

# Prevalence and clinical characteristics of inappropriate myocardial perfusion imaging tests at a community hospital

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## BACKGROUND

Myocardial perfusion imaging (MPI) is a cornerstone for the diagnosis and management of patients with coronary artery disease (CAD). However, the persistence of inappropriate MPI tests as documented by meta-analyses undermines their clinical utility.<sup>1</sup> Inappropriate MPI tests reduce diagnostic accuracy and increase false-positive results that can subject patients to unnecessary invasive procedures with additional risks, including radiation exposure, renal insufficiency and bleeding.<sup>2-3</sup> Indirect effects at our hospital include prolongation of waiting time for procedures and referrals (currently 5 months for outpatient MPI) and consumption of limited healthcare resources (\$350–\$500 per test)<sup>4</sup> in a predominately uninsured population.<sup>5</sup> Inappropriate tests led to more than \$500 million of additional costs in 2010 alone.<sup>6</sup>

To address these challenges, cardiovascular societies promulgated appropriate use criteria (AUC) for MPI, and Congress directed the Centers for Medicare & Medicaid Services to consider AUC in reimbursement decisions.<sup>7</sup> Risk calculators that emerged from these efforts are useful to identify appropriate patients who may benefit from MPI tests but remain underused. To investigate the utility of this approach, we evaluated the prevalence and characteristics of inappropriate MPI orders at one general community hospital.

## METHODS

We conducted a 3-month retrospective electronic medical record review of all patients (n=324) at a single hospital who were referred for MPI within 12 months of coronary angiography. Subjects who did not undergo prior MPI and subjects without complete clinical information were excluded (n=262). The appropriateness of MPI orders was adjudicated using the 2009 criteria for radionuclide

imaging.<sup>1</sup> Pretest probabilities of obstructive CAD were estimated using revised Diamond-Forrester Index (DFI) and atherosclerotic cardiovascular disease (ASCVD) calculators. Positive predictive values (PPVs) were calculated for >50% angiographic stenosis. Comparisons of categorical variables were evaluated using  $\chi^2$  or Fisher exact tests. The severity of perfusion defects was compared using Spearman's rank-order tests.

## RESULTS

Sixty-five subjects (49% female, 58% current or former smokers) met all inclusion criteria. The distribution of appropriate (78%), inappropriate (17%) and indeterminate (5%) MPIs was similar to historical data. However, the normalcy rate (30%) was significantly less than expected (90%) and was correlated with the prevalence of obesity. Elevated body mass index (34.0 in men and 37.1 in women) may result in decreased normalcy rates due to breast and/or abdominal attenuation.<sup>8</sup> Seventy percent of MPI referrals, including all inappropriate referrals, originated from outpatient clinics. In contrast, none of the hospital inpatient (22%) or emergency department (8%) referrals were inappropriate. Inappropriate referrals were most frequently requested for patients with low pretest probabilities of CAD, as defined by a DFI of <10% (74.1%) or an ASCVD of <5% (40.7%). Inappropriately referred patients were more likely to present with preserved systolic function and were less likely to present with angina. The most common presenting symptom of appropriately referred patients was atypical angina (51.9%). The mean HbA1c values (5.9% vs 7.4%, p=0.02) and estimated ASCVD 10-year risk (9.0% vs 17.4%, p=0.08) of inappropriately referred patients were lower than those for appropriately referred patients (table 1). The PPV of

**Table 1** Comparison of patients who underwent appropriate and inappropriate myocardial perfusion imagings stratified by pretest probabilities

Characteristic	Inappropriate (n=10, 17%)		Appropriate (n=49, 78%)	
	Mean	$\sigma$	Mean	$\sigma$
Ejection fraction	58%	4.5	48%	14.7
Referral location	Outpatient	100%	Inpatient	100%
DFI*	<10%	0.5	>10%–90%	0.7
ASCVD score†	9.0%	8.0	17.4%	15.4
A1c level‡	5.9%	0.8	7.4%	2.0

\*P=0.06.

†P=0.08.

‡P=0.02.

ASCVD, atherosclerotic cardiovascular disease; A1c, haemoglobin A1c; DFI, Diamond-Forrester Index.

inappropriate MPI studies (22%) was also lower than that of appropriate studies (49%,  $p=0.07$ ; table 2).

## CONCLUSION

In a contemporary hospital-based cohort with prevalent CAD, we found that inappropriate MPI orders remain common and are related to predictable factors. Most inappropriate referrals originated from a small number of providers and involved low-probability patients who had normal left ventricular systolic function and did not present with typical anginal chest pain. The lower PPVs of inappropriate studies, in comparison with those of appropriate studies, are associated with diminished clinical utility for diagnosis and treatment.<sup>9</sup> Inappropriate studies also increase the likelihood of potential harm from unnecessary interventions and exacerbate the misdirection of limited clinical resources. These observations highlight the potential financial and clinical impacts of educational interventions or interactive pop-up alerts in the electronic medical record to reduce inappropriate MPI referrals. We are currently assessing the effectiveness

**Table 2** The PPV of inappropriate MPI tests was lower than that of appropriate MPI tests

Test result	Inappropriate (n=10)		Appropriate (n=52)	
	+CAD	-CAD	+CAD	-CAD
Abnormal MPI	2	7	19	20
Normal MPI	0	1	3	10
PPV	22%		49%	

CAD, at least one &gt;50% coronary lesion by coronary angiography; MPI, myocardial perfusion imaging; PPV, positive predictive value.

of targeted information sessions at the same hospital to promote provider awareness and to change test ordering patterns.<sup>10</sup>

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