review

Magnetic resonance of the thoracic aortic disease

Pavel Berden

Clinical Institute of Radiology, University Medical Center, Ljubljana, Slovenia

Conventional ECG gated spin-echo (SE) magnetic resonance imaging (MR) and magnetic resonance angiography (MRA) are excellent methods for diagnosing thoracic aortic disease. SE image provides a good spatial resolution for defining aortic anatomy and relationships to adjacent tissues. MRA shows flow but temporal resolution is inferior to conventional MR images. Contrast-enhanced 3D (three-dimensional) MRA is very accurate for defining thoracic aortic anatomy and is particularly good for defining branch vessel abnormality. The sensitivity and specificity for diagnosing aortic dissection are the highest in comparison to other modalities (echocardiography, CT angiography) and range from 95 % to 100 % and 94 % to 100 %, respectively. MR can define clearly the full diameter of aortic aneurysm and also shows the amount of thrombi within it and its craniocaudal extent. A combination of SE and cine MRA is usually necessary. The same sequence with contrast enhancement provides all the required information on the congenital abnormalities of the aorta. MR is very reliable in congenital aortic abnormalities, aortic aneurysm and aortic dissection in hemodynamically stable patients. It should be used for all chronic thoracic aortic disease and postsurgical follow-up. Unstable patients that need intensive hemodynamic monitoring are unsuitable for MR.

Key words: aortic disease; aorta, thoracis; magnetic resonance angiography

Introduction

Examination of the thoracic aorta was one of the first uses of conventional ECG gated spin-echo magnetic resonance imaging (SE MR) and remains the fundamental imaging method in diagnosing the thoracic aortic disease. MR provides, non-invasively, the information on anatomy, function, and blood flow with no exposure to ionising radiation. It has become increasingly useful for evaluating suspected aortic dissection, aneurysm, and congenital anomaly. We present our experience with MR technique in evaluating the pathologic conditions of the thoracic aorta.

MR aortic imaging techniques

Magnetic resonance (MR)

Conventional ECG-gated SE is in many respects the reference standard for thoracic aortic MR imaging. It provides a good spatial

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Correspondence to: Pavel Berden, M.D., Clinical Radiology Institute, University Medical Centre Ljubljana, Zaloška 7, SI-1525 Ljubljana. Phone: +386 1 5408 400; Fax: +386 1 133 31 044; E-mail: pavel.berden@mf.uni-lj.si

resolution for defining an aortic anatomy and relationships to adjacent tissues. However, it can be time consuming, and complicated 3D anatomy may be difficult to represent.[1] Artefacts related to slow flow or flow within the imaging plane may mimic thrombus, and, unfortunately, the conventional SE is susceptible to respiratory artefacts.

Breath-hold imaging methods are fast, but may lack the spatial resolution required for making confident anatomical diagnosis. Techniques, such as HASTE and turbo-FLASH, may provide adequate information in some cases. Most turbo-FLASH sequences without gadolinium enhancement do not have adequate signal-to-noise ratios and spatial resolution in the chest. With contrast enhancement, the turbo-FLASH technique is relevant for diagnosing aneurysms and dissections.[2]

Magnetic resonance angiography (MRA)

Non-breath-hold time-of-flight MRA - cine MRA is useful for the assessment of some lesions - coarctation, flow abnormalities (identifying true and false lumens in the patients with aortic dissection). Image quality can be improved in most patients by reducing respiratory artefacts with breath-hold cine MRA, although temporal resolution is slightly inferior to conventional non-breath-hold cine MRA.

Contrast-enhanced 3D MRA is very accurate for defining thoracic aortic anatomy and particularly good for branch vessel abnormality.[3] 3D image processing is easier due to the high signal provided by vascular contrast enhancement. Very short TR and TE are necessary. Timing the injection is very important for proper enhancement and to prevent aortic anatomy being obscured by adjacent veins. Contrast enhancement is useful for defining the abnormalities that may be obscured or mimicked by a slow or turbulent flow.

