Diagnosis and Treatment of Intracranial Aneurysms with 320-Detector Row Volumetric Computed Tomography Angiography

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OBJECTIVES: The objective of the study was to determine the clinical utility of 320-detector row volume-computed tomographic angiography (VCTA) in the management of intracranial aneurysms.

METHODS: Between February 2011 and May 2015, 550 patients successfully underwent 320-detector row VCTA for suspected intracranial aneurysms. Three-dimensional (3D) digital subtraction angiography (DSA) was used as the ultimate reference standard, and the sensitivity, specificity, and accuracy of both nonsubtracted and subtracted VCTA in identifying aneurysms were analyzed.

RESULTS: Nonsubtracted VCTA identified 417 aneurysms (2 false-positive readings, 12 false-negative readings). The diagnostic sensitivity, specificity, and accuracy of nonsubtracted VCTA, on a per-aneurysm basis, were 97.2%, 99.0%, and 97.6%, respectively. Subtracted VCTA identified 426 aneurysms (2 false-positive readings, 3 false-negative readings). The sensitivity, specificity, and accuracy of subtracted VCTA, on a per-aneurysm basis, were 99.3%, 99.0%, and 99.2%, respectively. No differences in diagnostic accuracy were found between subtracted VCTA and 3D DSA. Nonsubtracted VCTA, however, was observed to be significantly less sensitive than 3D DSA and subtracted VCTA. Twenty-six aneurysm cases were referred for surgical treatment based on VCTA imaging. All aneurysms were deemed completely occluded during surgical clipping. On the basis of VCTA imaging, 299 aneurysms were found suitable for endovascular coiling, of which 293 aneurysms (98%) were treated successfully.

CONCLUSIONS: The 320-detector row subtracted VCTA technique is an effective, first-line diagnostic imaging modality for surgical and endovascular treatment of aneurysms. The nonsubtracted VCTA was less accurate than the subtracted VCTA, especially for intracranial aneurysms adjoining bone tissue.

INTRODUCTION

Nontraumatic subarachnoid hemorrhage (SAH) is a neurologic emergency, associated with a high rate of mortality and severe complications.[1] Eighty percent of nontraumatic cases of SAH have been shown to be caused by a ruptured intracranial aneurysm.[2] The symptoms of aneurysmal SAH include sudden onset of severe headache, vomiting, nausea, photophobia, neck pain, and loss of consciousness.[3] Most patients presenting with a ruptured aneurysm either die of their initial hemorrhage, a rehemorrhage, vasospasm, or medical complications.[4,5] Therefore, prompt intervention remains critical for patients developing aneurysmal SAH.[6] Cerebral 3-dimensional (3D) digital subtraction angiography (DSA) represents the current gold standard for the diagnosis of intracranial aneurysms,[7,8] and its high level of accuracy allows for rapid endovascular intervention. DSA is an invasive and expensive modality, however, with a 1.3% risk for neurologic complications,

Key words
- Computed tomographic angiography
- Diagnosis
- Digital subtraction angiography
- Intracranial aneurysm
- Treatment

Abbreviations and Acronyms
3D: 3-dimensional
CT: Computed tomography
CTA: Computed tomographic angiography
D: Dome
DSA: Digital subtraction angiography
IPH: Intraparenchymal hemorrhage
MIP: Maximum-intensity projection
N: Neck
SAH: Subarachnoid hemorrhage
VCTA: Volume-computed tomographic angiography
VRT: Volume-rendering technique

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including permanent neurologic deficits that occur in approximately 0.5% of all cases.[9] Therefore, the development and evaluation of more-accurate and less-invasive imaging modalities are imperative.

Computed tomography angiography (CTA) represents a less-invasive and accurate procedure that can be easily performed from the same single-contrast material injection. Multidetector (4-, 16-, and 64-row detector) CTA with the use of helical scans represents the primary mode of screening and treatment of intracranial aneurysms, although it is not considered to be a viable substitute for DSA.[10-12] Recent clinical innovations include a 320-detector row computed tomography (CT) featuring a 16-cm-wide scanner.[3] The scanner enables full brain coverage in a single gantry rotation, enabling the acquisition of combined volumetric angiographic data after the injection of a single contrast material.[13,14] Because subtracted 320-detector row volume-computed tomography angiography (VCTA) has been shown to be comparable with DSA for the detection of intracranial aneurysms,[15] the present study was designed to evaluate the diagnostic accuracy of the 320-detector row VCTA for intracranial aneurysms and determine its clinical utility.

