Clinician-dependent variations in inappropriate use of myocardial perfusion imaging: Training, specialty, and location

David E. Winchester, MD, MS,[a,b] Joseph Hymas, MD,[b] Ryan Meral, BA,[b] Daniel Nguyen, MD,[b] Raman Dusaj, MD,[a,b] Leslee J. Shaw, PhD,[c] and Rebecca J. Beyth, MD, MSc[a,b]

[a] Malcom Randall VA Medical Center, Gainesville, FL
[b] University of Florida College of Medicine, Gainesville, FL
[c] Emory University School of Medicine, Atlanta, GA

Received Dec 17, 2013; accepted Feb 17, 2014
doi:10.1007/s12350-014-9887-3

Background. **Inappropriate use of myocardial perfusion imaging (MPI) may vary depending on the training, specialty, or practice location of the clinician.**

Methods. **We conducted a cross-sectional investigation of consecutive patients who underwent MPI at our Veterans Affairs medical center between December 2010 and July 2011. Characteristics of the MPI ordering clinicians were extracted to investigate any associations with inappropriate use.**

Results. **582 patients were included, 9.8% were inappropriate. No difference in inappropriate use was observed between cardiology and non-cardiology clinicians (n = 21, 9.5% vs n = 36, 10.0%, *P* = .83); no difference was noted between nurse practitioners/physician assistants, attending physicians, and housestaff (7.5% vs 11.2% vs 1.8%, *P* = .06). Comparing inpatient, emergency department and outpatient clinician groups, the difference was null (8.6% vs 6.3% vs 10.1%, *P* = .75). For most clinician groups, the most common inappropriate indication was an asymptomatic scenario; however, some groups were different: definite acute coronary syndrome for inpatient clinicians and low risk syncope for emergency medicine clinicians.**

Conclusions. **Clinician groups appear to order inappropriate MPI at similar rates, regardless of their training, specialty, or practice location. Differences in the most common type of inappropriate testing suggest that interventions to reduce inappropriate use should be tailored to specific clinician types. (J Nucl Cardiol 2014;21:598–604.)**

Key Words: Myocardial perfusion imaging • appropriate use criteria • coronary artery disease

INTRODUCTION

Appropriate use criteria (AUC) for myocardial perfusion imaging (MPI) were developed in 2005, revised in 2009, and encompass a variety of clinical scenarios where MPI might be used.[1] Due to this variety, MPI tests are ordered by many different types of clinicians crossing specialties and types of training. Depending on their practice pattern and patient profile, a clinician may routinely encounter only a fraction of the 67 clinical scenarios enumerated in the AUC. For example, ED clinicians are not likely to order screening tests for asymptomatic patients, and busy primary care providers are unlikely to order viability testing.

While AUC for MPI have been in use for nearly a decade, adoption has not been widespread.[2] This observation is in keeping with other investigations showing

Reprint requests: David E. Winchester MD, MS, Malcom Randall VA Medical Center, 1601 SW Archer Rd 111D, Gainesville, FL 32608; *david.winchester@va.gov*
1071-3581/$34.00

that while some medical advances are adopted rapidly, numerous barriers slow the adoption of clinical guidelines into clinical practice.[3,4] Barriers to adoption by physicians in practice could result in physicians in training being more likely to order MPI appropriately.

In a contemporary health care environment, patients may encounter clinicians with varied training backgrounds. Most clinicians are empowered to order MPI, including physicians, nurse practitioners (NP), physician assistants (PA), and housestaff trainees. As a result of differences in training, familiarity with the evidence base for MPI and possible limitations of the technology range from nonexistent to thorough and detailed. These differences may result in higher rates of inappropriate MPI ordered for some clinician groups.[5,6]

For all these reasons, variability in the use of MPI may exist when stratified based on the training, specialty, or practice location of the clinician. We conducted this investigation to ascertain the roles that these factors might play in the appropriate use of MPI. We hypothesized that some groups of clinicians will order fewer inappropriate MPI than other clinicians.

