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Absence of Adverse Outcomes After Magnetic Resonance Imaging Early After Stent Placement for Acute Myocardial Infarction: A Preliminary Study

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ABSTRACT

Previous studies have documented the safety of magnetic resonance imaging (MRI) of stents in vitro, when placed in animals in vivo, and in patients after elective stent placement. The safety of imaging patients with stents early after myocardial infarction (MI) has not been examined. We studied 13 patients in an MRI study of myocardial viability on day 3 ± 1 after stent placement for acute MI. No patient had any clinical events in the early post-MI period, and only 1 of 13 patients demonstrated in-stent restenosis with a mean follow-up of 7 ± 2 months. For comparison, a group of 17 patients studied concurrently at Allegheny General Hospital as part of the Stent PAMI study, without undergoing MRI, suffered two early deaths and three episodes of in-stent restenosis within 6 months. Based on a review of the literature and this preliminary study, recent stent placement for acute MI should not be considered a contraindication to MRI.

KEY WORDS: *Coronary stents; Magnetic resonance imaging; Myocardial infarction.*

INTRODUCTION

Manufacturers of ferromagnetic intracoronary stents and magnetic resonance imaging (MRI) hardware recommend that clinicians wait 6–8 weeks after stent placement to image a patient by MRI. No waiting time is necessary for nonferromagnetic materials such as elgiloy, tantalum, nitinol, or titanium. However, recent literature supports the safety of imaging even ferromagnetic or weakly ferromagnetic materials. The safety of metallic stents has been documented in a 1.5-T environment (1). MRI of vascular stents in the abdomen has been performed without adverse events (2). Scott and Pettigrew (3) demonstrated that intracoronary stents do not move in a magnetic field. A recent study suggested no evidence of heating around coronary stents in vitro and in vivo in animal models in

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Table 1

Clinical Characteristics of the Study Patients

Patient	Age (yr)	Sex	Artery	Lytic	Stent Type	CK Peak	Days to MRI	6-Month Follow-up
1	43	m	LAD	tPA	Multi-link	1525	3	Unstable angina, stent patent
2	44	m	RCA	tPA	Multi-link	2172	2	
3	43	m	LAD		Multi-link	4440	5	
4	52	m	RCA		Multi-link	3655	3	
5	67	m	LAD		Multi-link	4840	2	Unstable angina, stent patent
6	73	m	LAD	r-tPA	Multi-link	3540	5	
7	34	m	LAD		Multi-link	2556	2	
8	36	f	RCA		Crown	753	3	
9	48	m	LCx		AVE	4300	3	Restentosis, repeat PTCA
10	66	m	LAD	tPA	Multi-link	802	5	
11	41	m	Ramus		AVE	897	3	
12	64	m	RCA		Crown	4386	3	
13	41	m	RCA		Nirvana	1039	3	
Mean	50					2685	3	

Lytic, thrombolytic agent; CK, creatine kinase; LAD, left anterior descending; RCA, right coronary artery; LCx, left circumflex artery; Ramus, ramus intermedius; tPA, tissue plasminogen activator; r-tPA, recombinant tPA; PTCA, percutaneous transluminal coronary angioplasty.

an MR environment (4). Jost and Kumar (5) suggested that all current coronary stents are MRI safe. Another study in humans established the safety of imaging patients early after percutaneous transluminal coronary angioplasty with stent placement for evaluation of patency (6).

The recognition of the potential utility of MRI in evaluation of the post-myocardial infarction (MI) patient is growing (7), and stenting for acute MI is becoming increasingly common (8). However, the post-MI period is a thrombotic milieu, and concerns have been raised that any alteration in the local environment may predispose to early stent thrombosis. The purpose of our study was to examine the safety of MRI in patients early after stent placement for acute MI. We compared our study population with a concurrent group of stented patients enrolled at our institution in the Stent PAMI (Primary Angioplasty in Acute MI) study (9), a study of stenting versus angioplasty alone for acute MI.

