% and for less than 5 mm, it was 97.4 and 100% for reader A and B, respectively (Table 1).

Interobserver agreement

The interobserver agreement for MSCTA was excellent (κ = 0.98, CI [0.96–1]) on a per aneurysm basis. The calculation of Pearson’s linear correlation coefficient for aneurysm size on a per-aneurysm basis demonstrated a very good agreement between techniques (DSA, n = 17 measurements).

Figure 1 Angiographic images showed aneurysm of the intracavernous section of ICA (6.8 mm, arrow). A, B. Preoperative studies including a 2D MPR MSCTA coronal reconstruction (A) and a 2D DSA anterior view. Only coronal reconstruction clearly demonstrated this aneurysm.

Figure 2 Angiographic image of an associated 1.9 mm aneurysm (white arrow) of the posterior communicating artery (PComA). A–D. Preoperative studies including 2D right anterior lateral view (A), axial and lateral MSCAT image (B and C) and 3D VR MSCTA lateral reconstruction. Note the wide ostium of choroidal artery (black arrow).
with slope = 0.86, \( r = 0.91 \times 10^{-7} \) and between readers (MSCTA, \( n = 38 \) measurements) slope = 1.04, \( r = 0.99, p < 10^{-6} \) (Fig. 3). Finally, if no significant difference was found between readers for diameter measurement on MSCTA (Blant-Altman's results: mean -0.15; SD 0.6 mm; 95% limits of agreement: \( 4 \times 0.6 = 2.44 \) mm corresponding to \( [-1.07 \text{ mm}; 1.37 \text{ mm}] \); \( p = 0.13 \), MSCTA overestimated aneurysm measurement as regards to DSA (\( -0.85 \pm 1.4 \) mm, \( p < 0.05 \)).

Discussion

In this study, on a per aneurysm basis, the sensitivity and specificity were both 100% after analysis by reader B. Only one aneurysm of the intracavernous portion of the ICA was overlooked by the reader A. The interobserver agreement was excellent for aneurysm diagnosis and measurement, \( \kappa = 0.98 \) and \( R = 0.99, p < 10^{-6} \), respectively.

Sensitivity and specificity of MSCTA

If in the first studies with helical CT, the sensitivity on a per patient basis was low (83 to 91%) [3,4], it was dramatically improved with the advent of multi slice technology (97.7 to 100%) [7,12–15], like in our series. This implies that when an aneurysm is depicted by MSCTA in coherence with the SAH distribution based on CT-scan, DSA could be substituted by MSCTA. In our institution, MSCTA was always performed in emergency when SAH was diagnosed and contributed to therapeutic decision.

A constant disability to diagnose the small aneurysms [3–5] was notified with the used of helical CT; the diagnostic sensitivity for aneurysms less than 3 mm varied between 44 and 66.7%. Despite the routine use of 16 and 64 detectors in new generation of MSCTA, the sensitivity for small aneurysms remained between 77.8 and 92.3%. Our results reported

Table 2  Sensitivity and specificity of CTA compared to DSA for the detection of small aneurysms.

<table>
<thead>
<tr>
<th>Authors</th>
<th>Detectors</th>
<th>Thickness</th>
<th>Number</th>
<th>Size (mm)</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
<th>Review</th>
</tr>
</thead>
<tbody>
<tr>
<td>McKinney AM et al. (2008) [6]</td>
<td>64</td>
<td>0.67</td>
<td>13</td>
<td>&lt; 4</td>
<td>92.3</td>
<td>100</td>
<td>VR, MPVR, MIP, raw</td>
</tr>
<tr>
<td>Lubicz B et al. (2007) [7]</td>
<td>64</td>
<td>0.75</td>
<td>11</td>
<td>&lt; 3</td>
<td>81.8</td>
<td>100</td>
<td>VR, MPVR, MIP</td>
</tr>
<tr>
<td>Yoon DY et al. (2007) [8]</td>
<td>16</td>
<td>1</td>
<td>27</td>
<td>&lt; 3</td>
<td>77.8</td>
<td>93.3</td>
<td>VR, MPVR, raw</td>
</tr>
<tr>
<td>Tipper G et al. (2005) [9]</td>
<td>16</td>
<td>0.75</td>
<td>12</td>
<td>&lt; 3</td>
<td>91.7</td>
<td>None</td>
<td>VR</td>
</tr>
<tr>
<td>Teksam M et al. (2005)</td>
<td>4</td>
<td>1.25</td>
<td>49</td>
<td>&lt; 5</td>
<td>85</td>
<td>65</td>
<td>MIP, VR, MPVR, raw</td>
</tr>
<tr>
<td>Dammert S et al. (2004) [18]</td>
<td>4</td>
<td>1</td>
<td>18</td>
<td>&lt; 4</td>
<td>83.3</td>
<td>None</td>
<td>VR, MIP, MPVR ± rawb</td>
</tr>
<tr>
<td>Karamessini MT et al. (2004) [5]</td>
<td>1</td>
<td>1</td>
<td>15</td>
<td>( \leq 3 )</td>
<td>66.7</td>
<td>100</td>
<td>SSD, MIP, VR ± rawb</td>
</tr>
<tr>
<td>White PM et al. (2001) [4]</td>
<td>1</td>
<td>1</td>
<td>16</td>
<td>&lt; 3</td>
<td>50</td>
<td>93</td>
<td>MPVR, MIP</td>
</tr>
<tr>
<td>Korogi Y et al. (1999) [3]</td>
<td>1</td>
<td>1</td>
<td>14</td>
<td>&lt; 3</td>
<td>64</td>
<td>None</td>
<td>VR</td>
</tr>
<tr>
<td>Our series</td>
<td>16</td>
<td>0.625</td>
<td>10</td>
<td>&lt; 3</td>
<td>100</td>
<td>100</td>
<td>Raw, MPVR, MIP and VR</td>
</tr>
</tbody>
</table>