MATERIALS AND METHODS

Patients

Between February 2011 and May 2015, 618 patients with suspected intracranial aneurysms were enrolled in this study. Of these, 29 patients who had undergone previous surgical clipping or endovascular coiling for intracranial aneurysms and were excluded from the study, 27 patients who failed to undergo DSA because of rapid clinical deterioration were excluded, and 12 patients who were treated with emergent surgical clipping without DSA also were excluded. No adverse reactions to intravenously administered iodinated contrast material were observed. Our final study population consisted of 550 patients, including 280 men and 270 women (age range, 20–91 years; mean age = 57 years). Patients were assigned to VCTA imaging by a physician on the basis of symptoms and signs suggestive of intracranial aneurysm. The 550 patients included 368 with SAH; 63 with SAH and intraventricular hemorrhage; 27 with SAH and intraparenchymal hemorrhage (IPH); 20 with IPH; 27 with combined SAH, intraventricular hemorrhage, and IPH; 28 with headache; and 17 with oculomotor paralysis.

320-Detector Row VCTA Acquisition Studies

All 550 patients underwent a single session of VCTA via the 320-detector row volume CT (Aquilion ONE; Toshiba Medical Systems Corporation, Tochigi, Japan). Images were reconstructed with 3D adaptive iterative dose reduction (AIDR 3D; Toshiba, Otawara, Japan). After the administration of 50 mL of iodinated contrast material (Ultavist 370 mg I/mL; Bayer Schering Pharma, Berlin, Germany) at 5.0 mL/s, 20 mL of saline was injected at the same rate with an 18-gauge catheter. The CT scanning parameters were as follows: gantry rotation speed, 0.35 s/rot; width of the detector, 320 × 0.5 mm; beam pitch, 0; matrix, 512 × 512; field of view, 180–240 mm; 80 kV, 300 mA. All subjects were placed in the supine position with the head maintained in a neutral position during CT to prevent motion artifacts. The procedure was performed in the caudocranial direction, from the first cervical vertebra to the superior aspect of the frontal sinuses. Thirty-two patients with confusion or agitation or both were administered intravenous sedation, and no patient needed general anesthesia before the VCTA scan. The initiation scan time of mask and VCTA was 5 seconds and 12.8 seconds, respectively, after the start of intravenous injection infusion, and 9 phases of VCTA image volume data were obtained every 2 seconds. The 5-second rotation was considered as a noncontrast scan, (the contrast had not yet arrived in the region of interest) and was used as a mask for postprocessing.

The subtracted data were obtained by filtering the mask image volume data from the conventional unfiltered VCTA volume data. The procedure was initiated by loading all unfiltered data into the software of the console. The 9 unfiltered data were subtracted and archived as 9 new DICOM (i.e., Digital Imaging and Communications in Medicine) files by applying the subtraction process. The skull was removed automatically. After we loaded the subtracted images into the 4-dimensional application of the scanner, the VCTA images could be viewed in any desired direction similar to a DSA exam. The nonsubtracted images were reconstructed without a bone filter. These procedures enable 3D visualization on the basis of maximum-intensity projection (MIP) or volume-rendering technique (VRT).

DSA Acquisition

Selective transfemoral internal carotid angiography was performed with a biplanar DSA unit with rotation (Artis Zee Biplane; Siemens Medical Systems, Forchheim, Germany) and nonionic contrast material (Omnipaque 350 mg I/mL; Amersham Life Science, Clearbrook, Illinois, USA). Contrast material injections were carried out using a power injector (Medrad, Stellant, Pennsylvania, USA). Each acquisition was performed with 6–9 mL of nonionic contrast medium to obtain 1 anteroposterior view, 1 lateral view, and 1–2 oblique views. The catheter was inserted into both internal carotid arteries and 1 or more vertebral arteries. The procedures included a 38-cm field of view (anteroposterior), 30 cm field of view (lateral and oblique), and a 1024 × 1024 matrix. A

Table 1. Location and Number of Aneurysms

Location	Aneurysm Number
Anterior communicating artery	112
Posterior communicating artery	105 (right 56)
Internal carotid artery	90 (right 40)
Middle cerebral artery	59 (right 28)
Anterior cerebral artery	16 (right 9)
Vertebral artery	13 (right 6)
Basilar artery	13
Posterior inferior cerebellar artery	9 (right 4)
Posterior cerebral artery	5 (right 3)
Anterior inferior cerebellar artery	3 (right 2)
Ophthalmic artery	2 (right 1)