METHODS

Patient Selection and Data Collection

Subjects in this investigation were veterans who underwent MPI at one of two hospital-based nuclear cardiology laboratories affiliated with our Veterans Affairs medical center in Gainesville, FL. Data from this investigation demonstrating associations between patients characteristics and inappropriate MPI were reported previously.[7] All consecutive patients undergoing MPI, between December 2010 and July 2011, were included. Data were collected from the Computerized Patient Record System and included patient demographics and characteristics and the results of the MPI test. The training, specialty, and ordering location of the clinicians ordering each MPI was documented and analyzed as described below.

Appropriateness categorization was made retrospectively, not at the point of ordering, using a modified version of the Formation of Optimal Cardiovascular Utilization Strategies data collection instrument[8] and based on the information in the medical record including the chief complaint, medical history, and laboratory and electrocardiogram results. Data were extracted and AUC initially determined in an unblinded fashion by two of the authors, neither of whom are affiliated with the nuclear lab at our facility (RM, DN). Two additional acknowledged investigators (SR, RC) assisted by providing further clarification when necessary. If any doubts or discrepancies were noted, or if the MPI met multiple AUC categories, then the final adjudication of AUC was made by the primary author (DEW). A formal accounting of the interrater and intrarater variation was not kept. The reason that the test was ordered was ascertained from the medical progress note and the documentation of the patient complaint, not the review of systems. When clinicians ordered MPI for subjects with symptoms, the clinician was presumed to be concerned that the symptoms were due to ischemia. We used the following definitions: coronary artery disease defined as prior infarction or revascularization, and diabetes mellitus defined as glycated hemoglobin >8% or prescription of oral or injected antihyperglycemic medications. Our investigation was reviewed and approved by our Institutional Review Board which provided a waiver for informed consent.

Outcomes and Statistical Analysis

The primary outcome of this investigation was to determine if MPI use varied by clinician type. At our facility, MPI can be ordered by any type of clinician (physician, NP/PA, or trainee) in the hospital or in the outlying clinics that refer to our laboratories for testing. All ordering providers have full access to a patient's medical record at the time the MPI is ordered. Three comparisons were made. First, cardiologists were compared vs all other specialties. The significant majority of all other specialties were primary care clinicians and hospital-based internal medicine clinicians. A pre-operative clinic is operated at our facility by the anesthesiology service; however, clinicians there refer patients needing cardiovascular evaluation to cardiology clinic prior to surgery. Second, we compared clinicians by training categories: housestaff trainees (resident or fellow), NP/PA, and attending physicians (independent physician without trainees). Although all housestaff encounters and most NP/PA encounters included oversight of an attending physician, encounters were categorized based on the primary author of the note associated with the MPI test being ordered. The supervising physicians could be of any specialty, and as noted above, the significant majority of tests are ordered either by cardiology or by primary care/hospitalist practices. The third comparison was between inpatient, outpatient, and emergency department encounters.

To facilitate testing as a dichotomous variable, appropriate and uncertain MPI tests were combined and compared to inappropriate MPI tests. Based on ordering patterns at our facility, we estimated that roughly one third of MPI tests are ordered by cardiology providers. To detect a 10% difference in the rate of inappropriate MPI tests and all other specialties, with two-tailed α of 0.05 and 1-β of 0.8, a sample size of 572 would be adequate. Power analysis was performed using G*Power version 3.1.7 (Dusseldorf, Germany).[9] Categorical variables were compared by Chi square test. Multivariate logistic regression was performed to estimate the odds ratios (OR) and 95% confidence intervals (CIs) of any correlations between inappropriate testing and characteristics of the patients and providers. Dummy variables were created to compare the correlation with each of the categories from the three clinician comparisons. Statistical analysis was performed using SPSS version 21 (IBM; Armonk, NY). The investigation was performed in accord with the Strengthening the Reporting of Observational Studies in Epidemiology methodology.[10]

