Inappropriate utilization of SPECT myocardial perfusion imaging on the USA-Mexico border

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Background. **The American College of Cardiology/American Society of Nuclear Cardiology published revised appropriate use criteria (AUC) for SPECT MPI in 2009. We assessed adherence to these guidelines and factors associated with inappropriate utilization at the University Medical Center.**

Methods. **The AUC was applied retrospectively to 420 SPECT MPI studies. Two-sample *t* test, Fisher's exact test, and multivariable logistic regression models were used for analysis.**

Results. **There were 322 appropriate (86%) and 54 (14%) inappropriate studies. The odds of having an inappropriate test increased with younger age ($P < .001$) and female gender ($P < .001$). Subjects with diabetes ($P = .007$) and chest pain ($P < .001$) were less likely to have an inappropriate test. Academic outpatients were three times more likely to have an inappropriate study ($P = .123$), while community PCPs were 5.6 times ($P = .011$) and community cardiologists eight times more likely to order inappropriate tests ($P = .031$).**

Conclusions. **Inappropriate SPECT MPI in low risk younger women is an important issue on the USA-Mexico border. Initiatives to reduce inappropriate SPECT MPI should focus on a few indications and evaluation of cardiovascular symptoms in younger age women in outpatient/community practices. (J Nucl Cardiol 2014;21:544–52.)**

Key Words: Myocardial perfusion imaging • SPECT • appropriate use criteria

INTRODUCTION

The use of single photon emission computed tomography myocardial perfusion imaging (SPECT MPI) has increased significantly in the last decade and more than 10% of studies performed in the USA have been found to be inappropriate.[1-4] The American College of Cardiology (ACC) in conjunction with the American Society of Nuclear Cardiology (ASNC) published appropriate use criteria (AUC) for cardiac radionuclide imaging in 2005 and revised them in 2009.[5,6] Several studies have shown using the 2005 criteria that the factors affecting inappropriate use vary according to demographics, time of assessment, ordering specialty, and practice setting.[1,7-9] Fewer studies have been performed with the revised 2009 guidelines.[4,10] There is therefore an ongoing need to examine the adherence to these revised guidelines and characterize the factors related to inappropriate use in various practice settings and institutions. The purpose of this study was to (A) assess adherence to these guidelines and (B) determine the factors associated with inappropriate utilization of SPECT MPI in a medically underserved population on the USA-Mexico border referred for stress testing at the university medical center.

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METHODS

Study Population

A retrospective review of all consecutive exercise and pharmacological (adenosine) SPECT MPI studies performed from September 1 to December 31, 2009 at a University Medical Center. Of these records, studies identified as appropriate or inappropriate SPECT MPI utilization based on guideline criteria, were considered for this study.

Outcome Assessment

The test requisition, pretest screening, and data collection form and medical records were reviewed to assess the indications for testing and patient history by two internal medicine residents trained for the study. Data obtained included age, gender, indication for testing, symptom assessment, Framingham risk score, electrocardiogram (ECG), exercise capacity, renal function, presence of cardiovascular disease and prior cardiac procedures, cardiac enzymes, surgical risk, and planned surgical procedures. The specialty of the requesting physician and setting from which the study was requested, i.e., outpatient vs inpatient and academic vs community physician were also recorded. Finally, each study was classified by the two reviewers into one of three categories: appropriate, inappropriate, or uncertain in line with 60 indications in the guidelines that address SPECT MPI. The study protocol was approved by the Institutional Review Board of Texas Tech University Health Sciences Center, El Paso, TX.

Statistical Analysis

Descriptive statistics for continuous variables were presented as means and discrete variables as frequencies and percentages. The outcome variable of interest was the appropriateness of the SPECT MPI test defined as ''appropriate'' or ''inappropriate.'' The exposure variables of interest were classified into patient characteristics, medications, renal function/cardiovascular diseases, and procedures. The exposure variables were compared using Student's t test for continuous variable and Fisher's exact test for discrete variables. Multiple variable logistic regression models were utilized to identify the magnitude of an association (i.e., odds ratios) and the magnitude of inferential impact (i.e., P values) for each exposure variable, adjusted for the possible confounding, and/or interaction effects of the other exposures. Analyses were conducted for each exposure variable individually (i.e., crude model) and collectively (i.e., full model) to identify confounding effects. Variables were kept in the model if their specific P value was less than 0.05.

