

Clinical Safety of Magnetic Resonance Imaging Early After Coronary Artery Stent Placement

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OBJECTIVES	Our aim was to examine the rate of adverse cardiac events in patients undergoing magnetic resonance imaging (MRI) <8 weeks after coronary stent placement.
BACKGROUND	The risk of coronary stent thrombosis from dislodgement due to MRI early after stent placement is not well defined. Manufacturers recommend postponing MRI studies until eight weeks after coronary stent placement.
METHODS	We analyzed the Mayo Clinic Rochester Percutaneous Coronary Intervention Database and examined records of 111 patients who underwent MRI <8 weeks after coronary stent placement treated with aspirin and a thienopyridine. Occurrence of death, myocardial infarction (MI), and repeat revascularization within 30 days of MRI were recorded.
RESULTS	Magnetic resonance imaging (1.5 tesla) was performed within a median of 18 days (range, 0 to 54 days) after coronary stent placement. Four noncardiac deaths occurred, and three patients had repeat revascularization procedures. Stent thrombosis did not occur (95% confidence interval, 0% to 3.3%).
CONCLUSIONS	Magnetic resonance imaging <8 weeks after coronary stent placement appears to be safe, and the risk of cardiac death or MI due to stent thrombosis is low. Postponing MRI does not appear to be necessary. (J Am Coll Cardiol 2003;42:1295-8) © 2003 by the American College of Cardiology Foundation

Magnetic resonance imaging (MRI) is considered unsafe in the presence of many metallic cardiovascular devices because it may cause dislodgement of the device by ferromagnetic force, device heating, flow of electrical currents, or malfunction of a device's electrical system (1-3). Every year approximately 457,000 metallic coronary artery stents (CASs) are placed (4). In patients with CASs, MRI is believed to be safe once endothelialization (5) has occurred, because endothelialization presumably opposes possible dislodgement (3). Therefore, manufacturers of CASs (6,7) and professional associations of cardiologists (8) recommend postponing elective MRI examinations for four to eight weeks after stent placement.

However, the need for urgent or emergent MRI can arise within this period. Opinions differ about whether it is safe to perform MRI <8 weeks after CAS placement (9,10), and physicians may choose to avoid MRI because of safety concerns. Dislodgement could theoretically increase the exposure of metallic coronary stent material to platelets, which may trigger stent thrombosis, resulting in cardiac death, myocardial infarction (MI), or emergent revascularization. In vitro and animal studies (11-14) have shown that ferromagnetism and stent migration are absent or minimal with MRI of currently available stents. However, very few clinical data are available on the outcome of patients who undergo MRI early after CAS placement (15,16).

In addition to their clinical importance, data on the safety of MRI early after CAS placement are also needed for designing clinical studies that use MRI (e.g., to compare the efficacy of different treatment modes for acute MI or to assess the status of CASs) (16-18). Therefore, we retrospectively examined the rates of adverse cardiac events occurring within 30 days after MRI performed <8 weeks after placement of a CAS.

METHODS

Patients. We analyzed the Mayo Clinic Rochester Percutaneous Coronary Intervention Database, which contains demographic, clinical, angiographic, and procedural data. Immediate and in-hospital events are recorded, and all patients are contacted for follow-up at six and 12 months and yearly thereafter. For the present analysis, we identified all patients who had CAS placement between July 1, 1994, and November 30, 2001. After CAS placement, all patients had received a thienopyridine for no longer than four weeks in addition to aspirin. By cross-referencing the archive system of the Mayo Clinic Department of Radiology, we identified all patients who had undergone an MRI examination <8 weeks after CAS placement. If more than one CAS placement preceded MRI, the time interval to MRI was counted from the latest CAS placement.

The study was approved by the Mayo Foundation Institutional Review Board. Patients who denied access to their medical record for research purposes (n = 4) were excluded.

