Clin. Cardiol. 18, 175–177 (1995)

Short Communications

Localization of a Misplaced Coronary Artery Stent by Magnetic Resonance Imaging

RAAD H. MOHIADDIN, M.D., ROBIN H. ROBERTS, M.R.C.P.,* RICHARD UNDERWOOD, M.D., M.R.C.P., MARTIN ROTHMAN, F.R.C.P.*

Magnetic Resonance Unit, The Royal Brompton National Heart & Lung Hospitals; *Department of Cardiology, The London Chest Hospital, London, England

Summary: Coronary artery stents have been developed to overcome arterial abrupt closure and restenosis following balloon angioplasty. Complications of stent insertion include loss of the device from its delivery system into the peripheral circulation. Certain types of stents are almost radiolucent, making localization of the lost devices difficult. Nonferromagnetic metallic biomedical implants induce alteration of the local magnetic field and this leads to loss of signal from the surrounding tissues. We have used this property to localize a misplaced coronary artery stent in a 53-year-old man who underwent unsuccessful stent insertion. A 0.5 Tesla magnetic resonance scanner was used to acquire gradient-echo and spin-echo images. An in vitro experiment was first carried out on a stent similar to that used in our patient to establish that it was nonferromagnetic and to determine the optimum imaging technique. Gradient-echo images with a relatively long echo time (22 ms) gave the largest area of signal loss around the stent, and this sequence was used for localization of the stent found in the patient's left profunda femoris artery. This was subsequently confirmed by digital radiography. We have demonstrated the convenience and practicality of using magnetic resonance imaging for the localization of a misplaced coronary artery stent in a patient. The technique is safe, noninvasive, and uses no ionizing radiation.

Key words: magnetic resonance imaging, stent, coronary artery

Introduction

Coronary artery stents have been developed to overcome arterial abrupt closure and restenosis following balloon angioplasty.[1–4] Complications of stent insertion include loss of the device from its delivery system into the peripheral circulation. To our knowledge, no reports of attempts to localize lost stents exist, which may reflect the perceived difficulty in finding the devices, some of which, once deployed, are virtually radiolucent.

Certain ferromagnetic biomedical implants like cerebral aneurysm clips are considered to be contraindications to magnetic resonance imaging (MRI) because of the possibility of injury if the implant is dislodged. If the implant has little or no ferromagnetism, this risk is negligible and it is generally accepted that MRI is safe.[5–8]

Nonferromagnetic metallic biomedical implants are not visible by MRI, but they induce alteration of the local magnetic field leading to loss of signal from the surrounding tissues. The signal loss is small for spin-echo images, and neighboring structures normally are seen, but the defect is much larger in gradient-echo images.

We have used this property to localize a misplaced coronary artery stent.

Case Report

A 53-year-old man underwent quadruple-vessel coronary bypass surgery (CABG) in 1981. Angina recurred in 1991 and symptoms worsened over a 9-month period despite medical therapy. Cardiac catheterization in February 1992 revealed a patent right coronary artery vein graft and a patent but stenosed left anterior descending artery vein graft, with both grafts inserting beyond native coronary occlusions; the other grafts were occluded. There was minor circumflex artery disease, but a tight stenosis proximally in a large intermediate coronary artery. Percutaneous transluminal coronary angioplasty, performed in May 1992, achieved successful dilatation of the left anterior descending artery vein graft, complicated by local dissection. The intermediate vessel was then dilated prior to the insertion of a coronary artery stent (Johnson and Johnson Interventional System CPS stent). Unfortunately, during stent placement, the guiding catheter became displaced and the stent was lost, being swept from the aortic root into the peripheral vascular tree.

The Palmaz-Schatz balloon expandable stent (Johnson and Johnson, New Brunswick N.J., USA) is a relatively rigid slotted tube made of stainless steel, 15 mm in length, comprising two 7 mm mesh segments articulated by a 1 mm bridge to in-

Address for reprints:

Raad H. Mohiaddin, M.D.
Magnetic Resonance Unit
Royal Brompton National Heart and Lung Hospital
Sydney St.
London SW3 6NP, U.K.