RESULTS

Baseline Characteristics

We analyzed MPI tests for 582 subjects, of which 90.2% were appropriate (n = 467, 80.2%) or uncertain (n = 58, 10.0%), and 9.8% were inappropriate (Table 1). No AUC determination could be made for ten studies, which were not included in this investigation. The overwhelming majority of subjects were male (96%) with high prevalence of diabetes (41.4%), hypertension (82.4%), and hyperlipidemia (76.2%). Significant differences in several characteristics were noted between the appropriate/uncertain and inappropriate groups. Chest pain was the most common symptom for the appropriate/uncertain group (n = 284, 54.1%). The absence of symptoms was most common in the inappropriate group (n = 26, 45.6%), and prevalence was significantly different for some comparisons. Housestaff saw significantly fewer patients without symptoms (1.8%) vs other clinicians (16.3% for NP/PAs and 24.0% for MD/DO; $P < .0001$). No difference in asymptomatic patients was noted for cardiology (18.5%) vs non-cardiology clinicians (22.2%, $P = .28$). No patients seen in the ED were asymptomatic (inpatient 11.4%, outpatient 22.7%, ED 0.0%; $P = .03$). Of the 15 studies ordered for pre-operative evaluation, less than half were appropriate (n = 7 for AUC indication 43, n = 8 for AUC indications 40, 41, and 42).

Primary Outcome

The distributions of appropriate/uncertain and inappropriate MPI groups for each of the clinician comparisons are described in Table 2 and Figure 1. No difference was noted in the percentage of inappropriate MPI tests between cardiology and non-cardiology clinicians ($P = .83$). Housestaff had a slightly lower rate of inappropriate tests compared to the NP/PA group and the attending group; however, the result was not significant ($P = .06$). No difference was observed comparing ED, inpatient, and outpatient clinician locations ($P = .75$).

We performed multivariate logistic regression for further analysis of correlations between inappropriate MPI testing and selected provider and patient characteristics. Significant correlations were noted between inappropriate testing and diabetes (OR 0.18, 95% CI 0.08-0.40), coronary artery disease (OR 0.31, 95% CI 0.15-0.62), chest pain (OR 0.06, 95% CI 0.02-0.15), and fatigue (OR 0.21, 95% CI 0.05-0.90). None of the clinician characteristics were retained in the model.

Most Common Inappropriate MPI Testing

The most common inappropriate indication differed between clinician categories (Table 3), and a summary of all the inappropriate MPI indications is provided

Table 1. Baseline characteristics of 582 subjects who underwent myocardial perfusion imaging

	Appropriate/uncertain, N = 525	Inappropriate, N = 57	*P* value
Female	19 (3.6%)	3 (5.3%)	.536
Overweight	469 (89.3%)	51 (89.5%)	.994
Obese	354 (67.4%)	39 (68.4%)	.895
Diabetes	233 (44.3%)	8 (14.0%)	<.0001
Hypertension	440 (83.8%)	40 (70.2%)	.01
Hyperlipidemia	410 (78.1%)	34 (59.6%)	.002
CAD	228 (43.4%)	12 (21.1%)	.001
Prior MI	228 (43.4%)	12 (21.1%)	.001
Revascularization	197 (37.5%)	10 (17.5%)	.003
Current smoker	139 (26.4%)	11 (19.3%)	.239
Symptom[a]			
Chest pain	284 (54.1%)	5 (8.8%)	<.0001
Noncardiac	229	3	
Atypical	48	2	.387
Typical	7	0	
Dyspnea	217 (41.3%)	23 (40.4%)	.886
Fatigue	56 (10.7%)	2 (3.5%)	.087
No symptoms	95 (18.1%)	26 (45.6%)	<.0001

CAD, Coronary artery disease; *MI*, myocardial infarction.
[a] The presence of each symptom was recorded for each subject and are presented as prevalences for the appropriateness categories.

