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ORIGINAL ARTICLE

Dynamic contrast-enhanced magnetic resonance angiography for the localization of spinal dural arteriovenous fistulas at 3T

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KEYWORDS
Spinal dural arteriovenous fistulas;
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Accuracy

Summary
Objective: This study was undertaken to evaluate the accuracy of dynamic contrast-enhanced magnetic resonance angiography (DCE-MRA) in the precise location and demonstration of fistulous points in spinal dural arteriovenous fistulas (SDAVFs).
Methods: Fifteen patients (14 men, 1 woman; age range: 40—78 years; mean: 55.5 years) harboring SDAVF who underwent preoperative DCE-MRA and spinal digital subtraction angiography (DSA) between January 2012 and January 2015 were evaluated retrospectively. Two reviewers independently evaluated the level and side of the arteriovenous fistula and feeding artery on 3 T DCE-MRA and DSA images. The accuracy of DCE-MRA was assessed by comparing its findings with those from DSA and surgery in each case.
Results: All 15 patients underwent DCE-MRA and DSA. DSA was unsuccessful in two patients due to technical difficulties. All cases were explored surgically, guided by the DCE-MRA. Surgery confirmed that 14 AVF sites were located in the thoracic spine, 5 in the lumbar spine, and 1 in the cervical spine. The origin of the fistulas and feeding arteries was accurately shown by DCE-MRA in 11 of the 15 patients. DCE-MRA also detected dilated perimedullary veins in all 15 patients. Overall, DCE-MRA facilitated DSA catheterization in 10 cases. In six patients, the artery of Adamkiewicz could be observed. In 15 out of 20 fistulas (75%), both readers agreed

Abbreviations: SDAVF, Spinal dural arteriovenous fistula; DCE-MRA, Dynamic contrast-enhanced magnetic resonance angiography; DSA, Digital subtraction angiography; FOV, Field of view.

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on the location on DCE-MRA images, and the κ coefficient of the interobserver agreement was 0.67 (95% confidence interval [CI], 0.16—0.87). In 13 of 16 shunts (75%), the DCE-MRA consensus findings and DSA findings coincided. The intermodality agreement was 0.77 (95% CI: 0.35—0.92).
Conclusions: Our DCE-MRA studies benefited from the use of a high-field 3 T MR imaging unit and reliably detected and localized the SDAVF and feeding arteries. As experience with this technique grows, it may be possible to replace DSA with DCE-MRA if surgery is the planned treatment.

Introduction

Spinal dural arteriovenous fistulas (SDAVF) can render devastating neurological consequences and lead to considerable morbidity. SDAVF is the most common type of spinal vascular malformation in which an arteriovenous connection is typically located within the dura mater of a nerve root sleeve, underneath the vertebral body pedicle in the neural foramen between the radicular artery and the medullary vein [1,2]. Diagnosis and treatment prior to irreversible cord ischemia or infarction are extremely important, since the symptoms at that point can be reversed.

Accurately locating the fistula is of crucial importance before neurosurgery or superselective embolization. However, despite preoperative MRI and DSA, the precise localization and anatomic delineation of the fistula site remains challenging due to the complex angioarchitecture and small vascular caliber.

The aim of the following article is to compare the agreement between intra-arterial DSA and DCE-MRA at 3.0 T in localizing the shunting point of SDAVFs.

Methods

The protocol of this study was approved by the Ethical Committee of our institute. Between January 2012 and June 2015, a total of 15 patients (14 men and 1 woman; age range, 40—78 years; mean, 55.5 years) at a single institution were confirmed to have SDAVFs. All patients presented with congestive myelopathy (the mean length of the illness course was 6 months) and underwent MR imaging (MRI) and DSA. Our inclusion criteria were a diagnosis of SDAVF on the basis of spinal DSA scans, which was verified by surgery after spinal 3 T DCE-MRA. The fast DCE-MRA examinations were performed on an Achieva 3.0 T MRI system (Philips Healthcare, Amsterdam, The Netherlands). A test-bolus (1 mL of contrast) technique positioned through the aorta at T10 vertebral body level was employed to evaluate the cycle time before examination. The contrast agent was injected through the antecubital veins using a high-pressure syringe at a rate of 3 mL/s and a total volume of 20 mL (gadodiamide, 0.5 mmol/mL) based on the calculated cycle time using a test bolus injection. The technique was then implemented using a 3D radiofrequency-spoiled fast gradient-echo volume acquisition using the following parameters: TR/TE, 3.1 ms/1.1 ms; flip angle, 20°; voxel size, 1.0 × 0.9 × 0.9 mm; field of view (FOV), 357 × 440 mm; four slabs (180 slices); SENSE factor, 2. The FOV was positioned to cover the entire T2 hyperintense cord and serpentine flow voids. The placement of the FOV may also base on clinical suspicion of the location of the fistula. The data acquisition lasted 2 minutes and was performed during the contrast agent injection. The acquired image data sets were then transferred to a workstation (IntelliVue Guardian Early Warning Score; Philips Healthcare), in which reconstruction using maximum intensity projection and volume-rendering DCE-MRA images was performed using a 3D specialized software package (Volume Inspection, Philips Medical Systems, Amsterdam, The Netherlands). Fistulous points in these subjects were determined via maximum-intensity projection(MIP), volume rendering technique(VRT), multiplanar reformations (MPR) and their source images. Two neuroradiologists (W.-W. Gao and H.-T. Lu, with 25 and 10 years of experience in neuroimaging, respectively) were blinded to the subjects to analyze the images independently. They provided the diagnosis including the lesion range, feeding arteries, and fistulas. DSA was performed on a monoplanar unit (Axion Artis) with a 1024 × 1024 matrix and 17-20-cm FOV using conventional methods. The interval between DCE-MRA and DSA studies ranged from 0—8 days (mean, 3 days). Two authors (W.-W. Gao and G. Zhou) compared the DCE-MRA results with the DSA and surgical findings. Interobserver agreement on the angiographic findings was determined by calculating the κ coefficient. The accuracy of DCE-MRA was evaluated by checking whether the level and side of the AVF that it suggested corresponded with the DSA and surgical findings. All analyses were performed using the STATA 12 statistical package (StataCorp, College Station, TX, USA).

Results

DCE-MRA and surgery were performed successfully in 15 patients. Intra-arterial DSA was unsuccessful in two patients due to technical difficulties, mainly related to coexisting aortic atherosclerosis and tortuosity. These two patients were treated surgically only on the basis of the DCE-MRA results. Surgery confirmed that 14 AVF sites were located in the thoracic spine, 5 in the lumbar spine, and 1 in the cervical spine (Tables 1 and 2). The locations of the feeders and fistulas identified on the DCE-MRA and DSA images are shown in Table 1. DCE-MRA demonstrated a precise fistula angioarchitectural configuration in 11 (11/15) cases. In four cases, the small shunts inside the nidus could not be individualized. The draining radicular vein could be followed in all cases from the fistula site to the coronal venous plexus around the spinal cord. DCE-MRA was effective in demonstrating the feeding artery, fistula site, and dilated perimedullary veins in most cases. In 11 (75%) patients, the