Received: December 22, 1993
Accepted with revision: April 5, 1994

crease flexibility and to facilitate deployment in tortuous vessels. The collapsed stent is 1.6 mm in diameter and can be expanded to 5 mm. It is normally visible on digital angiography when undilated, but invisible after dilation.

Following angioplasty the patient remained well, with no chest pain or ECG changes and with no neurological or peripheral vascular signs of embolization. He was anticoagulated with heparin for 72 h and discharged from the hospital on warfarin, aspirin, and dipyridamole. MRI was performed as described below and the stent was localized in the left profonda femoris artery. Because of the position of the stent and because the patient was asymptomatic, no further action was taken. Unfortunately he had to be admitted repeatedly with unstable angina, and in September 1992 he underwent repeat CABG but developed postoperative heart failure. He underwent a successful heart transplant in January 1993 and is currently free of cardiac symptoms.

Magnetic Resonance Imaging

A Picker International Vista MR 2055 scanner operating at 0.5 Tesla was used with a surface receiver coil.

In Vitro Study

Appropriate imaging sequences were chosen from a preliminary in vitro experiment. A stent similar to that used in our patient was suspended in the air with a silk thread to assess its deflection in the static magnetic field. It was then immersed in a glass of water, and imaging parameters that maximized the area of signal loss were determined. Multislice gradient-echo (echo time, 22 and 14 ms) and spin-echo (echo time 40 ms) images were acquired in coronal and transverse planes. Slice thickness was 10 mm and field of view 30 cm with a resolution of 256 pixels in the frequency-encoding direction and 256 pixels in the phase-encoding direction. Each phase-encoding step was acquired twice and averaged. Magnitude and phase images were reconstructed.

There was no deflection of the stent in the static magnetic field. The area of signal loss was greatest in the gradient-echo images and with longer echo times (Fig. 1). The phase images were distorted around the stent because of magnetic susceptibility artefact.

Clinical Study

The patient was then imaged using multislice gradient-echo (echo time 22 ms) and spin-echo (echo time 40 ms) sequences. Both magnitude and phase images were reconstructed. Images were acquired in coronal and transverse planes through the pelvis and upper part of the lower extremities without electrocardiographic gating. Slice thickness was 10 mm and field of view was 45 cm with a resolution of 256 pixels in the frequency-encoding direction and 128 pixels in the phase-encoding direction. Each phase-encoding step was acquired twice and averaged.

Gradient-echo magnitude images (echo time of 22 ms) acquired in coronal and transverse planes showed an area of signal loss in the left profunda femoris artery, 17 cm distal to the greater trochanter of the left femur. There was also a phase distortion around the area. The appearance was compatible with the presence of a small metallic object. The spin-echo images showed minimal distortion (Fig. 2). The position of the stent was confirmed by digital radiography (Fig. 3).

