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Correlation between US-PSV and MDCTA in the quantification of carotid artery stenosis

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ABSTRACT

Purpose: Stroke is a major cause of death and serious long-lasting neurological disability and the severity of carotid artery stenosis is one of the most important determinants of cerebrovascular events. The purpose of this paper is to evaluate the correlation between multi-detector-row CT angiography (MDCTA) and ultra-sound peak-systolic-velocity (US-PSV) in the quantification of carotid artery stenosis.
Methods and material: 52 patients were retrospectively studied by using four-detector row CT and ultrasound. Each patient was assessed for stenosis degree by using NASCET method when studied by using MDCT and by using PSV when studied by using US. Statistic analysis was performed to determine the entity of correlation (method of Pearson) between MDCTA and US-PSV. The Bland-Altman analysis was applied to assess the level of inter-technique agreement.
Results: Sonographic PSV measurements ranged from 70 to 589 cm/s. Distal ICA velocities ranged from 29 to 238 cm/s. Linear regression analysis showed a good correlation (r^2 = 0.613) between MDCTA-NASCET linear percentage stenosis and PSV and measured. PSV value that corresponded to a NASCET linear percentage stenosis of 70% was 283 cm/s and with this values sensitivity, specificity, positive predictive value (PPV) and negative predictive value (NPV) were 75%, 88.6%, 90.7% and 70.5%, respectively.
Conclusions: Results of our study suggest that NASCET stenosis measured in MDCTA and PSV values have a good correlation. The use of a threshold of 283 cm/s allows obtaining good value of sensitivity and specificity.

1. Introduction

Stroke is a major cause of death and serious long-lasting neurological disability ranking as third cause of death for females and fourth for male in the United States [1]. It was shown that the number of stroke events in Europe would increase from 1.1 million per year in 2000 to more than 1.5 million per year in 2025, based only on demographic changes [2].

The results of two large randomized trials – the North American Symptomatic Carotid Endarterectomy Trial (NASCET) and the European Carotid Surgery Trial – have shown carotid artery endarterectomy to yield a considerable benefit in patients with 70–99% stenosis and a small benefit in patients with 50–69% stenosis [3–8]. In these studies, angiography was the gold standard technique used to quantify the carotid artery stenosis degree but angiography is also associated with an increased risk of thromboembolic events and a marked financial cost. Consequently, non-invasive techniques, such as sonography (US) [9–14], magnetic resonance (MR) [15–18] and multi-detector-row computed tomography angiography (MDCTA) [19–25] are now employed to quantify carotid artery stenosis.

Sonography is non-invasive and cost-effective, it provides morphologic and functional information and Doppler sonography is the most common imaging study performed for the diagnosis of carotid disease [11,27]. Investigators have confirmed that average Doppler velocity rises in direct proportion to the degree of stenosis as determined with angiography [10,26] and flow velocity is now considered the main parameter for evaluating the severity of carotid stenosis [9].

Isotropic voxels, high spatial and temporal resolution, use of fast contrast material injection rate and post-processing tools improved sensitivity and specificity of MDCTA in quantifying carotid stenosis degree and characterize carotid plaque [28–30].

The purpose of this paper is to evaluate the correlation between MDCTA and US peak-systolic-velocity (US-PSV) in the quantification of carotid artery stenosis.

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2. Materials and methods

2.1. Demographic data

52 consecutive in-patients (41 males, 11 females; average age 65.1 years; mean age 53–82 years), for a total of 104 carotids, were studied by using both MDCTA and US. Each MDCTA exam was performed when it was clinically indicated and it was ordered by the patient's physician and established by the attending radiologist. MDCTA was performed when a previous CD-US examination evidenced a stenosis >50% and\or a plaque alteration (irregular plaque surface, ulcerated plaque). MDCTA was also performed when US-ECD could not provide adequate information about stenosis degree and plaque morphology; i.e. in those patients with hostile neck (obese patients, edema), large calcified plaques with acoustic shadowing (type V plaque at CD-US), or high carotid bifurcation. MDCTA examination was obtained within 1 month following CD-US (mean time interval 18 days). Exclusion criteria for the study consisted in contraindications to iodinated contrast media, such as a known allergy to iodinated contrast material or elevated renal function tests. Since imaging undertaken was not additional to that performed routinely in this group of patients, it is the policy of our divisional research committee that specific ethical approval needs not to be obtained.