Pathology of the thoracic aorta on MR

Dissection

MR is suitable for the patients with chronic dissection or in postoperative evaluation.[2] It can be used also in acute dissection if the patients are hemodynamically stable. MR can image intramural hemorrhage, intimal tears, stagnant blood flow versus thrombosis and periaortic blood (Figure 1).

With SE sequences, errors can occur related to slow flow mimicking thrombus, chemical shift artefacts, respiratory artefacts, signal from adjacent veins (superior vena cava), etc. The use of MRA and contrast-enhanced MRA has largely improved the MR accuracy. The sensitivity for diagnosing aortic dissection ranges in different studies from 95 to 100 % and is the highest compared to other modalities (86 to 100 % for transesophageal echocardiography (TEE), and 94 to 100 % for CTA). The same is true for the specificity - 94 to 100 % for MRA, 67 to 94 % for TEE and 87 to 100 % for CTA.[4,5]

MR is probably the most reliable method for detecting postoperative complications such as anastomotic aneurysms, further dilatation, and extension of false lumens into branch vessels. It is the best way for routinely following the patients with chronic or progressive aortic abnormalities, such as patients with Marfan syndrome.

Aortic ulceration and intramural hematoma

Aortic ulcers are seen as focal outpouchings from the lumen of the aorta and frequently progress to aneurysm. Ulcers are typically found in the descending or abdominal aorta and may be filled with thrombus. Increased signal from ulcers on T1- and T2-weighted images can mimic an intramural hematoma or thrombosed false lumen in aortic dissection.[6]

The intramural hematoma is characterised by a localised thickening of the aortic wall due to hematoma formation without an inti-

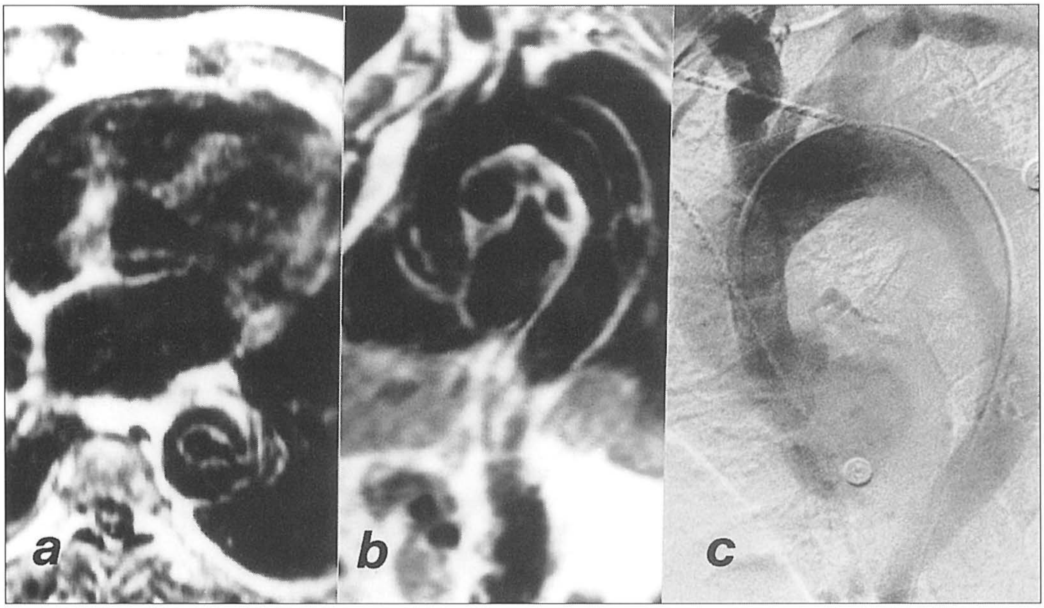

Figure 1. Aortic dissection type A. **a** - Axial SE image showing a near circular intimal flap in the descending aorta. **b** - Axial SE image in LAO plane. Intimal flap is seen as thin structure of increased signal intensity passing across the ascending aorta, through the aortic arch, into the descending aorta. **c** - corresponding angiography confirms MR findings showing flow in both lumens.

mal tear or a double lumen. It can precede classic aortic dissection. An acute intramural hematoma may be overseen on T1 images due to the isodense appearance of the blood and aortic wall; a high signal intensity on T2 images might be helpful.