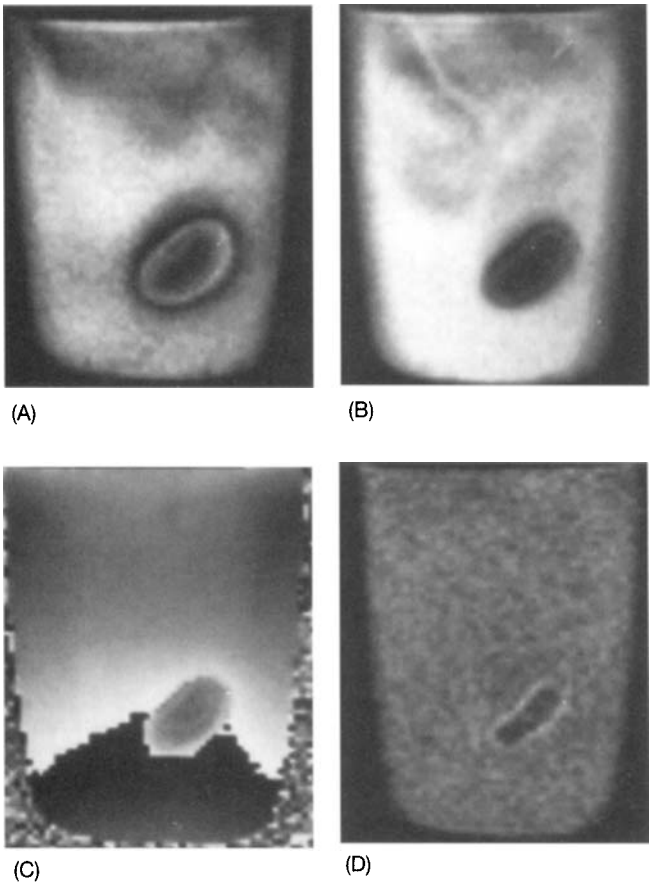

FIG. 1 Coronary artery stent (Johnson and Johnson CPS 15) attached to a silk thread and immersed in a glass of water, imaged with a gradient-echo sequence with an echo time of 22 ms (A), and 14 ms (B), showing an area of signal loss around the stent. A corresponding phase image (C) and spin-echo image (D) in a plane similar to (A).

Discussion

To our knowledge, this is the first description of the localization of a misplaced coronary stent by MRI. While such stents may cause no clinical symptoms, they are a potential source of thrombus or emboli, and so it is important to know the site of the stent for patient management. In extreme cases, surgical removal may be required. The undilated stent can be seen by digital x-ray fluoroscopy, but conventional fluoroscopy may be unrewarding and fluoroscopy of the whole patient involves considerable exposure to radiation.

MRI is limited mainly in the abdomen and chest, where signal loss can be caused by gas in the bowel and lungs. Metallic clips used during coronary bypass grafting can also create areas of signal loss that would be difficult to differentiate from that of

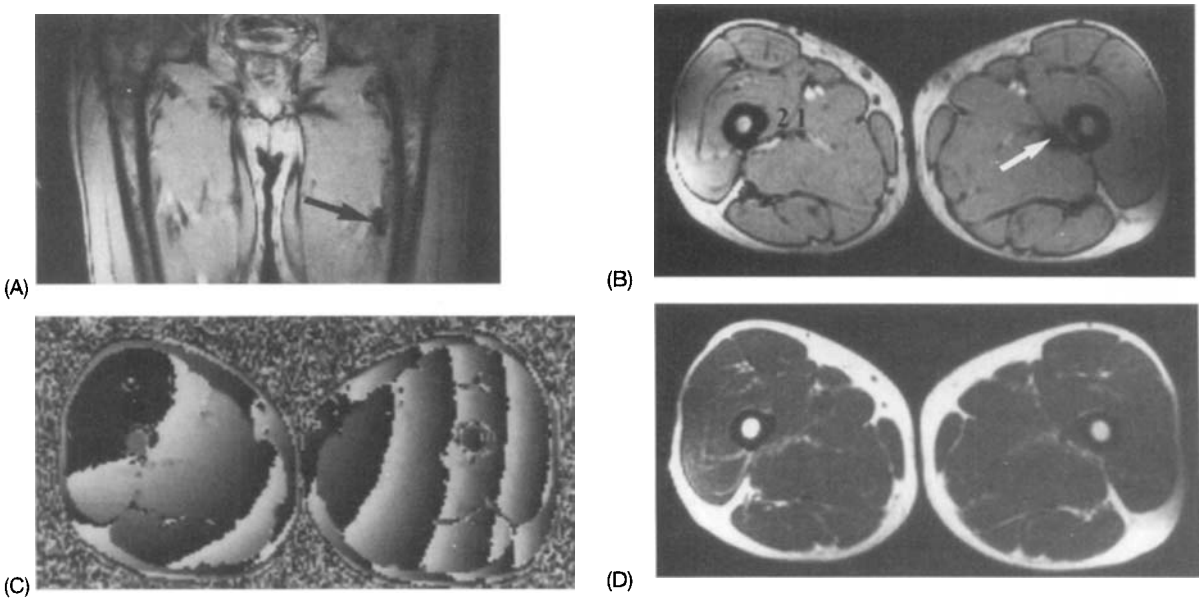

FIG. 2 Gradient-echo images (echo time 22 ms) in coronal (A) and transverse (B) planes through the thighs of our patient, showing the signal loss caused by the stent in the left profunda femoris artery (arrows). A corresponding phase map (C) and spin-echo image (D) in a plane similar to (B). 1 = right profunda femoris artery, 2 = right profunda femoris vein.

