Original article

Contrast-enhanced three-dimensional MR angiography in the assessment of subclavian artery diseases

M. Cosottini, V. Zampa, P. Petruzzi, S. Ortori, R. Cioni, C. Bartolozzi

Department of Radiology, University of Pisa, V. Paradisa, 2, 56100 Pisa, Italy

Received: 18 May 1999; Revised: 5 January 2000; Accepted: 27 March 2000

Abstract. The purpose of this prospective study was to determine the potential diagnostic value of 3D breath-hold contrast-enhanced MRA (CEMRA) in the evaluation of subclavian artery pathology, and to compare CEMRA and digital subtraction angiography (DSA) findings. The study group included 50 patients with suspicion of subclavian artery pathology: 40 suspected steno-occlusive disease and 10 different vascular anomalies. The MRA examinations were performed on a 1.5-T system using fast 3D sequences. A fixed dose of 40 ml Gd-DTPA was administered at 2 ml/s after previous bolus tracking. Images were analyzed to assess: subclavian depiction; luminal changes; collateral branches; and feeders of arterial venous malformations (AVM). A multireader blinded fashion was used. The CEMRA revealed an optimal agreement with DSA findings in the different types of diseases. Sensitivity and specificity were 90 and 95%, respectively, in detecting steno-occlusive disease (including functional and arteritic stenoses), and 100 and 100%, respectively, in cases of vascular anomalies (dilation, kinking, anomalous origin and AVM). Contrast-enhanced MRA can be proposed as a non-invasive, robust technique for imaging subclavian pathologies with high diagnostic performance.

Key words: MR contrast enhancement – MR angiography – MRA subclavian artery – Comparative study

Introduction

The most frequent subclavian pathologies include atherosclerotic and inflammatory steno-occlusive disease, functional stenosis in patients with thoracic outlet syndrome (TOS) or with shoulder instability, dilatation associated to aortic coarctation and, less frequently, aneurysms or arteriovenous malformations (AVM).

Subclavian stenosis causes arm claudication, paresthesia, weakness and pain. In cases of stenosis, subclavian steal can be observed and can determine vertebrobasilar insufficiency [1].

The identification of the pathology is fundamental for correct therapeutic planning. In the case of steno-occlusive disease, depending on the category of lesion [2], digital subtraction angiography (DSA) can be integrated with percutaneous transluminal angioplasty (PTA) or stenting, to treat specific types of lesions.

Conventional angiography is considered the standard of reference for evaluating supra-aortic vessels. Risks of complications, such as thromboembolic events, allergic reactions and nephrotoxicity of iodinate contrast media, are well known [3].

Ultrasound and colour Doppler US offer important information about structural phenomena as well as haemodynamic aspects, but are operator-dependent and provide a poor anatomic representation compared to the paramount vessel visualization of conventional angiograms.

Magnetic resonance angiography represents an alternative non-invasive tool, capable of depicting vascular structures, and is already widely used to study different anatomical regions.

Up to now, few studies concerning the use of MRA in the evaluation of subclavian artery pathology have been reported [4, 5, 6]. This reflects the inherent difficulties in visualizing this anatomical region [7, 8, 9].

The traditional MRA techniques (TOF and PC), based on the signal properties of moving blood, give a suboptimal image quality [10] due to respiratory and cardiac artefacts and saturation effects in vessels with slow and turbulent flow. Furthermore, an adequate coil geometry is needed to obtain high signal-to-noise-ratio angiograms.

The widespread application of contrast-enhanced MRA (CEMRA) has dramatically improved diagnostic accuracy of MRA in studying vascular structures [11].
This technique is flow independent and exploits T1 shortening effect due to paramagnetic contrast infusion. Stronger and faster gradient systems accelerate MR data acquisition and permit acquisition of a set of 3D gradient-echo data within a single breath-hold during the arterial phase of contrast injection [12].

Non-breath-hold gadolinium-enhanced MRA is insensitive to arch vessel occlusive disease [13].

The purpose of this study was to determine the diagnostic value of 3D breath-hold contrast-enhanced MRA in the evaluation of subclavian artery, to compare MRA and DSA findings and to optimize CEMRA technique in the assessment of this vascular region.

Subjects and methods

Our study group included 50 patients (31 men and 19 women; mean age 61.4 years, range 16–77 years) with suspicion of subclavian artery pathology on the basis of clinical data and colour Doppler US. Our series included 40 cases of steno-occlusive disease (33 atherosclerotic and 7 functional) and 10 of different vascular anomalies (2 AVM, 6 aortic coarctation, 1 congenital absence of brachio-cephalic trunk and 1 non-atherosclerotic aneurysm).