Outcomes. We queried the database for the occurrence of death from any cause, MI, or repeat revascularization procedures within 30 days after the MRI examination. If

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Abbreviations and Acronyms

CAS(s) = coronary artery stent(s)
MI = myocardial infarction
MRI = magnetic resonance imaging

more than one MRI was performed <8 weeks after CAS placement, the follow-up period was extended to 30 days from the latest MRI. An investigator reviewed medical records to establish the nature of clinical events recorded in the database. For patients who died, clinical data and autopsy reports were reviewed, and death was classified as cardiac or noncardiac. For repeat percutaneous coronary interventions, catheterization reports and films were reviewed.

An MI was diagnosed if any two of the following three criteria were met: 1) "typical" chest pain that lasted ≥ 20 min; 2) an elevation of creatine kinase or of its MB isoenzyme ≥ 2 times the upper limit of normal; or 3) new Q-waves or ST-T segment changes suggestive of MI on an electrocardiogram.

Stent thrombosis was considered to have occurred if at least one of the following was present: 1) confirmation on autopsy or by coronary angiography; 2) MI in the territory of the treated vessel without definite exclusion of stent thrombosis; 3) sudden death without a clear noncardiac cause.

Statistical analysis. Data are presented as mean \pm SD, median, or percentages. Exact binomial confidence intervals were calculated.

RESULTS

Of 112 patients who underwent CAS placement followed by MRI within eight weeks and were eligible for the study, one was lost to follow-up. The remaining 111 (mean age, 67 \pm 12 years) had a median of two stents placed (range, one to six). Comorbid conditions and angiographic and procedural characteristics are shown in Table 1.

All MRI examinations were performed on one of two types of 1.5-tesla MRI units (Signa, General Electric Medical Systems, Waukesha, Wisconsin, or Gyroscan, Philips Medical Systems, Best, The Netherlands). During the eight weeks after CAS placement, 128 MRI examinations were performed. The following body parts were imaged: head or neck, 50 (39%); spine, 27 (21%); abdomen or pelvis, 18 (14%); extremities, 13 (10%); chest, 11 (9%); and combined examination of several body parts, 9 (7%). Fifteen patients had >1 MRIs (13 patients had 2; 2 patients had 3).

The mean time interval from CAS placement to MRI was 21 \pm 17 days (median, 18; range, 0 to 54 days). Magnetic resonance imaging was performed within two days after CAS placement in 15 patients (14%) and within 14 days in 52 patients (47%).

Stent thrombosis as defined by the study criteria did not

Table 1. Baseline Clinical and Procedural Characteristics of the Study Population at Time of Coronary Artery Stent Placement (n = 111)

Characteristics	Value*
Men	81 (73)
Prior MI	60 (54)
Prior PTCA	30 (27)
Prior CABG	20 (18)
Prior CVA/TIA	25 (23)
Diabetes	38 (34)
Current/former smoker	75 (68)
Moderate/severe renal disease†	12 (11)
Cancer	3 (3)
Acute coronary syndrome	59 (53)
CHF on presentation	14 (13)
Preprocedural shock	3 (3)
No. of coronary arteries with significant stenoses	
2	41 (37)
3	43 (39)
Type B2 or C lesion (20)	89 (80)
Thrombus in any lesion	30 (27)
Summed length of stents used, mm	22 \pm 15
≥ 3 Stents placed	16 (14)
Average stent size, mm	3.3 \pm 0.6
Stent diameter <3 mm	17 (15)

*Categorical variables are expressed as number (percentage) and continuous variables as mean \pm SD; †Creatinine >265 μ mol/l, current dialysis, or history of kidney transplant.

CABG = coronary artery bypass graft; CHF = congestive heart failure; CVA = cerebrovascular accident; MI = myocardial infarction; PTCA = percutaneous transluminal coronary angioplasty; TIA = transient ischemic attack.

occur. The 95% exact confidence interval for no events in 111 patients is 0% to 3.3%. Seven clinical events occurred in six (5%) of the 111 patients during the 30 days after MRI (Table 2), including four noncardiac deaths and three repeat revascularization procedures (all percutaneous coronary interventions).

DISCUSSION

This study shows that the risk of cardiac death, MI, or need for repeat revascularization due to stent thrombosis associated with MRI performed <8 weeks after CAS placement is very low. The results are consistent with the 30-day cardiac event rates (0.5% to 1.9%) after CAS placement with contemporary antiplatelet therapy in patients not undergoing MRI (19).