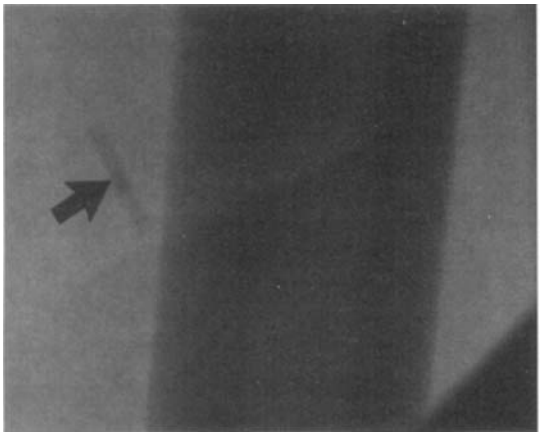

FIG. 3 Digital radiography showing the stent in the left profunda femoris artery (arrow).

a stent. The size of coronary stents means that, if embolized, they are likely to lodge in small diameter, peripheral arteries where these factors are less of a problem. Another limitation of MRI is its relatively long acquisition time. This study required two separate 15-min acquisitions to cover the pelvis and the upper part of the lower extremities. A similar time would have been required to image other anatomical regions if the stent had not been localized in the leg. Electrocardiographic gating is required to image the chest and this further prolongs the scanning time. The confined bore of the magnet may preclude use of the technique in patients with claustrophobia. These limitations may become less important with the development of real-time and subsecond MRI techniques and open access magnets.

Conclusion

We have presented the method and demonstrated the convenience and practicality of using magnetic resonance imaging for the localization of a misplaced coronary artery stent in a patient. The technique is safe, noninvasive, and does not use ionizing radiation.

References

1. Dotter CT, Judkins MP: Transluminal treatment of atherosclerotic obstruction: Description of a new technique and preliminary report of its application. *Circulation* 30, 654–670 (1964)
2. Schatz RA, Baim DS, Leon M, Ellis SG, Goldberg S, Hirshfeld JW, Cleman MW, Cabin HS, Walker C, Stagg J, Buchbinder M, Teristein PS, Topol EJ, Savage M, Perez JA, Curry RC, Whitworth H, Sousa JE, Tio F, Almagor Y, Ponder R, Penn IM, Leonard B, Levine SL, Fish RD, Palmaz JC: Clinical experience with Palmaz-Schatz stent: Initial results of a multi-centre study. *Circulation* 83, 148–161 (1991)
3. White CJ, Ramee SR, Salter LF, Garratt KN, Kramer PH, Shimshak TM, Beauchamp GD, Giorgi LV, Franco I, Toole JC, Glover MU, Losordo DW, Buchbinder M: Wiktor coronary stent multicentre trial on prevention of restenosis: Early results and complications (abstr). *Circulation* 86(suppl 1), I-115 (1992)
4. Schatz RA, Palmaz JC, Garcia F, Garcia O, Reuter S: Balloon-expandable intracoronary stents in the adult dog. *Circulation* 76, 450–457 (1987)
5. Soulen R, Higgins CB, Budinger TF: Magnetic resonance imaging of prosthetic cardiac valves. *Radiology* 154, 705–707 (1985)
6. Randall PA, Kohman LJ, Scalzetti EM, Szeverenyi NM, Panicek DM: Magnetic resonance imaging of prosthetic cardiac valves in vitro and in vivo. *Am J Cardiol* 62, 973–976 (1988)
7. Shellock FG: MR imaging of metallic implants and materials: A compilation of the literature. *Am J Roentgenol* 151, 811–814 (1988)
8. Shellock FG, Crues JV: High-field-strength MR imaging and metallic biomedical implants: An ex vivo evaluation of deflection forces. *Am J Roentgenol* 151, 389–392 (1988)