Dual-Energy CTA with Bone Removal for Transcranial Arteries:

Intraindividual Comparison with Standard CTA without Bone Removal and TOF-MRA[1]

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Rationale and Objectives. Dual-source computed tomography enables bone removal on computed tomographic angiographic data on the basis of simultaneous dual-energy (DE) acquisition. The aim of this study was to evaluate the impact of this technique for the assessment of transcranial arteries. Therefore, the degree of stenosis of the transcranial arteries on DE computed tomographic angiography (CTA) with bone removal was compared to those on standard CTA and time-of-flight (TOF) magnetic resonance angiography (MRA).

Materials and Methods. DE-CTA was performed using a dual-source computed tomographic scanner in 50 patients with suspected cerebrovascular disease. From the source images on DE-CTA, data sets with and without bone removal were reconstructed. TOF-MRA was performed on a 1.5-T scanner. Two blinded radiologists evaluated the segments of the internal carotid artery (C2–C7), the vertebral artery (V4), and the basilar artery for degree of stenosis. A five-step scale (0%–49%, 50%–69%, 70%–89%, 90%–99%, and 100% [occlusion]) for degree of stenosis was applied. Wilcoxon's signed-rank test was used for statistical analysis.

Results. The degrees of stenosis on standard CTA were consistent with those on TOF-MRA in all segments. In contrast, DE-CTA showed significantly higher degrees of stenosis compared to standard CTA and TOF-MRA in both C2 segments ($P < .001$). In addition, DE-CTA revealed a significantly higher degree of stenosis compared to standard CTA and TOF-MRA in the left C4 segment ($P < .01$ and $P < .005$, respectively). All other segments showed no significant differences of stenosis among TOF-MRA, DE-CTA, and standard CTA.

Conclusions. Compared to TOF-MRA, standard CTA showed similar results. In contrast, DE-CTA revealed significant overestimation of stenosis for segments with close relations to bony structures as well as in calcified stenosis. Consequently, such findings on DE-CTA require confirmation with standard CTA or MRA to eliminate false-positive results.

Key Words. Dual energy; computed tomographic angiography; bone removal; stenosis grading; comparative study.

Computed tomographic (CT) angiography (CTA) is a frequently used method for the evaluation of vessel pathologies of the supra-aortic and intracranial arteries. In particular for emergency assessment such as in acute stroke, computed tomography (1–3) is used because of its wider availability, easier patient surveillance in the emergency setting, and fewer contraindications compared to magnetic resonance imaging (eg, metal implants, pacemakers) (4,5). Data from the literature emphasize the potential of noninvasive CTA for the assessment of acute and chronic cerebrovascular disease. The advantages of magnetic resonance angiography (MRA; eg, lack of radiation exposure) have already been described elsewhere (6,7), and this method is increasingly used in the evaluation of neurologic emergencies (8,9).

Acad Radiol 2009; 16:1348–1355

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doi:10.1016/j.acra.2009.05.007

Magnetic resonance imaging of the transcranial arteries is typically performed with time-of-flight (TOF) MRA (8–10).

In contrast to MRA, the delineation of vessels adjacent to bony structures (eg, the skull base) can be limited on CTA. Several techniques have been presented to eliminate bony structures from CT angiographic data sets on the basis of region-growth algorithms, section-by-section digital subtraction, and matched mask bone elimination (11,12). These bone-removal techniques have been assessed in several studies, which have shown partially correlative results (11,12). Therefore, none of these techniques has become standard in CTA of the transcranial arteries. The recent innovation of dual-source CT technology offers a new technical approach for bone removal in CTA (13). The two tubes of a dual-source scanner can be operated at different settings. This allows the simultaneous acquisition of two data sets at different tube voltages (13,14). Theoretically, bone and contrast-enhanced vessels can be identified by the different spectra of radiation absorption at two distinct tube voltages (eg, 80 and 140 kVp). Thereby, the selective elimination of bony structures and the preservation of contrast-enhanced vessels can be achieved (13).

As is known from CTA using other techniques for bone removal (eg, bone subtraction), the degree of stenosis tends to be overestimated in case of calcified plaques or adjacent bony structures (11). Because of the methodological and physical basis of bone removal using dual-energy (DE) techniques, similar limitations may be considered.

Therefore, the aim of this study was to assess the degree of stenosis of transcranial arteries on DE-CTA with bone removal in comparison to standard CTA without bone removal (S-CTA) and TOF-MRA.

MATERIALS AND METHODS

Patient Characteristics

Fifty consecutive patients (27 men [54%], 23 women [46%]; mean age, 63.4 ± 15.3 years) with suspected cerebrovascular disease were included in this intraindividual comparative study. Patient characteristics, including age, gender, symptoms, and risk factors, are summarized in Table 1. Informed consent was obtained from patients or their next of kin according to legal requirements. The study protocol was approved by the local ethics committee.

All patients underwent as part of a routine protocol non-enhanced cranial computed tomography and CTA of the extracranial and intracranial arteries. Follow-up MRA of the transcranial and intracranial arteries using the TOF technique was performed within 48 hours (mean, 42.6 ± 5.4 hours).

Exclusion criteria for this study were contraindication to contrast-enhanced computed tomography, such as known allergic reaction to iodinated contrast agent or renal impairment (eg, serum creatinine > 1.5 mg/dL), and contraindication to magnetic resonance imaging, such as metal implants (eg, pacemakers) or claustrophobia.

Table 1
Patient Characteristics (*n* = 50)

Characteristic	Value
Age (y)	63.4 ± 15.3
Gender	
Male	27 (54%)
Female	23 (46%)
Symptoms	
Aphasia/dysarthria	14 (28%)
Hemiplegia	15 (30%)
Hemihypesthesia	6 (12%)
Vision Impairment	3 (6%)
Diplopia	6 (12%)
Vertigo	9 (18%)
Coma	2 (4%)
Cardiovascular risk factors	
Arterial hypertension	33 (66%)
Diabetes mellitus	11 (22%)
Hyperlipidemia	19 (38%)
Smoking	11 (22%)
None	9 (18%)

Data are expressed as mean ± standard deviation or as number (percentage).

Examination Protocol

All patients were examined using a dual-source 64-detector-row (32 × 2; flying focal spot technique) scanner (Somatom Definition; Siemens Medical Solutions, Forchheim, Germany) using a DE examination protocol (tube voltage, 140 kVp [tube A] and 80 kVp [tube B]; tube current–time product, 50 mAs [tube A] and 210 mAs [tube B]; collimation, 64 × 0.6 mm; rotation time, 0.5 seconds; table feed, 26.9 mm/rotation). Eighty milliliters of iodinated contrast agent (Ultravist 370; Bayer-Schering-Pharma AG, Berlin, Germany), followed by a 50-mL saline flush, was injected with an automated power injector (Stellant CT; Medrad Europe, Beek, The Netherlands), with a flow rate of 4 mL/s through a 18-gauge cannula in the right cubital vein. The start delay was determined from a test bolus injection prior to CTA.

CT angiographic data sets with two tube voltages of 140 and 80 kVp were reconstructed (field of view, 250 mm; reconstructed slice thickness, 1.0 mm). Additionally, a standard CT angiographic data set with a tube spectrum of 120 kVp was reconstructed using the DE data sets of 140 and 80 kVp (mixed tube spectrum, 120 kVp). An additional CT scan was not required for the standard data set.

All reconstructed data sets were sent to a workstation (Syngo MMWP 2008A, VA20/21; Siemens Medical