VR: volume-rendering; MPVR: multiplanar volume-reformatted; MIP: maximum intensity projection; SSD: shaded-surface display.

a Raw data and MPR were only review on cine mode.
b Only in difficult cases; when there were several readers, only the best results were noted.
values (100%) slightly higher than comparable previous studies performed with 16 or 64 detector-CTA (Table 2) [6—9]. Several factors could be considered for explaining this discrepancy. First, the spatial resolution: in the study of Yoon et al. [8], the millimeter acquisition was probably responsible for a less optimal spatial resolution. Nevertheless, the other studies (16 or 64 detectors) [6,7,9], shared an equivalent spatial resolution with infra-millimeter acquisitions. Second, the role of native acquisitions must be considered. In most of the studies, the native acquisitions were not available [7,9,16] or only reviewed in a cine mode [8]. The segmentation of arteries (or aneurysms) from adjacent bones or vessels was feasible from native slices and turned out to be suboptimal on 3D images [17]. Moreover, in the study by Tipper et al. [9], only the review of native acquisitions and MPR images allowed the diagnosis of the single missed 2 mm aneurysm of PComA. In the other articles [7,8,14], all missed aneurysms were retrospectively depicted in conjunction with DSA images, without description of procedure. In our study, like in the experience by McKinney et al. [6], native acquisitions and thin MPR (0.4 mm) projections were available and the examination was always started with conscientious review and completed by the studies of MIP and 3D VR images.

Interobserver agreements

Previous studies using single or multi detector CTA have evaluated interobserver agreement for the detection of aneurysms. If the first studies (single [4] and four slices [18] CTA) reported good mean $\kappa$ values (0.60 to 0.73), slight improvements were allowed by the use of 16 and 64 MSCTA (mean $\kappa$ values = 0.73 to 0.83) [6—8]. Our results were in agreement, showing $\kappa$ values of 0.98 (0.96—1) for inter observer agreement. Moreover, regarding the measurement of aneurysm size, previous studies [6—8,19] found an excellent agreement between technique and observer. Although Yoon et al. [8] and Lubitzcz et al. [7] found that the neck/diameter ratio of aneurysm at MSCTA was slightly higher as compared to DSA: this trend did not reach statistical significance. Our series found similar results for interobserver (diameter, $r=0.99$ and neck $r=0.87$) and intertechnique (diameter only, $r=0.91$) agreement, with a trend to overestimate diameters with MSCTA ($\pm 1.5$ mm, $p<0.05$).

Place of MSCTA in the diagnosis of SAH

Another important aim of MSCTA was its ability to triage between clipping and coiling. To choose the appropriate treatments, different factors like the clinical grade, the patient age, the presence of hematoma, the location of aneurysm and the morphologic features of aneurysm must be considered. Concerning the morphology, the sac maximal diameter, the neck width and the presence of branch arising from malformation were necessary to consider. If DSA could be substituted by MSCTA to choose an appropriate treatment, MSCTA must provide precise information regarding aneurysm morphology. Previous studies with four detectors raw scanner [20,21] showed that MSCTA could triage between treatments in 70 to 86% of patients. This percentage was improved with 64 detectors raw scanner technology [7,15] (95.7 to 100%). In our study, the morphologic features of aneurysm were correctly depicted in 17/20 patients, with the use of all types of MSCTA images (thin MPR, MIP and VR). In the three last cases, an ineffective enhancement disallowed correct analysis of aneurysm morphology, like in the study by Taschner et al. [19]. Finally, in the case of multiple aneurysms, CT and MSCTA allowed correct diagnosis of ruptured aneurysm. In our opinion MSCTA is a reliable technique for triage between clipping and coiling when injection procedure and reading method were optimal. In other cases, additional DSA remains useful.

Study limitations and potential efficiency

Our study presents some limitations: first there was a limited number of inclusions ($n=28$), nevertheless, our population of small lesions (diameters < 3 mm) was comparable to the recently published ones (16 and 64 detectors) (Table 2). Second, in the analysis of the aneurysm size, the groups were defined by using the mean measurements of MSCTA (readers A and B) as only 44% of the measurements by DSA were available. Nevertheless, as MSCTA was shown to overestimate aneurysm measurement as regards to DSA ($-0.85 \pm 1.4$ mm, $p<0.05$), small aneurysms (<3 mm) defined by MSCTA could not be statistically bigger than 3 mm if measured by DSA. Finally, only 17 diameters measurements with DSA (17/38, 44%) were available for intertechnique agreement. Nevertheless, our result was in range with the last published results [6—8,19]. Third, we did not use a 3D DSA, as our device could not perform 3D acquisitions. Recently, many studies have shown that 3D DSA could depict more small intracranial aneurysms than conventional DSA [22,23]. So, it was possible that some cases of small aneurysm were overlooked by both MSCTA and 2D DSA in our study. On another hand, one tiny ‘’blister-like’’ deformation less than 1 mm was described only by MSCTA in our study. This finding was confirmed by surgery, which seems to confirm the ability of MSCTA in detecting small lesions.

Conclusions

MSCTA was an accurate and reproducible non-invasive imaging technique for detection and measurement of intracranial aneurysm, even if it was of small diameter. Per aneurysm basis, the diagnostic sensitivity and specificity of MSCTA were, respectively, 97.4 and 100% for reader A, 100 and 100% for reader B. For aneurysms less than 3 mm, sensitivity was 100% for both readers. The MSCTA may be proposed in first intention after the diagnosis of SAH was established, with special care regarding injection procedure and a strict reading method using native images and thin MPR.

References