Table 2. Comparison of inappropriate MPI testing by clinician categories

	Appropriate/uncertain, N = 525	Inappropriate, N = 57	*P* value
Clinician specialty			.83
Cardiology	201 (90.5%)	21 (9.5%)	
Other	324 (90.0%)	36 (10.0%)	
Clinician training			.06
NP/PA	74 (92.5%)	6 (7.5%)	
Attending	396 (88.8%)	50 (11.2%)	
Housestaff	55 (98.2%)	1 (1.8%)	
Clinician location			.75
Inpatient	32 (91.4%)	3 (8.6%)	
ED	30 (93.8%)	2 (6.3%)	
Outpatient	463 (89.9%)	52 (10.1%)	

Results are reported as n (%).
ED, Emergency department; *MPI*, myocardial perfusion imaging; *NP/PA*, nurse practitioner or physician assistant.

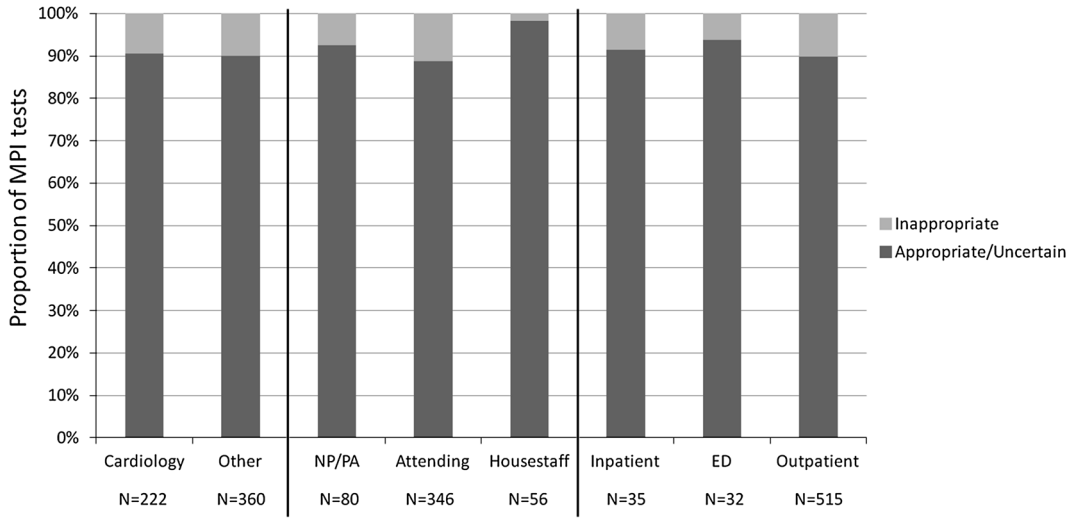

Figure 1. Comparison of appropriate/uncertain vs inappropriate MPI for each clinician group. The *stacked bar graph* indicates the proportion of MPI for each clinician group that is inappropriate (top section in *gray*). Three comparisons were made cardiology vs non-cardiology ($P = .83$), NP/PA vs attending vs housestaff ($P = .06$), and inpatient vs ED vs outpatient ($P = .75$). Each comparison is divided by a *vertical line*. *ED*, Emergency department; *MPI*, myocardial perfusion imaging; *NP*, nurse practitioner; *PA*, physician assistant.

(Table 4). Of the eight categories examined, all but two of the most common inappropriate indications involved asymptomatic patients. Furthermore, asymptomatic patients with low or intermediate coronary heart disease risk were the top inappropriate for four of the categories. AUC indication #13 (asymptomatic with intermediate risk, n = 10) was the most common inappropriate indication for attending clinicians, followed by #12 (asymptomatic with low risk, n = 9) and #1 (symptomatic with low risk and normal ECG, n = 8). Cardiology providers ordered MPI inappropriately for asymptomatic patients with prior, recent percutaneous coronary intervention (AUC #59), while housestaff ordered MPI inappropriately for asymptomatic patients with prior, recent testing (AUC #27). Inappropriate testing was commonly ordered for symptomatic patients by clinicians practicing in the emergency department (ED) (low risk syncope, AUC #20) and inpatient settings (definite acute coronary syndrome, AUC #10).

