



## Role of Stress Cardiac Magnetic Resonance Imaging in Women With Suspected Ischemia But No Obstructive Coronary Artery Disease



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### ABSTRACT

#### Keywords:

Myocardial ischemia  
Coronary microvascular dysfunction  
Cardiac magnetic resonance imaging

**Objective:** Signs and symptoms of ischemia but no obstructive coronary artery disease (CAD) is often a diagnostic dilemma in women. The use of stress cardiac magnetic resonance imaging (CMRI) for advanced diagnostic assessment in these patients is a nonionizing radiation option, but the diagnostic utility in this population is unknown. We examined the diagnostic role of stress CMRI in our patient population of these women.

**Methods:** We analyzed 113 consecutive female patients from February 2006 to November 2007 who had prior cardiac evaluations for signs and symptoms of ischemia but no obstructive CAD who underwent stress CMRI, which included anatomic, functional, adenosine stress perfusion, and delayed enhancement imaging.

**Results:** The population demographics of 113 women included a mean age of  $55 \pm 12.2$  years with an average body mass index of  $25 \pm 4.5$ . Overall, 43% had hypertension, 4% had diabetes, and 3% were smokers. Overall, 80 of 113 (70%) demonstrated abnormal stress CMRI results. Most patients demonstrated findings consistent with subendocardial perfusion abnormalities suggestive of coronary microvascular dysfunction (CMD). Of note, three patients (4%) were diagnosed with congenital coronary anomalies or cardiomyopathy not detected in prior cardiac evaluations.

**Conclusion:** Among women with signs and symptoms of ischemia but no obstructive CAD, stress CMRI is frequently abnormal and valuable in diagnosis of CMD. Stress CMRI appears useful for advanced diagnostic assessment in these diagnostically challenged patients.

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### Introduction

Signs and symptoms of ischemia but no obstructive coronary artery disease (CAD) is often a diagnostic dilemma in women. Compared with men, women have a lower burden of obstructive CAD but relatively high rates of adverse cardiac events and near-term mortality, related to coronary microvascular dysfunction (CMD) (Shaw, Bugiardini, & Merz, 2009). Both stress testing with single-photon emission computed tomography (SPECT) and echocardiography, optimized for segmental abnormalities related to epicardial CAD, are routinely used diagnostically; however, they may be less sensitive and specific for detecting ischemia in women without obstructive CAD (Shaw et al., 2006). Diagnosis is important for both prognostic and therapeutic reasons.

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Detection of perfusion abnormality consistent with myocardial ischemia is an important diagnostic finding with prognostic and therapeutic implications. Routine imaging with SPECT and echo does not specifically evaluate the subendocardium and may fail to detect CMD. Technological developments over the past decade allow for comprehensive cardiac magnetic resonance imaging (CMRI), which includes myocardial perfusion, function, and anatomical assessment. Stress CMRI is a noninvasive method for evaluating myocardial perfusion that may offer an additional diagnostic value for differentiation of symptomatic patients with and without ischemia (Sawlan & Collins, 2016). The absence of ionizing radiation furthers its appeal as an imaging modality in women who have the double burden of radiation exposure to both lungs and breasts.

We report our findings from women with signs and symptoms of ischemia but no obstructive CAD who underwent stress CMRI to better understand the utility for diagnosis.

## Methods

We analyzed 113 women with signs and symptoms of ischemia but no obstructive CAD who underwent stress CMRI for further evaluation between February 2006 and November 2007. Institutional review board approval was obtained for the study. All subjects gave written informed consent before study participation.

### Cardiac Magnetic Resonance Imaging

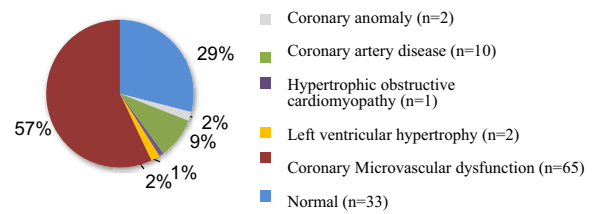
All stress CMRI studies were performed at Cedars-Sinai Medical Center with a 1.5-T magnet (Siemens Sonata, Erlangen, Germany) with electrocardiographic gating and a phased array coil using a highly standardized protocol with 0.05 mmol/kg of gadolinium first-pass perfusion three-slice stress, followed by rest first-pass perfusion. All patients tolerated pharmacologic stress using adenosine at  $140 \mu\text{g}/\text{kg}^{-1}/\text{min}^{-1}$  infused for 2 min before and continued during first-pass perfusion image acquisition. Cine imaging was performed in left ventricular short axis slices from above the base to the apex in addition to left ventricular long axis and outflow tract views. Delayed enhancement imaging in matched image positions was performed for exclusion of myocardial infarction.