The MRA examinations were performed with a 1.5-T superconductive MRI system with high performance gradients (maximum gradient strength over 20 mT/m, rise time up to 120 ms) using body coil.

After a fast gradient-echo scout acquisition and bolus test in the axial plane, a 3D coronal spoiled gradient-echo sequence was performed [TR/TE: 6.4/1.3 ms, flip angle 40, matrix 128 × 512, no. of excitations (NEX) 1, partitions 32, slice thickness 2.6 mm, zero filling in slice direction, field of view (FOV) 38–40 cm, scan time 24 s].

Forty millilitres of gadolinium-DTPA were intravenously administered by means of power injector (Spectris MEDRAD) with a flow rate of 2 ml/s. Scan delay was properly established with test bolus application using 1 ml of Gd-DTPA [14]. The venous access was antecubital in 40 and dorsal foot in 10 patients. In two breath-holds, we acquired a first scan, during the arterial phase of enhancement, and a second scan during the venous phase of enhancement.

In cases of suspected prevertebral subclavian stenosis, before CEMRA acquisition, a single-slice 2D phase-contrast sequence with phase display was carried out in the axial plane, perpendicularly to the vertebral arteries, using a dedicated neurovascular coil (TR/TE: 25/8.6 ms, FA 20, matrix 192 × 256, NEX 12, slice thickness 10 mm, FOV 20 cm, Velocity encoding (VENC) 30 cm/s, flow-encoding direction Anterior–Posterior Superior–Inferior Right–Left (AP–SI–RL), scan time 2 min 53 s).

In cases of suspected functional stenosis, the exam was carried out with the arms hyperabducted, waiting for occurrence of clinical signs and symptoms. Total time examination was 15–25 min.

The single image slices obtained were displayed using a maximum intensity projection (MIP) algorithm on an independent console, and multiplanar volume reconstructions (MPVR) were performed.

No more than 5 weeks after MR examination, all patients were submitted to DSA. The DSA was performed with an arterial femoral access using a 5-F Headhunter catheter and consisted of a panoramic study of the aortic arch and its branches and in a bilateral selective subclavian artery injection. Angiograms included anterior–posterior and oblique projections. Total amount of 50 ml of iodinate contrast media was usually used.

The MRA 3D angiograms and multiplanar volume reconstruction (MPVR) were evaluated on films in a consensus manner by two radiologists blinded to DSA results and to clinical history. The DSA exams were read by an expert radiologist independently from MRA results.

A qualitative analysis of MRA images was based on the presence of artefacts and the quality of vessel enhancement (poor, satisfactory, good).

The MRA image interpretation included: subclavian and collateral branch visualization; luminal changes (normal, non-significant stenosis, significant stenosis, occlusion, dilation); and presence of feeders in cases of vascular malformations. The degree of stenosis was established comparing the narrowest point of the residual lumen with a normal distal portion of the vessel. The absence of data about clinical relevance of subclavian stenosis induced us to grade stenosis using the following criteria: normal; non-significant stenosis when the residual lumen was greater than 50%; significant stenosis when it was less than 50%; and occlusion when no signal in the vessel lumen was clearly detectable.

Results

In one case the exam was considered as non-diagnostic due to lack of patient cooperation and was excluded from the study. In the 98 arteries visualized in 49 patients the degree of enhancement was considered by the two observers poor in 4 (4%), satisfactory in 24 (24.4%), and good in 70 (71.4%) arteries.

In 39 patients, in whom contrast media was injected in the antecubital vein, an artefact was observed in the distal part of 34 of 78 arteries: narrow signal void in 8 (10%) and blurring artefact in 26 (33%). In the 10 patients in whom the dorsal foot vein access was used, this artefact was not visualized and the arteries were completely visualized.

The described artefact did not cause any diagnostic error.

All the subclavian arteries studied (n = 98) were completely visualized from the origin to the axillary artery. The tirocervical trunk and, in particular, the transverse scapular artery, were visible in 39 patients. Mammarian artery was rarely depicted (9 cases). In the 49 patients studied, both observers correctly identified two groups of alterations: steno-occlusive alterations in 27 of 39 patients (1 arteritis, 4 functional stenoses, and 25 atherosclerotic steno-occlusive lesions) and vascular abnormalities in 8 of 10 (2 AVM, 4 aortic coarctation, 1