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ORIGINAL ARTICLE

Anatomical variations of the anterior cerebral arterial circle visualized by multidetector computed tomography angiography: Comparison with 3D rotational angiography

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KEYWORDS
CT scan;
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Summary
Objectives: Multidetector computed tomography angiography (MD-CTA) has become the first-line screening technique for patients with subarachnoid hemorrhage not only for detecting aneurysms, but also for providing decisive angioarchitectural information. The anterior cerebral arterial circle (ACAC) is the most common location for anatomical variations and aneurysms. The aim of this study was to assess the diagnostic performance of 64-section MD-CTA in the detection and characterization of anatomical variations of the ACAC compared with three-dimensional rotational angiography (3DRA).
Material and methods: In 104 patients, MD-CTA and 3DRA images of the internal carotid arteries were independently reviewed by two radiologists for variations, focusing on four arterial segments of the ACAC: the anterior communicating artery (ACoA); the A1 segments; the A2—A4 complexes; and the M1 segments. The percentages of variations detected by MD-CTA and 3DRA were compared using the chi-square test. Characterizations of the variations by MD-CTA compared with 3DRA were evaluated using the kappa statistic.
Results: A total of 114 variations in 624 segments (18.3%) were detected by MD-CTA compared with 90 variations in 453 segments (19.9%) by 3DRA. The difference was not significant ($P = 0.56$). In 453 selected segments analyzed with both techniques, 15 discordances in characterization were noted, mostly in the ACoA (10/15). However, the overall intertechnical κ was excellent. Sensitivity, specificity, positive predictive values and negative predictive values were all greater than 90%.
Conclusion: The overall diagnostic performance of MD-CTA in detecting anatomical variations of the ACAC was excellent compared with 3DRA. However, its lower spatial resolution led to misclassifications, especially in the ACoA.

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Introduction

Multidetector computed tomography angiography (MD-CTA) has become the first-line screening technique for patients with subarachnoid hemorrhage (SAH) not only for detecting aneurysms, but also for facilitating discussion of the appropriate method of treatment (neurosurgical clipping or endovascular coiling) [1—7]. Its spatial resolution, improved multitechnique reconstruction and faster completion of acquisitions within the arterial window, and the use of a greater number of detectors all combine to give MD-CTA high sensitivity and specificity for the detection of even small intracranial aneurysms, and the ability to provide valuable anatomical information [3—8]. Another advantage is the ease and speed of this non-invasive technique in the management of patients with SAH, and the fact that relationships between bone and blood vessels can be shown. On the other hand, with the recent advances in three-dimensional rotational angiography (3DRA), higher-resolution images can be obtained with this technique. However, digital subtraction angiography (DSA) remains the gold standard, and should be performed when MD-CTA is negative or ineffective in patients with SAH [9].

Detection of anatomical variations in the cerebral arterial circle (CAC) is important for treatment planning. Such variations are common, particularly those of the anterior cerebral arterial circle (ACAC), which includes the anterior cerebral arteries (ACAs), anterior communicating artery (ACoA) and middle cerebral arteries (MCAs) [10—16]. The ACA is usually divided into an A1 segment (between the carotid bifurcation and the ACoA), an A2 segment (from the rostrum to the genu of the corpus callosum), an A3 segment (around the genu of the corpus callosum) and A4—A5 segments (the horizontal trajectory over the corpus callosum) [10]. The MCA is divided into an M1 segment (from its origin to its main bifurcation at the limen insulae), an M2 segment (along the insula) and M3—M4 segments (cortical segments) [10]. Multiple ACoAs, hypoplasia of the A1 segment, triple ACAs and fenestrations are the most common variations found in the ACAC [10—15,17,18]. In addition, the ACAC is also the most common site of intracranial aneurysms [13]. However, knowing the basic principles of cerebral artery embryology helps to improve understanding of the genesis of the most common variations of the ACAC. In the embryological stage, the CAC is formed by three so-called ACAs — the two ACAs and the median artery of the corpus callosum (MACC) — and the anterior communicating plexus (ACoP) connecting these three arteries [19]. The MACC and the ACoP normally regress, and failure to do so leads to numerous anatomical variations such as triple ACAs or double ACoAs. In addition, some segments that should persist may abnormally regress, thereby resulting in, for example, aplasia or hypoplasia of the A1 segment [19].

The present study systematically reviewed 104 datasets of 64-section MD-CTA and 3DRA images of the internal carotid artery (ICA) in 104 consecutive patients with suspected intracranial aneurysms to assess the diagnostic performance of 64-section MD-CTA in the detection and characterization of anatomical variations of the ACAC compared with the performance of 3DRA.

Material and methods

Patients

This retrospective study initially identified 111 consecutive patients who had undergone both 64-section MD-CTA and 3DRA of one or both ICAs between May 2008 and March 2010, and all within a 24-month period (0—290 days; average: 35 days). Of these 111 patients, seven were excluded due to the poor quality of one or both procedures: six involved a major vasospasm with both techniques; and one had significant motion artifacts on MD-CTA. Ultimately, 104 patients were included in the study. All patients with acute pathology underwent both MD-CTA and 3DRA within 2 days.

MD-CTA

Helical MD-CTA was performed using a 64-slice CT scanner (LightSpeed VCT, General Electric Medical Systems, Milwaukee, WI, USA). The examination included the region from the first vertebral body up to the vertex, and used the following parameters: 120 kV; 300 mAs; and a reconstructed image thickness of 0.6 mm with 0.3-mm overlap. To ensure optimal enhancement of the intracranial arteries, 70 mL of the non-ionic contrast medium iobitridol (Xenetix® 300, Guerbet, France) was routinely used, injected intravenously at a flow rate of 4 mL/s, followed by a 40-mL saline flush using a power injector. A bolus-tracking method was also routinely used to achieve optimal synchronization of contrast-medium flow and scanning. Acquired data were transferred to a GE Advantage Workstation 4.2 (General Electric Healthcare, Milwaukee, WI, USA) for analysis and post-processing.

DSA/3DRA

Angiographic imaging was performed on a biplane neuroangiographic unit (Allura Xper FD 20/30; Philips Medical Systems, Best, The Netherlands). DSA imaging included selective injection of the ICA, with intracranial views (anteroposterior and lateral projections) supplemented by additional views as working projections where necessary. For each projection, an 8-mL bolus at a rate of 6 mL/s of contrast medium was injected with a power injector. 3DRA was performed with a 4.1-s 220° rotational run with acquisition of 122 images and injection of a 24-mL bolus at a rate of 4 mL/s of contrast medium in the ICA.

Data analysis

The data obtained by 3DRA and MD-CTA were separately, but consensually, reviewed by two experienced radiologists, who both focused on the anterior part of the CAC (ACoAs, ACAs and MCAs) and carotid tips. The MD-CTA data were read in random order; then, three to five weeks later, the 3DRA data were randomly read, with the reviewers blinded to the MD-CTA results.

For each technique, the following patient and imaging characteristics were recorded: gender; date of birth;