MRI after coronary stent placement. In a series of 13 patients who underwent MRI 3 \pm 1 days after CAS placement for MI, no early adverse cardiac events occurred in the postinfarct period (16). In other small observational studies with longer intervals from elective CAS placement to MRI, stent thrombosis was also rare (15,17).

Our study includes the largest series to date of patients who underwent MRI before CASs could be fully endothelialized (5). For all MRIs, the heart was at or near the isocenter of the magnet, and therefore, the CAS were exposed to the scanners' full magnetic field strength and spatial gradient. Our patients underwent MRI early after CAS placement, contrary to conventional clinical practice,

Table 2. Clinical Events During 30-Day Follow-up in Six of 111 Patients Who Underwent MRI Within Eight Weeks of Coronary Stent Placement

Patient	Gender	Age, yrs	Vessel/Lesion Type (20)	Comorbid Conditions at Time of Stent Placement	Stent Placement to MRI, days	Body Part Imaged	MRI to Clinical Event, days	Event
1	M	45	RCA/B1	ACS, prior MI, 3-VD	2	Extremity	1	PCI in different vessel (LAD)
2	M	81	LM/C, LAD/C	ACS, shock, CHF, prior MI, 3-VD, DM, CRF	14	Head	7	Death (withdrawal of respiratory support)
3	F	67	LAD/B2	CHF, prior PCI, 2-VD, DM, CRF	15	Head	6	Death (withdrawal of respiratory support)
4	F	77	LAD/B2, LCx/B2, RCA/B2	ACS, prior MI, 3-VD, prior CVA	2	Head	4	Death (recurrent stroke)
5	M	68	LAD/C	ACS, prior MI, prior PCI, prior CABG, 2-VD	40	Extremity	9	Repeat PCI of LAD (in-stent restenosis)
6	F	62	RCA/C	ACS	7	Head	8	Repeat PCI of RCA (remote from original treatment site)
					24	Head/spine	25	Death (withdrawal of respiratory support)

ACS = acute coronary syndrome; CABG = coronary artery bypass graft; CHF = congestive heart failure; CRF = chronic renal failure; CVA = cerebrovascular accident; DM = diabetes mellitus; F = female; LAD = left anterior descending coronary artery; LCx = left circumflex coronary artery; LM = left main coronary artery; M = male; MI = myocardial infarction; MRI = magnetic resonance imaging; PCI = percutaneous coronary intervention; RCA = right coronary artery; 2-VD = two-vessel disease; 3-VD = three-vessel disease.

because of severe comorbidity (Table 1). Accordingly, all deaths during the follow-up period resulted from withdrawal of respiratory support or from stroke (Table 2).

The prevalence in our study group of factors known to be associated with increased risk of stent thrombosis (19,20) (Table 1) suggests that our patients were at least at intermediate risk of adverse cardiac events. Therefore, the absence of CAS thrombosis in our study cannot be attributed to selection bias toward patients with low procedural risk. The three repeat percutaneous coronary interventions were performed remote from the original treatment sites (n = 2) or for in-stent restenosis (n = 1), which was easily distinguished from stent thrombosis by its far less acute course (21).

Study limitations. Without complete 30-day angiographic follow-up, we cannot exclude the possibility that the presence of subclinical stent thrombosis was not detected in some patients with concurrent, critical illness. However, subclinical stent thrombosis is believed to be a very rare occurrence, and the close observation of this patient group warranted by their comorbid conditions may actually have resulted in higher than normal sensitivity for detecting cardiac events.

Despite the large number of patients in this series, the confidence intervals remain wide, and a stent thrombosis rate as high as 3.3% cannot be excluded with certainty. In addition, the MRI field strength in our study was limited to 1.5 T. Thus, it may not be appropriate to extrapolate from our data to newer, higher field strength MRI scanners.

Nevertheless, our data suggest that MRI with field strengths up to 1.5 T can be performed safely <8 weeks after CAS placement. Current clinical practice and recommendations by manufacturers of CASs to postpone MRI

studies until after eight weeks from CAS placement do not seem necessary.

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