

# Late Gadolinium Enhancement CMR Predicts Adverse Cardiovascular Outcomes and Mortality in Patients With Coronary Artery Disease: Systematic Review and Meta-Analysis

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## Abstract

Cardiovascular magnetic resonance (CMR) has a recognized role in diagnosing and monitoring coronary artery disease (CAD). Multiple studies have shown that CMR can predict adverse outcomes. We reviewed contemporary available literature to establish the role of CMR with late gadolinium enhancement (LGE) in predicting mortality and major adverse cardiac events (MACEs) in patients with CAD. Meta-analysis of available prospective studies showed that the presence of LGE increases the hazards of death by more than 4 times and of MACE by almost 4 times. The size of LGE (per gram or percent) increases the hazards of death and MACE by 4% and 5%, respectively. The presence and size of LGE predict mortality and MACE in CAD. Various parameters derived from LGE images enhance the predictive value. Large randomized controlled trials are needed to establish the actual value of LGE and other derived parameters in the wider population. (Prog Cardiovasc Dis 2011;54:215-229)  
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## Keywords:

Late gadolinium enhancement; Cardiovascular magnetic resonance; Coronary artery disease; Predictive value; Death; Mortality; Major adverse cardiac event

## Background/Introduction

Coronary artery disease (CAD) is one of the most common diseases and causes of mortality in the modern world. Cardiovascular magnetic resonance (CMR) has a recognized role in diagnosing and monitoring CAD by assessing left ventricular (LV) function, myocardial perfusion, myocardial infarction (MI), and myocardial

viability. Multiple studies have assessed the role of CMR modalities in predicting outcomes.<sup>1-4</sup> One recent meta-analysis summarized available literature on perfusion CMR as a predictor of CAD.<sup>5</sup>

We reviewed contemporary available literature to establish the role of CMR with late gadolinium enhancement (LGE) in predicting mortality and major adverse cardiac events (MACEs) in patients with CAD.

Statement of Conflict of Interest: see page 228.

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## Methods

This systematic review was carried out using the methodology described by the Centre for Reviews and Dissemination of the University of York.<sup>6</sup> A detailed review protocol was agreed upon before performing the review.

Abbreviations and Acronyms
<b>95% CI</b> = confidence interval
<b>CABG</b> = coronary artery bypass surgery
<b>CMR</b> = cardiovascular magnetic resonance
<b>CS</b> = cohort study
<b>DM</b> = diabetes mellitus
<b>HF</b> = heart failure
<b>HR</b> = hazard ratio
<b>ICD</b> = implantable cardioverter-defibrillator
<b>LGE</b> = late gadolinium enhancement
<b>LV</b> = left ventricular
<b>MACEs</b> = major adverse cardiac events
<b>MI</b> = myocardial infarction
<b>MVO</b> = microvascular obstruction
<b>PCI</b> = percutaneous coronary intervention
<b>RCT</b> = randomized controlled trial
<b>STEMI</b> = ST-segment elevation myocardial infarction
<b>UA</b> = unstable angina
<b>VT/VF</b> = ventricular tachycardia or fibrillation

### Identification of studies

The articles cited in this publication were found through a search in Medline, Medline without Revisions, and EMBASE databases using the OvidSP platform ([www.ovidsp.com](http://www.ovidsp.com)) on December 17, 2010. We also looked for conference proceedings in the EMBASE database and performed hand searching of CMR journals and the 2011 Society for Cardiovascular Magnetic Resonance (SCMR)/EuroCMR Congress Joint Scientific Sessions proceedings up to February 1, 2011. Screening the bibliographies of articles identified in the searches above identified additional studies.

We performed the search for meta-analyses, controlled trials and prospective studies using the following keywords (alone and in different combinations): “myocardial ischemia,” “coronary artery dis-

ease,” “angina,” “magnetic resonance imaging,” “cardiovascular magnetic resonance,” “gadolinium,” “microvascular obstruction,” “mortality,” “MACE,” “myocardial infarction,” “heart attack,” “arrhythmia,” “heart failure,” “left ventricular dysfunction,” and “ejection fraction.” The detailed search strategy, which included abbreviations and different spellings for all search parameters, is presented in Table 1.

We did not identify any relevant clinical trials on <http://www.clinicaltrials.gov/> and <http://apps.who.int/trial-search/websites>.

### Study selection

In our search strategy, we followed the population, intervention, outcomes and study design elements from the Population, Intervention, Comparison, Outcome, Setting (PICOS) system.<sup>6</sup>

Table 1  
Search criteria

Search Criteria
1 exp Myocardial Ischemia/
2 (ischemic heart disease or CAD).mp.
3 (coronary artery disease or cad or angina).mp.
4 exp Magnetic Resonance Imaging/
5 mri.mp.
6 (cardiac magnetic resonance or cmr).mp.
7 (gadolinium or lge).mp.
8 (microvascular obstruction or mvo or no-reflow).mp.
9 exp Mortality/
10 mortality.mp.
11 (myocardial infarction or heart attack or mi or heart failure).mp.
12 ((left ventricular or lv) adj (dysfunction or impairment or function)).mp.
13 (ejection fraction or ef or arrhythmia or mace).mp.
14 1 or 2 or 3
15 4 or 5 or 6 or 7 or 8
16 9 or 10 or 11 or 12 or 13
17 14 and 15 and 16
18 limit 17 to (evidence based medicine reviews and “review articles” and “topic reviews (cochrane)”)
19 limit 17 to (abstracts and English language and (clinical trial, all or clinical trial))
20 exp *Magnetic Resonance Imaging/
21 19 and 24
22 limit 17 to (conference abstract or conference paper or “conference review” or proceeding)

1 to 21 were performed in Medline and EMBASE searches, and 22, performed additionally in EMBASE Conference Database.

### Population

We included male and female adults (age >18 years) with a diagnosis of CAD. The range of CAD consisted of patients with suspected CAD, previous or acute MI, previous percutaneous coronary intervention (PCI), coronary artery bypass surgery (CABG), previously recognized disease by means of angiography, exercise testing, or clinical history and patients with ischemic cardiomyopathy.

### Intervention (or test)

We have included patients who underwent CMR with LGE.

### Outcomes

We defined our primary end point as at least 6-month cardiac or all-cause mortality and malignant arrhythmias—ventricular tachycardia or fibrillation (VT/VF)—detected and terminated by overdrive pacing or shock delivered by implantable cardioverter-defibrillator (ICD) as a surrogate for death. If cardiac and all-cause mortality were reported, “cardiac” was included in the analysis.

Our *secondary end points* were defined as MACE and included death, non-fatal MI, new or worsening heart failure (HF) or LV dysfunction, unstable angina (UA), VT/VF, and stroke. The MACE definition varied between

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