2.2. MDCTA technique

All patients underwent MDCTA of the supra-aortic vessels by using a 4-multi-detector-row CT system (Philips MX8000, formerly Picker, Andover, MA). Written consent to perform MDCTA was obtained from the patients after discussion about the associated risks with contrast enhanced MDCTA and the potential benefits deriving from this examination. Patients were placed in the supine position, with the head tilted back in order to prevent dental artefacts on the images. Patients were also instructed not to breathe and not to swallow. 110 mL of a contrast medium (Iomeron 350; Bracco, Milan, Italy) were injected into a cubital vein, by using a power injector at a flow rate of 4–6 mL/s and an 18 gauge intravenous catheter. We used a delay time variable from 12 to 18 s. CT technical parameters included: matrix 512 × 512, field of view (FOV) 11–19 cm; 180–200 mA; 120–140 kV; section thickness 3.2 mm, increment 1.6 mm. Subsequently, obtained data were processed with a workstation, to create multi-planar reconstruction (MRP), maximum intensity projection (MIP) and volume rendered post-processed images. Axial images were analyzed with a varying zoom from 70% to 150% in comparison to the acquisition. As indicated by Saba and Mallarini [25] the window level was preset at 200 HU with a width of 750 in case of fatty and mixed plaques whereas window level was preset at 300 HU with a width of 850 in case of calcified plaques.

Angiographic acquisition included carotid siphon. None of the patients included in the study had a medical history of cardiac output failure, any contraindications to iodinated contrast media, such as a known allergy to iodinated contrast media or elevated renal function tests.

2.3. CD-US technique

Color duplex ultrasound scanning was performed with an Acuson XP 128 with 7-MHz linear-array transducers. The carotid arteries were scanned, and tape recordings were made of vessel walls and blood flow velocities in all segments. The Doppler waveform were obtained with an angle of insonation less than or equal to 60°, as measurements obtained with an angle of insonation greater

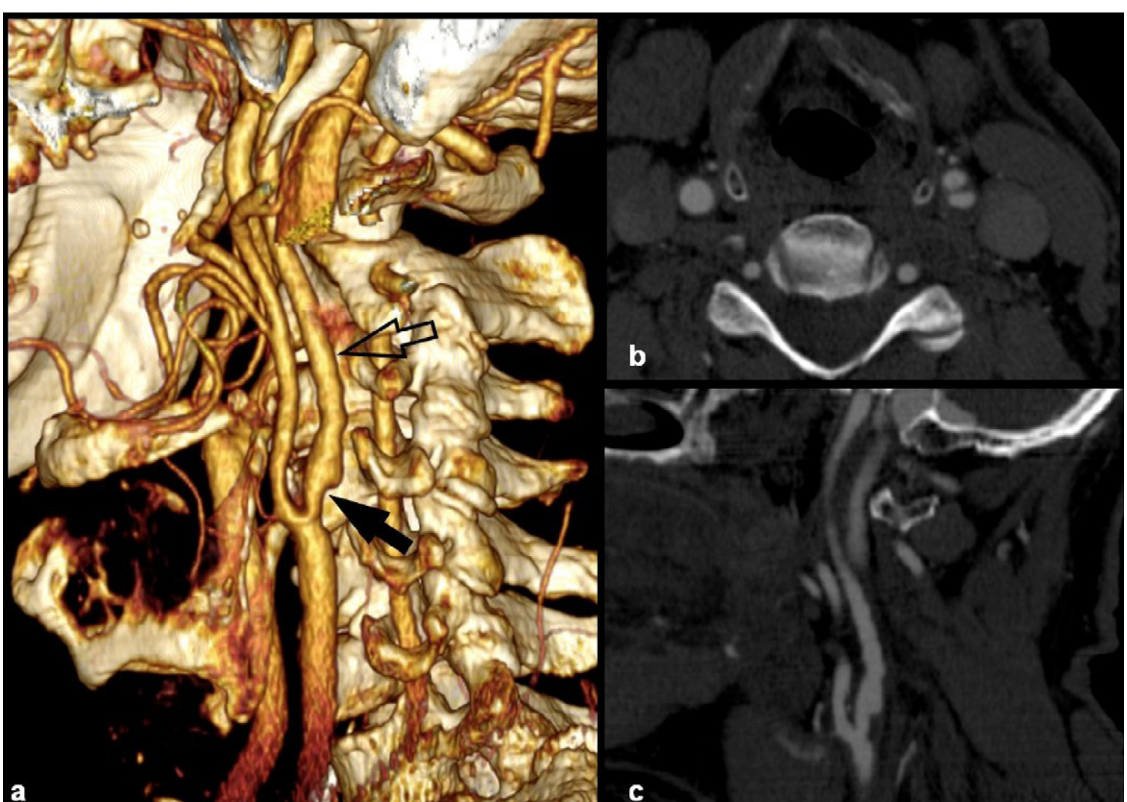

Fig. 1. 68 years old patient: volume rendered (a) CTA axial and (b) MPR images. The volume rendered post-processed CTA image (a) show the anatomic sites of measurement in the carotid artery for calculating percent stenosis for the NASCET method. The ratio between the residual luminal surface (inner-to-inner lumen) at the stenosis (black arrow) and the surface of the distal normal lumen (inner-to-inner lumen) where there is no stenosis (black open arrow) was calculated.