RESULTS

General

There were 420 subjects. The studies were appropriate in 322 (86%) and inappropriate in 54 (14%) and uncertain in 44 (10%). The mean age was 56 years and 211 (56%) were female.

Distribution of the Studies by Specialty

Figure 1A, B presents the distribution of appropriate and inappropriate studies by requesting specialty. Figure 1C shows that there was no significant difference in the proportion of inappropriate studies from the three major ordering specialties of Family Medicine, Internal Medicine, and Cardiology.

Patient Characteristics

Table 1 presents the descriptive statistics for patient characteristics for each appropriateness classification. The subjects in the inappropriate category were found to be younger and female compared with subjects with appropriate indications. They were also less likely to be diabetic and more likely to have hypertension. In addition, they were less likely to be smokers and report chest pain or shortness of breath. Table 1 also shows the distribution of Insurance categories by appropriateness category. There was no significant difference found between the appropriate and inappropriate categories.

Table 2 shows the distribution of medication use by appropriateness category. Those identified as inappropriate were less likely to have been on any of the medications considered, however, the difference was not statistically significant for nitrates, angiotensin receptor blockers, Ca channel blockers, or clopidogrel.

Renal Function/Cardiovascular Diseases and Procedures

Table 3 presents results of renal function/cardiovascular diseases and procedures. The studies classified as inappropriate were not found to be significantly different than the studies classified as appropriate with regards to renal function and cardiovascular diseases except for coronary artery disease (CAD). The subjects with studies classified as inappropriate were significantly less likely to have coronary artery disease than subjects with appropriate indications. Also, with regards to cardiac procedures, the subjects with studies classified as inappropriate were significantly less likely to have had a cardiac catheterization (CATH) and percutaneous intervention (PCI).

Analysis by Practice Setting

Table 4 shows the distribution of studies based on the settings from which the tests were requested. Most of

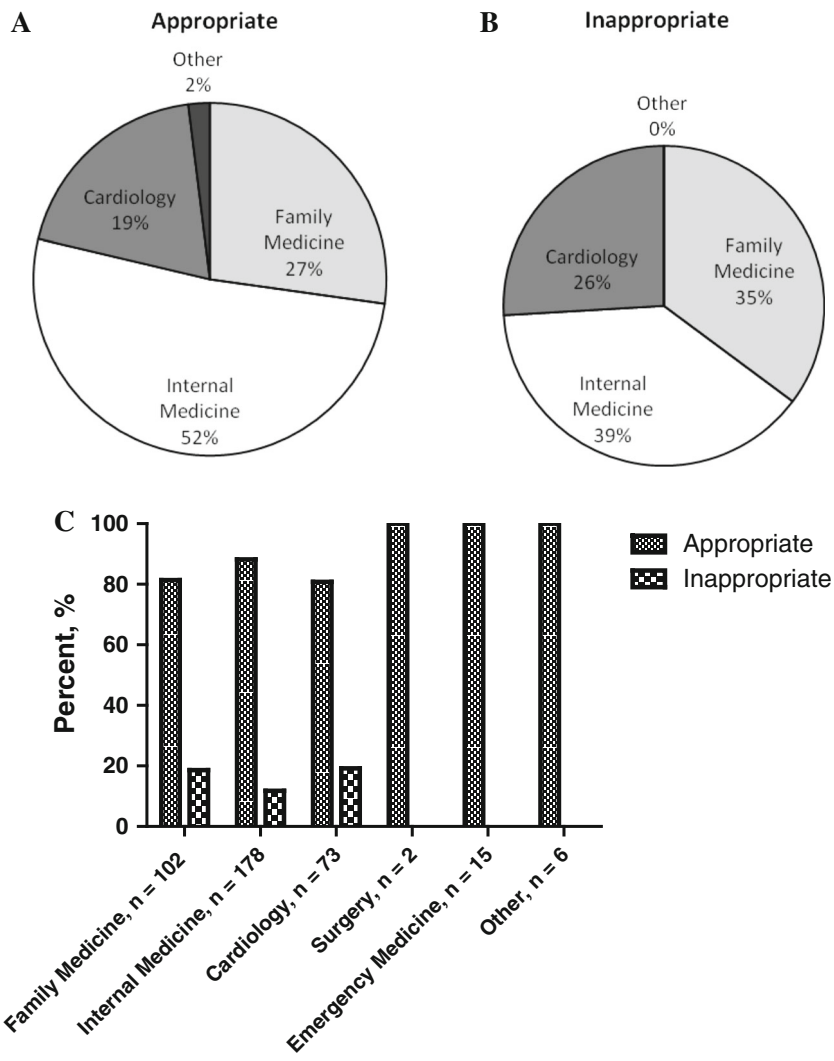

Figure 1. Analysis of studies by requesting department: (**A**) appropriate studies, (**B**) inappropriate studies, and (**C**) proportion of inappropriate studies, $P = .201$.

the inappropriate studies were observed to have been ordered by primary care physicians from the community outside the academic environment.