DISCUSSION

We examined the indications for MPI to ascertain any differences in the patterns of inappropriate use

Table 3. Most common inappropriate indication for each clinician category

Clinician specialty	
Cardiology	Asymptomatic patient with less than 2 years after percutaneous coronary intervention (AUC# 59)
Other	Asymptomatic patient with intermediate CHD risk (ATP III risk criteria) with no ischemic equivalent and an interpretable ECG (AUC #13)
Clinician training	
NP/PA	Asymptomatic patient with low CHD risk (ATP III risk criteria) and no ischemic equivalent (AUC #12)
Attending	Asymptomatic patient with intermediate CHD risk (ATP III risk criteria) with no ischemic equivalent and an interpretable ECG (AUC #13)
Housestaff	Asymptomatic/stable symptoms with prior abnormal angiography/stress imaging less than 2 years ago (AUC #27)
Clinician location	
Inpatient	Definite acute coronary syndrome (AUC #10)
ED	Syncope with low CHD risk (AUC #20)
Outpatient	Asymptomatic patient with low CHD risk (ATP III risk criteria) and no ischemic equivalent (AUC #12)

AUC, appropriate use criteria; *ATP*, adult treatment panel; *CHD*, coronary heart disease; *ECG*, electrocardiogram; *ED*, emergency department; *MPI*, myocardial perfusion imaging; *NP/PA*, nurse practitioner or physician assistant.

Table 4. Summary of all inappropriate MPI, ranked by frequency

AUC indication	N	Percent
12: Asymptomatic patient with low CHD risk (ATP III risk criteria) and no ischemic equivalent	12	21.1
13: Asymptomatic patient with intermediate CHD risk (ATP III risk criteria) with no ischemic equivalent and an interpretable ECG	10	17.5
1: Ischemic equivalent with low pretest probability, interpretable ECG, and can exercise	9	15.8
59: Asymptomatic patient with less than 2 years after percutaneous coronary intervention	7	12.3
41: Prior to intermediate risk surgery with moderate to good functional capacity	4	7.0
20: Syncope with low CHD risk	3	5.3
37: Prior treadmill with low risk Duke Score	3	5.3
27: Asymptomatic/stable symptoms with prior abnormal angiography/stress imaging less than 2 years ago	2	3.5
42: Prior to intermediate risk surgery with no clinical risk factors	2	3.5
10: Definite acute coronary syndrome	1	1.8
23: Asymptomatic/stable symptoms with low CHD risk and last stress imaging done less than 2 years ago	1	1.8
25: Asymptomatic/stable symptoms with low CHD risk and last stress imaging done more than 2 years ago	1	1.8
33: Asymptomatic with prior coronary calcium Agatston score less than 100	1	1.8
40: Prior to low risk surgery	1	1.8

ATP, Adult treatment panel; *CHD*, coronary heart disease; *ECG*, electrocardiogram; *MPI*, myocardial perfusion imaging.

between specialties, level/type of training, and patient location. Our hypothesis was that differences in the inappropriate use of MPI would vary between clinician types. The investigation was powered to detect a modest difference (10%) in inappropriate testing for a comparison between cardiology and non-cardiology providers. While we did not detect any difference in the rate of inappropriate studies, we did detect more nuanced differences. Specifically, we observed differences in the types of inappropriate tests ordered by each group of clinicians. This finding bears relevance to those seeking to reduce inappropriate MPI test use.