The percentage of myocardial perfusion abnormality was defined semiquantitatively by two experienced readers (DB and LEJT) who were blinded to the clinical status of the patient. Studies were analyzed using visual semiquantitative five-point 16-segment American Heart Association scoring system: 0—normal, 1—mildly reduced/equivocal, 2—moderately reduced, 3—severely reduced, and 4—absent perfusion. Scores in the basal-mid and distal-short axis slices were summed to obtain a summed rest score (SRS) and a summed stress score (SSS). A summed difference score was obtained from the difference of the SRS and SSS. The percentage of abnormal myocardium was estimated by the SSSs divided by 64 and then multiplied by 100 (Cerqueira et al., 2002; Thomson et al., 2007).

**Table 1**  
Baseline patient characteristics

Demographics (n = 113)	
Age (years ± SD)	55 ± 12
Hypertensive	43%
BMI (mean ± SD)	25 ± 5
Diabetics	4%
Current smokers	3%

SD = standard deviation; BMI = body mass index.

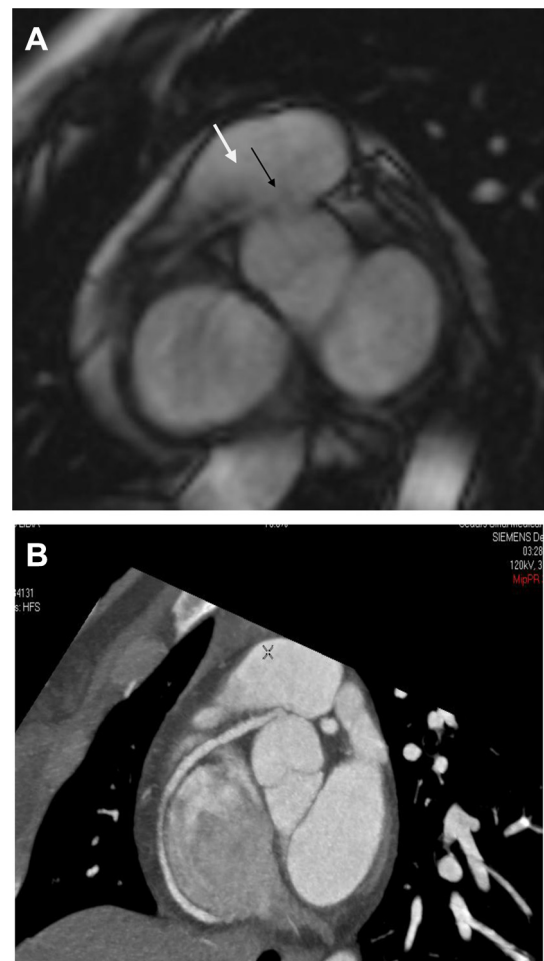


**Figure 1.** Cardiac magnetic resonance imaging (CMRI) findings. Stress CMRI findings in 113 patients with signs and symptoms of ischemia in cardiac workup and no prior diagnosis.

We defined left ventricular noncompaction as prominent left ventricular trabeculae and deep intertrabecular recesses with ratio of trabeculated to normal myocardium >2.

### Invasive Coronary Flow Reserve Determination

All women underwent clinically indicated invasive coronary reactivity testing (CRT). During the CRT, we evaluated that coronary microvascular and macrovascular endothelial and nonendothelial-dependent functions were evaluated as previously published (Bugiardini, Manfrini, Pizzi, Fontana, & Morgagni, 2004).



**Figure 2.** Case example 1. (A) Stress cardiac magnetic resonance imaging cine imaging in the basal short axis suggested the presence of anomalous origin of the right coronary artery from the left coronary sinus with course between the aortic root and the right ventricular outflow tract (black arrow). (B) This congenital abnormality was subsequently confirmed by coronary computed tomography angiography.

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