Analysis of Common Indications for Inappropriate studies

Table 5 shows the frequency of the inappropriate indications, ordered by AUC table and specific indication. Almost half (46%) of the 54 subjects classified as inappropriate were identified by the criteria of a low pretest probability of CAD, ECG interpretable, and ability to exercise. In addition, 87% of the inappropriate studies were for one of three indications.

Multivariable Analysis on Inappropriateness and Related Variables

Table 6 describes the result of multivariate logistic regression on inappropriateness and its related variables. The odds of having an inappropriate test decreased by 13% with a 1 year increase in age of the patients when adjusting for other variables ($P < .001$). Males were 89% less likely to have an inappropriate study than females after adjusting for other variables ($P < .001$). Diabetics were 72% less likely to have an inappropriate test ($P < .001$), and the patients with chest pain were 95% less likely to be subject to an inappropriate test ($P = .006$) after adjusting for other variables. Lastly, academic outpatients were three times more likely to

Table 1. Descriptive analysis of patient characteristics for the appropriateness classification and *P* values from Student's *t* test and Fisher's exact test

	Appropriate (n = 322)	Inappropriate (n = 54)	*P* value
Mean age (years)	56.8	49.1	<.001
Mean BMI	30.0	29.8	.858*
Gender			.002
Female	52.8	75.9	
Male	47.2	24.1	
Diabetes			<.001
No	57.5	85.2	
Yes	42.6	14.8	
Hypertension			.007
No	24.2	42.6	
Yes	75.8	57.4	
Smoking			.072
No	81.7	92.5	
Yes	18.3	7.6	
Obesity			.557
No	48.8	53.7	
Yes	51.2	46.3	
Family history			1.000
No	87.6	88.9	
Yes	12.4	11.1	
Chest pain			<.001
No	17.2	55.6	
Yes	82.8	44.4	
Shortness of breath			.033
No	60.6	75.9	
Yes	39.4	24.1	
Insurance			.276
Medicare	13.7	7.4	
Private	6.2	9.3	
Medicaid	6.2	9.3	
Charity	54.8	63.0	
Self-pay	17.8	9.3	
Other	1.3	1.9	

* Two-sample *t* test with unequal variances.

have an inappropriate study ($P = .123$), while community PCPs were 5.6 times ($P = .011$) and community cardiologists were eight times more likely to order inappropriate tests ($P = .031$).

DISCUSSION

The number of inappropriate tests in this study is similar to that of previous publications.[1-3,8] However, this study is the first to examine adherence to the 2009 AUC in a predominantly Hispanic population in a medically underserved area on the US-Mexico border. More than half of the patients had no insurance and majority of the inappropriate studies were ordered by nurse practitioners and primary care physicians in community clinics and outpatient settings. This is in keeping with the study by Nelson et al[4] that showed that non-physicians were more likely to order inappropriate studies in the Veterans affairs medical center than physicians and that non-cardiologists account for a higher number of inappropriate studies than cardiologists in the University of Miami Medical Group. Previous reports have suggested that self-referral and financial incentives drive testing.[11-13] However, majority of the subjects in our study do not have private insurance

Table 2. Descriptive analysis of medications for appropriateness classification and *P* values from Fisher's exact test

Medications (%)	Appropriate (n = 322)	Inappropriate (n = 54)	*P* value
Aspirin			.004
No	59.4	79.6	
Yes	40.6	20.4	
Clopidogrel			.063
No	86.8	96.2	
Yes	13.2	3.8	
Beta blocker			.007
No	71.8	88.9	
Yes	28.2	11.1	
Angiotensin-coverting enzyme inhibitor			.010
No	59.1	77.8	
Yes	40.9	22.2	
Angiotensin receptor blocker			.285
No	90.9	96.3	
Yes	9.2	3.7	
HMG-CoA reductase inhibitor			.003
No	60.2	81.1	
Yes	39.8	18.9	
Nitrates			.331
No	94.1	98.2	
Yes	5.9	1.9	
Calcium channel blocker			.396
No	85.9	90.7	
Yes	14.1	9.3	

and the referring clinicians have no financial incentive for ordering the stress tests. Hendel et al[3] also showed in their study that the contribution to inappropriate use was greater in those who lack financial self-incentive compared with those who perform SPECT MPI and stand to gain financially. Other factors such as training/education, habit, and fear of litigation may therefore be more important.