Occasionally, the chemical shift artefact from the surface of the luminal thrombus may simulate a dissection. The differentiation between the slow flow in a false lumen and thrombus can be made using cine or contrast-enhanced MRA (Figure 2). The differentiation of the intramural hematoma from true aortic dissection is important as the distal (type B) hematoma may resolve without surgical treatment, while the proximal (type A) hematoma usually progresses to dissection and requires surgical treatment.[6]

Figure 2. Aortic dissection type B. **a** - Axial SE image in the thoraco-abdominal region shows an increased aortic diameter, signal-void centrally (flowing blood) and increased signal around it (slow, turbulent flow or thrombosed false lumen). **b** - GE at the same level shows intermediate signal parietally corresponding to thrombosed lumen.

Aortic aneurysm

MR can define clearly the full diameter of aortic aneurysm and also shows the amount of thrombi within it and its craniocaudal extent (Figure 3). Many thoracic aneurysms extend into the abdomen and, hence, the ability to image the entire aorta is important. The relationship of the aneurysm to the major branch arteries, particularly the head and neck vessels, is essential when planning the surgical approach. MR can define the branch vessel anatomy and congenital variations. In ascending aortic aneurysm, the assessment of aortic valve morphology, aortic regurgitation, and relationship of aneurysmal disease to the coronary arteries are required. To provide all this information, a combination of imaging protocols is usually necessary. The combina-