MATERIALS AND METHODS

Thirteen (12 men and 1 woman) patients (Table 1) with first MI were studied as part of a comparison of two MRI techniques and low-dose dobutamine echocardiography for the evaluation of postinfarction viability. The protocol was approved by the Institutional Review Board of Allegheny General Hospital. All patients signed informed consent after the nature of the study was explained to them. The mean age was 50 ± 13 yr, and the mean peak creatine kinase was 2685 ± 1573 U/l. Four patients had failed thrombolytic therapy and received rescue stent placement, and the remaining nine had primary stent placement. The involved arteries were the left anterior descending (n = 6), the right coronary artery (n = 5), left circumflex (n = 1), and ramus intermedius (n = 1). One stent was placed in each patient. Four different stent types were used: Multi-link ACS (Guidant, Columbia, MD, n = 8), Crown (Cordis/Johnson & Johnson, Miami, FL, n = 2), GFX (Arterial Vascular Engineering [AVE], Santa Rosa, CA, n = 2), and Nirvana (Boston Scientific Scimed, Maple Grove, MN, n = 1). All stents are made of 316L stainless steel, which can cause artifacts on MR images (10). The Multi-Link and Crown stents are second-generation slotted tube stents, and the latter two are modular designs. The Multi-Link and GFX stents were demonstrated to be safe ex vivo in a prior study (4).

MRI was performed on day 3 ± 1 after stent placement for acute MI in a Siemens 1.5-T Vision system with a phased-array body coil placed around the patients' chest. The patients were monitored by electrocardiography (In Vivo Medical Systems, Orlando, FL) and by

blood pressure monitoring with a cardiac nurse in the scan room and a cardiologist in the control room. MRI techniques included breathhold tagged gradient echo cine images at rest and with low-dose dobutamine (5 and 10 μg/kg/min) (11). Seven-millimeter-thick short-axis slices were obtained using a breathhold and segmented k-space sequence with 8-mm tag stripe separation. Phase duration was 35 msec, matrix size 126 × 256, field of view 28 cm, and 1 acquisition was obtained over 18 heartbeats. After dobutamine was allowed to wash out, contrast MRI was performed after a bolus of gadolinium (0.1 mmol/kg at 5 ml/sec). Inversion recovery imaging was performed with a repetition time of 1.6 msec, echo time of 0.8 msec, and inversion time of 150 msec (12). Imaging was performed during the first pass of gadolinium contrast and again 5–7 min later. Finally, breathhold, two-dimensional, fat-suppressed MRI coronary angiography was performed in the plane of the stented vessel (4) (Fig. 1). Total imaging time was 45–55 min per patient.

The study patients were compared with a control group of 17 patients admitted to Allegheny General Hospital during the same period (Table 2) and enrolled in the multicenter Stent PAMI study that randomized patients with acute MI to heparin-coated stent versus angioplasty alone (9). Ten of the 17 patients were men, the mean age was 57 ± 9 yr, and the peak creatine kinase was 2745 ± 3216 U/l. None had received thrombolytic agents as per protocol. The involved arteries included 6 left anterior descending, 10 right coronary, and 1 diagonal branch. All patients had heparin-coated stents placed, and two patients had two stents placed in the culprit artery. All had 6-month telephone follow-up per protocol.

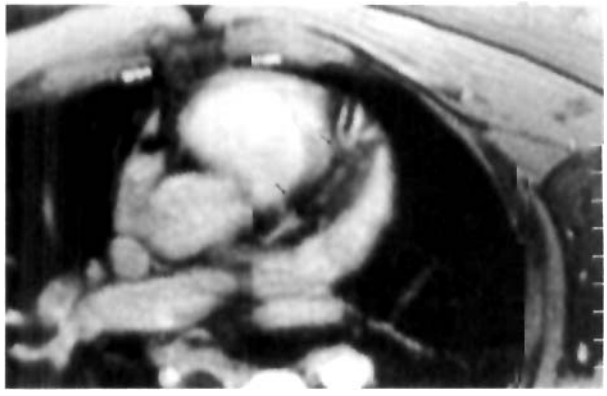

Figure 1. Breathhold, two-dimensional, fat-suppressed coronary angiogram in a transverse plane from patient 1 in Table 1 imaged on day 3 post-MI. This 43-year-old man had been treated with tissue plasminogen activator followed by rescue stenting with a Multi-link ACS stent in the proximal left anterior descending artery (LAD). Note the artifact from the stent in the LAD (between the arrows) and the LAD and its septal and diagonal branch seen exiting the distal portion of the stent.