Although, the proportion of inappropriate tests did not vary according to specialty, most of the tests at our institution are ordered by the primary care (Internal and Family Medicine) specialties. Multivariable analysis showed that community cardiologists were eight times more likely to order inappropriate tests. However, due to the relatively small number (17%) of tests ordered by the cardiologists in our study an analysis of the inappropriate indications for SPECT MPI ordered by the cardiologists was not thought to be meaningful. A Mayo Clinic study using the 2005 AUC criteria also showed that there was no significant difference in the overall appropriateness classification in the five specialty groups studied although 50% of the tests were ordered by cardiologists.[9]

Most of the inappropriate tests were in symptomatic patients able to exercise with interpretable ECGs and asymptomatic patients with low coronary heart disease risk as was the case in prior studies.[1-3] Majority (87%) of the inappropriate tests in this study were restricted to three indications. This suggests that educational efforts should focus on these specific indications. However, a study from the Mayo Clinic showed that intensive educational efforts were not successful in reducing the number of inappropriate studies.[14] Younger age, female gender,[1,3,8] and the absence of diabetes[3] were the most consistent predictors of inappropriate testing as in prior studies. The study by Gupta et al[8] showed that 11% of the tests were inappropriate and majority of the tests were ordered by primary care physicians for women similar to what this study showed.

To reduce the total number of inappropriate studies at our institution, a ''gatekeeper approach'' is now being utilized. Emphasis is placed on requesting the necessary information for determining appropriateness from the primary care providers. Patients are screened at the time of the test and the best test is selected for the patient by trained nurses in

Table 3. Descriptive analysis of renal function/cardiovascular (CV) diseases and procedures for appropriateness classification and *P* values from Fisher's exact test

	Appropriate (n = 322)	Inappropriate (n = 54)	*P* value
Renal function/CV disease (%)			
Creatinine > 2.0			.228
No	95.6	100.0	
Yes	4.4	0.0	
Coronary artery disease			.012
No	83.2	96.3	
Yes	16.8	3.7	
Myocardial infarction			.241
No	87.9	94.4	
Yes	12.2	11.4	
Congestive heart failure			.369
No	96.9	100.0	
Yes	3.1	0.0	
Peripheral vascular disease			.600
No	97.8	100.0	
Yes	2.2	0.0	
Cerebrovascular accident			.376
No	96.6	100.0	
Yes	3.4	0.0	
CV procedures			
Abnormal ECG			1.000
No	94.7	94.4	
Yes	5.3	5.6	
Cardiac catheterization			.027
No	85.5	96.3	
Yes	14.5	3.7	
Percutaneous intervention			.027
No	88.7	98.2	
Yes	11.3	1.9	
Coronary artery bypass graft			.229
No	96.3	100.0	
Yes	3.7	0.0	

Table 4. Practice setting by appropriateness classification and *P* values obtained from Fisher's exact test

	Appropriate (n = 322)	Inappropriate (n = 54)	*P* value
Settings			<.001
Academic hospital	32.7	2.6	
Academic outpatients	28.0	27.8	
Community PCP	35.2	57.4	
Community cardiologists	4.1	9.3	

Table 5. Inappropriate utilization of stress test by AUC table and specific indication

Appropriateness table no.	Indication	Description	Frequency (%) n = 54	Cardiologists (%) n = 14
1	1	Low pretest probability of CAD, ECG interpretable AND able to exercise	25 (46)	8 (57)
2	12	Low CHD risk (ATP III risk criteria)	15 (28)	3 (22)
2	13	Intermediate CHD risk (ATP III risk criteria)	7 (13)	0
1	10	Definite ACS	2 (4)	0
4	42	No clinical risk factors	2 (4)	0
3	25	Low CHD risk (ATP III risk criteria), Last stress imaging study done more than or equal to 2 years ago	1 (2)	1 (7)
3	27	Known CAD on coronary angiography or prior abnormal stress imaging study, Last stress imaging study done less than 2 years ago	1 (2)	1 (7)
6	59	Less than 2 years after PCI	1 (2)	1 (7)