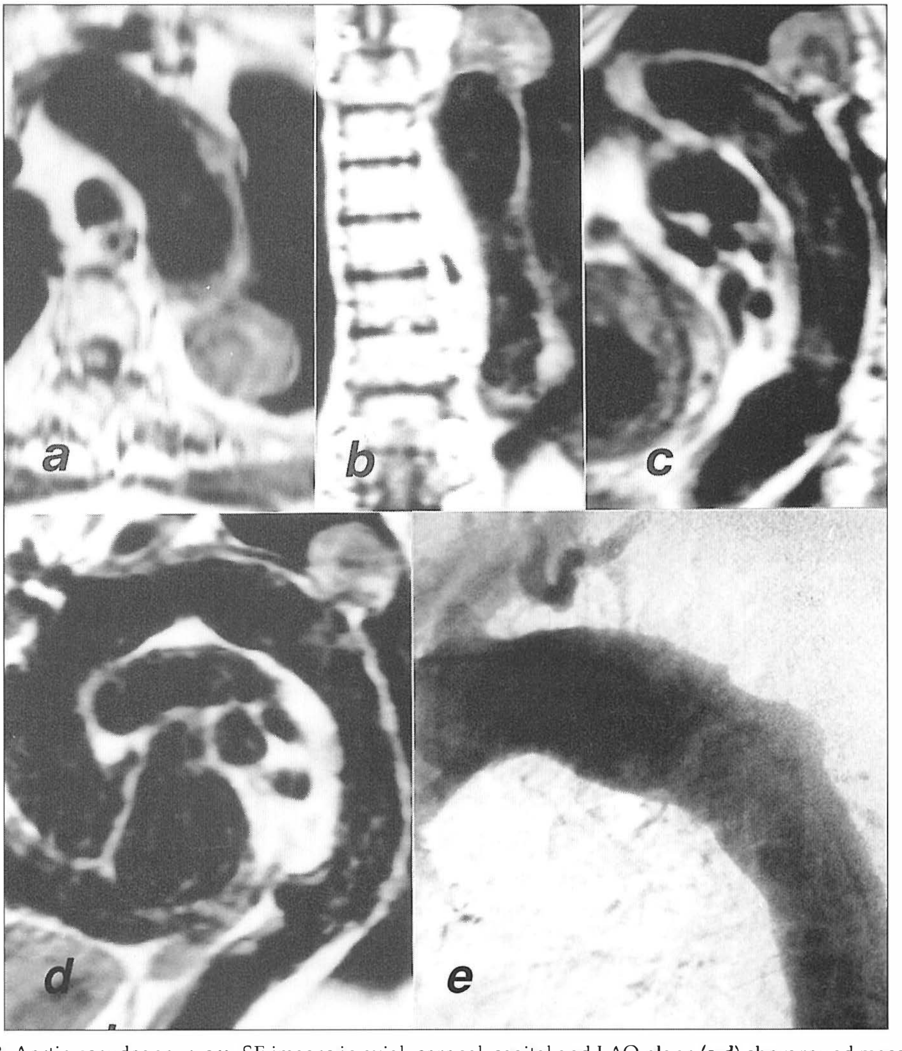

Figure 3. Aortic pseudoaneurysm. SE images in axial, coronal, sagital and LAO plane **(a-d)** show round mass of different signal intensity attached to the dorsal wall of the proximal descending aorta. Various signal intensity corresponds to the thrombus of different age. Aortic ulceration is seen distally on **d. e** - Corresponding aortography confirms small outpouching - most of the pseudoaneurysm is filled with thrombus.

tion of SE and cine MRA will show the size of the aneurysm (SE), branch vessel involvement and aortic regurgitation (MRA). The contrast-enhanced 3D MRA is excellent to define branch vessel anatomy, but the unenhanced SE sequence may also be required to define more precisely the true diameter of the thrombosed part of the aneurysm.[7]

Congenital abnormalities of the aorta

MR with MRA usually provides all the information required about aortic anatomy, its relationships to adjacent structures, and branch vessel anatomy, and is as accurate as angiography.[8]

Conclusion

The advantages of MR for vascular diagnosis are well known and include non-invasiveness, wide field of view, multiplanar imaging, and the ability to show complicated 3D relationships which is not always possible with conventional angiography. Similar information may be acquired using echocardiography and CT angiography. Transthoracic echocardiographes, TTE and TEE, are widely available and are the usual initial methods for investigating aortic disease. Large parts of the aorta are obscured by the overlying lung or bone and are inaccessible to echocardiography. The high specificity of MR, its non-invasive nature and the ability to image the aorta below the diaphragm are major advantages over TEE.

CTA and MRA are extremely accurate in evaluating the thoracic aorta. CTA uses large volumes of iodinated (more toxic) contrast medium, and inflow dilution effects may mimic or obscure the disease; nevertheless, it has no potential to assess aortic regurgitation. The branch vessel anatomy may be obscured by calcifications in the vessel wall.

In many instances, no contrast medium needs to be given with aortic MRA and complicated 3D anatomy can be evaluated non-invasively. When branch vessel anatomy is unclear, the contrast-enhanced 3D MRA allows accurate definition of branch vessel anatomy. The accuracy of this combined approach using MR has limited the use of aortography mainly to those patients who are ineligible for MR (metal implants, pace-makers, claustrophobia). In addition to defining the aortic anatomy, a simultaneous imaging of intracardiac abnormalities (including valve lesions and congenital abnormalities) and complications of aortic diseases (hemopericardium, left ventricular dysfunction, valvular regurgitation) is possible during the same examination.

MR has also some limitation in evaluating aortic diseases. The patients with acute thoracic aortic dissection are medical emergencies and may be unstable. The need for intensive hemodynamic monitoring makes them unsuitable for MR. The same problems arise in traumatic aortic rupture. CTA and TEE are more appropriate in these circumstances.

MR is very reliable in congenital aortic abnormalities, aortic aneurysm and aortic dissection in hemodynamically stable patients. It should be used for all chronic thoracic aortic diseases and postsurgical follow-up.

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