The overall use of MPI by a clinician is largely driven by the population of patients seen. For example, most ED clinicians are unlikely to encounter asymptomatic patients. Thus, they are unlikely to order MPI for one of the AUC indications involving asymptomatic patients. In contrast, primary care providers, seeing patients for primary prevention of heart disease, see asymptomatic patient more frequently. While some might question the need for MPI in asymptomatic patients, the 2009 AUC for Radionuclide Imaging include indication 15, ''Detection of CAD in asymptomatic patients with high CHD risk (ATP III criteria)'' with an ''appropriate'' AUC score of 7. Seemingly, a common concern among primary care clinicians at our facility is the need to screen for CAD in asymptomatic patients; however, a tendency to overestimate CHD risk leads to the determination that many of these MPI are actually inappropriate (2009 AUC indications 12-14).

Another factor which could affect the appropriateness of MPI use is the volume of patients who warrant a MPI. One might expect that clinicians who more frequently order MPI would be more familiar with its advantages and disadvantages, and therefore more likely to order MPI appropriately. ED clinicians may see few patients in need of MPI, while cardiologists see many patients in need of MPI. Despite ordering one third of all the MPI in our investigation and in contrast to the findings from another study,[6] cardiology clinicians had the same rate of inappropriate MPI as non-cardiology clinicians. This finding suggests that efforts to reduce inappropriate MPI through education will need to be tailored specifically to different clinicians groups.

Educational initiatives to reduce inappropriate testing are the topic of few published studies. Gibbons et al performed a multi-faceted investigation including lectures, individual meetings with high volume ordering clinician groups, and a notice in their institutional newsletter. Despite these efforts, no difference was observed in the rate of inappropriate test ordering.[11] Willens et al found no effect of a grand rounds lecture intervention informing referring cardiologists of the AUC for the most common inappropriate echocardiography requests at their facility, and scenarios where non-imaging stress testing would be more appropriate.[12] In contrast, inappropriate echocardiography ordering was reduced from 13% to 5% with an intervention consisting of a lecture, a pocket card summary, and biweekly email feedback to participants by Bhatia et al.[13] Varying effectiveness of interventions to change providers' behavior has been well documented,[14] with more successful interventions being more active in their approach, targeting specific barriers to change, and including an element of personal feedback.

Bhatia's intervention was directed toward housestaff; interestingly, in our investigation, physicians in training ordered nonsignificantly fewer inappropriate studies than attendings and NP/PAs ($P = .06$). This could represent a true difference ordering behavior and understanding of AUC; perhaps related to an exposure to AUC while in training and being more malleable in their decision making processes, as compared to physicians who have been out of training for a long duration. Trainees, however, also more commonly encountered symptomatic inpatients with chest pain, which we and others have observed is associated with appropriate testing. The other group in our comparison of types of training was comprised NP/PAs. In contrast to another study which assessed the effect of training,[5] we did not observe any difference in appropriateness comparing NP/PAs to physicians. This question may warrant further investigation, particularly with regard to tailoring efforts to reduce inappropriate MPI as noted previously. Since housestaff and NP/PAs practice under supervision and some are trained by attendings who could have been part of this investigation, there could be a common practice effect resulting in the negative finding for this comparison. This phenomenon, however, would not be at play in the other provider comparisons because no supervisory relationship exists.

Limitations

Our investigation is not without limitations. The study was powered to detect a 10% difference in inappropriate use; while no difference was observed, the numerical differences for most comparisons were quite small and would require a much larger sample to prove statistically. Some subgroups, such as the housestaff, were underrepresented and could show a significant reduction in inappropriate MPI in a larger investigation. As a chart review, the investigation is limited by the documentation made at the time the MPI was ordered. AUC determinations were not done in an automated fashion, but manually by individuals. This methodology for determining AUC could also lead to a ''grade inflation'' bias whereby AUC determinations may tend to minimize inappropriate indications, especially in circumstances where more than one AUC category may apply to a single patient. The primary data extractors in our investigation are not directly affiliated with our nuclear laboratory.

NEW KNOWLEDGE GAINED

Our manuscript adds to the growing body of literature attempting to define how characteristics of clinicians contribute to variations in practice,

specifically as related to MPI. While the literature on the magnitude of difference is mixed, our investigation highlights relevant differences which could affect efforts to reduce unnecessary testing.