conjunction with supervising cardiologists. This sometimes requires a courtesy call to the referring physician which can be time-consuming. Several tools for reducing inappropriate SPECT MPI have been studied. Hendel et al[3] showed that computer-automated assignment of AUC is feasible for incorporation into the workflow of daily practice and Lin et al[15] showed that an automated Multimodality Point-of-Order Decision Support Tool is helpful in lowering the rates of inappropriate testing. The ACC FOCUS in imaging is a web-based community, quality improvement, and education product, which was successful in reducing a 10% inappropriate imaging rate by 50% within 3 years.[16]

This study shows that most of the inappropriate studies were ordered by primary care practitioners in low risk younger women. This has important implications in terms of lifetime radiation exposure and overall cost to the healthcare system. It also underscores the need for continued education, widespread dissemination of guideline information, and utilization of automated tools to reduce inappropriate testing.

STUDY LIMITATIONS

Performance at a single academic center although tests from community physicians with no affiliation to the medical center makes this study more applicable to a broader population than is the case in many academic centers. Incomplete documentation or unavailability of data as is the case with many retrospective studies may explain inappropriate classification of some studies. For instance in situations when the lipid profile was unavailable for calculation of the Framingham risk score, LDL was assumed to be high but in all cases the tests were still found to be inappropriate.

NEW KNOWLEDGE GAINED

The ordering practices and rates of inappropriate testing in a predominantly Hispanic and medically underserved population on the US-Mexico border are consistent with the national average and previously published data. Inappropriate utilization of SPECT

Table 6. Unadjusted and adjusted association of variables with appropriateness classification using odds ratios and *P* values obtained from multivariate logistic regression

	Inappropriate crude (*P*)	Full model OR (*P*)	Final model OR (*P*)
Age	0.93 (<.001)	0.87 (<.001)	0.87 (<.001)
Gender			
Female	1	1	1
Male	0.35 (.002)	0.10 (<.001)	0.11 (<.001)
Diabetes			
No	1	1	1
Yes	0.23 (<.001)	0.37 (0.052)	0.28 (.007)
Hypertension			
No	1	1	
Yes	0.43 (.006)	1.61 (0.369)	
Chest pan			
No	1	1	1
Yes	0.17 (<.001)	0.06 (<.001)	0.05 (<.001)
Shortness of breath			
No	1	1	
Yes	0.49 (.034)	0.41 (.046)	
Aspirin			
No	1	1	
Yes	0.37 (.006)	0.63 (.335)	
Beta blocker			
No	1	1	
Yes	0.32 (.011)	1.27 (.700)	
Angiotensin-coverting enzyme inhibitor (ACEI)			
No	1	1	
Yes	0.41 (.011)	0.68 (.478)	
HMG-CoA reductase inhibitor			
No	1	1	
Yes	0.35 (.005)	0.66 (.381)	
Coronary artery disease			
No	1	1	
Yes	0.19 (.024)	1.22 (.862)	
Cardiac catheterization			
No	1	1	
Yes	0.65 (.030)	0.81 (.385)	
Percutaneous intervention			
No	1	1	
Yes	0.15 (.012)	0.46 (.626)	
Practice setting			
Academic hospital	1	1	1
Academic outpatients	5.83 (.007)	3.50 (.092)	3.02 (.123)
Community PCP	9.60 (<.001)	5.34 (.016)	5.58 (.011)
Community cardiologists	13.46 (.001)	10.59 (.025)	8.15 (.031)

MPI in low risk younger women in outpatient/community practice settings is a problem that cuts across populations and geographic locations in the USA.

CONCLUSIONS

Inappropriate SPECT MPI in low risk younger women is an important issue on the USA-Mexico

border. Majority of the inappropriate tests were for one of three indications and younger age and females were highly associated with inappropriate selection of patients for SPECT MPI while diabetes and chest pain were associated with a reduced risk of inappropriate testing. This suggests that quality improvement initiatives to reduce inappropriate SPECT MPI should focus on a few indications and evaluation of symptoms in younger age women by primary care physicians in outpatient/community practice settings. Furthermore, SPECT stress labs must regularly assess the factors associated with inappropriate testing and design quality improvement initiatives unique to the practice setting and referral base, taking advantage of the currently available tools.

Disclosures

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