RESULTS

All patients tolerated the MRI without problems. The specific absorption rate (the mass-normalized rate at which energy from an electromagnetic field is coupled to biologic tissue) was maximal during the fat-suppressed MR angiography (0.18 for whole body, 0.22 for partial, and 0.55 for localized). These values are less than 10% of the recommended limits in W/kg. No adverse events occurred in the patients during the initial hospitalization. All have been followed clinically for a mean of 7 ± 2 months. Three patients underwent repeat catheterization for chest pain at a mean of 3 months post-MI. One patient (patient 9 in Table 1) with a left circumflex stent had in-stent restenosis at 6 months post-MI (overall rate 8%). Another patient's stent in the left anterior descending artery was widely patent at 6 weeks post-MI, but he required stenting for a significant right coronary artery lesion (patient 1 in Table 1). The third patient had a widely patent stent.

In the control group from the Stent PAMI study who did not undergo MRI, two patients died in the early poststent period, one of cardiogenic shock in the hospital and the other of sudden death, presumably due to subacute thrombosis at home. Five other patients had repeat catheterization within the 6-month follow-up period for clinical indications. Two had widely patent stents, whereas three (20% of the surviving patients) required repeat angioplasty within the stent, two for reinfarction and one for in-stent restenosis.

DISCUSSION

Our preliminary study demonstrates that MRI of patients early after stent placement for acute MI did not increase the risk of subacute thrombosis or in-stent restenosis. No study patient had any demonstrable clinical events in the early post-MI period, and only 1 of 13 (8%) patients had clinical evidence of in-stent restenosis with a mean follow-up of 7 ± 2 months. This compares favorably with the 20% rate of target vessel revascularization in the group of Stent PAMI patients. Therefore, there is no evidence from this patient group that MRI early after stent placement for acute MI worsens outcome.

Shellock and Shellock (1) recently examined the safety of metallic stents in general and found no significant evidence of heating or magnetic field interaction.

Table 2

Clinical Characteristics of the Control (Stent PAMI) Patients

Patient	Age (yr)	Sex	Artery	No. of Stents	CK Peak	6-Month Follow-up
1	52	m	RCA	1	4160	Restenosis, repeat PTCA
2	57	m	LAD	1	6592	Reinfarction, repeat PTCA
3	57	f	LAD	1	205	
4	55	f	LAD	1	432	
5	73	f	RCA	1	294	
6	64	m	RCA	1	2079	Reinfarction, repeat PTCA
7	46	f	RCA	1	2470	
8	70	f	LAD	1	2358	
9	60	m	RCA	1	256	
10	65	m	RCA	1	5460	Repeat cath, all patent
11	47	m	RCA	1	633	Unstable angina, all patent
12	61	m	RCA	1	1160	
13	46	f	Diag	1	347	
14	53	m	RCA	2	321	Unstable angina, RCA patent, died
15	67	f	LAD	2	9084	Died suddenly
16	53	m	RCA	1	731	
17	47	m	LAD	1	10,080	
Mean	57			1.12	2745	

Diag, first diagonal branch of the LAD; all other abbreviations, see Table 1.

The 10 stents studied included aortic, iliac, and tracheobronchial stents made of elgiloy, a metal alloy, that makes less of an artifact on MR images than 316L stainless steel stents used in the present study (1).

To examine the safety of MRI of intracoronary stents, Scott and Pettigrew (3) examined stents from five manufacturers in a standard 1.5-T clinical MRI magnet and found no deflection or rotation of the stents when suspended by suture in the bore of the magnet. A suture needle used as a control rotated 90 degrees and deflected by 78 degrees. Strohm et al. (4) examined 14 different stents from seven manufacturers in 1.0-T and 1.5-T systems with gradient systems up to 23 MT/m. They demonstrated no evidence of motion in the MR field. When the stents were placed in explanted pig hearts and imaged, no measurable change in temperature occurred as measured with a highly sensitive infrared camera. They stated that intracoronary stents are too short for antenna effects and unlikely to create a closed-loop system. Jost and Kumar (5) reviewed the literature and manufacturers' manuals and stated that MRI of patients with stents should be safe at any time after placement.

Previous clinical MRI studies in stented patients have concentrated on patients more than 6 weeks after stent implantation. Duerinckx et al. (13) was the first to report on using MR coronary angiography for documentation of coronary stent patency. The same group subsequently used two-dimensional coronary angiography in 16 asymptomatic patients with 26 stents and reported 96% sensitivity for flow distal to the stent (14). De Cobelli et al. (6) studied 18 stents in 13 arteries with breathhold gradient echo sequence from 1 day to 8 months after stent placement. Stent patency was demonstrated for all 18 stents. The latter study was the first to document safety of MRI early after elective stenting.

In summary, recent coronary stent placement, even in the setting of acute MI, should not be considered a contraindication to MRI.

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