CONCLUSIONS

Inappropriate MPI testing was observed at similar rates for clinicians regardless of their specialty, type/level of training, and the location of the ordering encounter. The most common inappropriate indications ordered by each group, however, were different. Interventions to reduce inappropriate use may be more successful if targeted to specific clinician groups and environments of care.

Acknowledgments

Ryan Chauffe, DO and Scott Ryals, MD are acknowledged for their participation in gathering of data for this investigation. This investigation was supported by NIH T35 Training Grant: T35-HL007489-28. This work was supported by resources provided by the North Florida/South Georgia Veterans Health System. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States government.

Disclosures

Dr. Winchester had full access to the data and accepts responsibility for its integrity.

References

1. Hendel RC, Berman DS, Di Carli MF, Heidenreich PA, Henkin RE, Pellikka PA, et al. ACCF/ASNC/ACR/AHA/ASE/SCCT/SCMR/SNM 2009 appropriate use criteria for cardiac radionuclide imaging: A report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force, the American Society of Nuclear Cardiology, the American College of Radiology, the American Heart Association, the American Society of Echocardiography, the Society of Cardiovascular Computed Tomography, the Society for Cardiovascular Magnetic Resonance, and the Society of Nuclear Medicine. Circulation 2009;119:e561-87.
2. Tilkemeier P, Green J, Einstein AJ, Fazel R, Reames P, Shaw LJ. The evolving practice of nuclear cardiology: Results from the 2011 ASNC member survey. J Nucl Cardiol 2012;19:1170-5.
3. Haynes B, Haines A. Barriers and bridges to evidence based clinical practice. Br Med J 1998;317:273-6.
4. Cabana MD, Rand CS, Powe NR, Wu AW, Wilson MH, Abboud PA, et al. Why don't physicians follow clinical practice guidelines? A framework for improvement. J Am Med Assoc 1999;282:1458-65.
5. Nelson KH, Willens HJ, Hendel RC. Utilization of radionuclide myocardial perfusion imaging in two health care systems: Assessment with the 2009 ACCF/ASNC/AHA appropriateness use criteria. J Nucl Cardiol 2012;19:37-42.
6. Gupta A, Tsiaras SV, Dunsiger SI, Tilkemeier PL. Gender disparity and the appropriateness of myocardial perfusion imaging. J Nucl Cardiol 2011;18:588-94.
7. Winchester DE, Meral R, Ryals S, Beyth RJ, Shaw LJ. Appropriate use of myocardial perfusion imaging in a veteran population: Profit motives and professional liability concerns. JAMA Intern Med 2013;173:1381-3.
8. FOCUS Initiative. http://www.cardiosource.org/Science-And-Quality/Quality-Programs/Imaging-in-FOCUS/. Accessed 10 Aug 2012.
9. Faul F, Erdfelder E, Lang AG, Buchner A. G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behav Res Methods 2007;39:175-91.
10. von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement: Guidelines for reporting observational studies. PLoS Med 2007;4:e296.
11. Gibbons RJ, Askew JW, Hodge D, Kaping B, Carryer DJ, Miller T. Appropriate use criteria for stress single-photon emission computed tomography sestamibi studies: A quality improvement project. Circulation 2011;123:499-503.
12. Willens HJ, Nelson K, Hendel RC. Appropriate use criteria for stress echocardiography: Impact of updated criteria on appropriateness ratings, correlation with pre-authorization guidelines, and effect of temporal trends and an educational initiative on utilization. JACC Cardiovasc Imaging 2013;6:297-309.
13. Bhatia RS, Milford CE, Picard MH, Weiner RB. An educational intervention reduces the rate of inappropriate echocardiograms on an inpatient medical service. JACC Cardiovasc Imaging 2013;6:545-55.
14. Grimshaw JM, Shirran L, Thomas R, Mowatt G, Fraser C, Bero L, et al. Changing provider behavior: An overview of systematic reviews of interventions. Med Care 2001;39:II2-45.