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The Impact of Individual Variation Analysis on Myocardial Perfusion Imaging Utilization Within a Hospitalist Group

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BACKGROUND: Increased recognition of ionizing radiation risks has placed an emphasis on the appropriate use of myocardial perfusion imaging (MPI). Hospitalists frequently order MPI in the evaluation of chest pain and are thus at the forefront of its inpatient utilization.

METHODS: We collected baseline figures for a group MPI rate (March 2010–February 2011) as well as individual MPI rates for hospitalists caring for cardiac floor patients at a community teaching hospital. We performed a 2-part intervention; we presented the individual MPI rate data back to the hospitalist division and carried out longitudinal educational efforts on MPI appropriateness criteria. We then calculated the group MPI utilization rate for 3 postintervention periods (March 2011–February 2012, March 2012–February 2013, and March 2013–February 2014) and the MPI rate for the subgroup of cardiac floor patients. Finally, we calculated the percentage of inappropriately performed stress tests before and after our intervention.

RESULTS: Group MPI rate declined from 6.1% to 5.0% in the first year after our intervention ($P = 0.009$); a decrease was maintained a year later—MPI rate 4.9% ($P = 0.004$)—and became even more pronounced 2 years later—MPI rate 3.9% ($P < 0.0001$). The MPI rate for the subgroup of patients on the cardiac floor similarly decreased from 8.0% to 6.7% ($P = 0.039$). Finally, we report a particularly encouraging and significant trend of a 46% postintervention decrease (from 16.5% to 9%, $P = 0.034$) in the proportion of inappropriate stress tests ordered.

CONCLUSIONS: Analyzing individual ordering rates and combining them with educational efforts was an effective strategy for impacting MPI utilization in the hospitalist group studied. *Journal of Hospital Medicine* 2015;10:190–193.

Myocardial perfusion imaging (MPI) is the single largest contributor to ionizing radiation in the United States, with a dose equivalent to percutaneous coronary intervention, or 5 times the yearly radiation from the sun.[1] Because MPI is performed commonly (frequently multiple times over a patient's lifetime), it accounts for almost a quarter of ionizing radiation in the United States.[1] It also ranks among the costliest commonly ordered inpatient tests. Although the utilization rate of the exercise tolerance test (ETT) without imaging, diagnostic coronary angiography, and echocardiography has remained stable over the last 2 decades, MPI's rate has increased steadily over the same time period.[2]

In the inpatient setting, MPIs are usually ordered by hospitalists. Chest pain admissions generally conclude with a stress test—frequently an MPI study. The recent evidence that ionizing radiation could be an underrecognized risk factor for cancer in younger individuals[3] has highlighted the hospitalist's role in reducing unnecessary radiation exposure. Appropriateness guidelines are published in the cardiology literature,[4] yet 1 in 7 MPI tests is performed inappropriately.[5] We examined the MPI ordering behavior of members of a hospitalist division, presented the data back to them, and noted that this intervention, in conjunction with longitudinal educational activities on MPI appropriateness use criteria, was associated with a decrease in the division's ordering rate.

METHODS

Database Collection

We performed a prospective study of MPI utilization at a 313-bed community teaching hospital in the greater Boston, Massachusetts area. The hospitalist division cares for 100% of medical admissions; its members have been practicing for a mean of 3.7 years (± 2.2), and its reimbursement was entirely fee-for-service during the study period. The institutional review board at our hospital approved the study. Our primary outcome was hospitalist group MPI rate before and after the intervention. For this outcome, the preintervention period was March 2010 to February 2011. We defined 3 postintervention time periods to examine the sustainability of any change: March 2011 to February 2012 (postintervention year 1), March 2012 to February 2013 (postintervention year 2), and March 2013 to February 2014 (postintervention year 3). Using the hospital's billing database, we identified the number of

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TABLE 1. MPI Volume, Inpatient Discharges, and MPI Ordering Rates for the Baseline and Postintervention Periods

	MPI Volume	Discharges	MPI Rate	ARR (95% CI)	RRR (95% CI)	*P* Value
Baseline period	357	5,881	6.1%			
Postintervention year 1	312	6,265	5.0%	1.1% (0.2-2.0)	18% (5–29)	0.009
Postintervention year 2	310	6,337	4.9%	1.2% (0.4-2.0)	19% (7–30)	0.004
Postintervention year 3	249	6,312	3.9%	2.1% (1.3-2.1)	35% (24–44)	<0.00001
All years after baseline combined	871	18,914	4.6%	1.5% (0.8-2.1)	24% (15–33)	<0.00001

NOTE: **Abbreviations:** ARR, absolute risk reduction; CI, confidence interval; MPI, myocardial perfusion imaging; RRR, relative risk reduction.

MPIs done on inpatients in each interval by the relevant Current Procedural Terminology codes. A similar database revealed the number of inpatient discharges.

To impact the group MPI rate via our intervention, we analyzed individual hospitalist ordering rates (using the same baseline period but a shorter postintervention period of July 2011–March 2012). For this subgroup analysis, we excluded 6 hospitalists working <0.35 clinical full-time equivalents (FTEs): their combined FTEs of 1.5 (rest of division, 15.5 FTEs) made analysis of small MPI volumes unfeasible. This resulted in 20 hospitalists being included in the baseline and 23 in the postintervention section. We assigned an MPI study to the discharging hospitalist, the only strategy compatible with our database. To make each hospitalist's patient population similar, we limited ourselves to patients admitted to the cardiac floor. Individual ordering rates were calculated by dividing the total number of MPIs performed by a hospitalist by the total number of patients discharged by that hospitalist.

Finally, to see if our intervention had caused a shift in test utilization, we collected data on the ordering of an ETT without imaging and stress echocardiography for the above 4 years; our institution does not currently utilize inpatient dobutamine echocardiography.

Intervention

Our intervention was 2-fold. First, we shared with the hospitalist division in a blinded format baseline data on individual MPI ordering rates for cardiac floor patients. Second, we conducted educational activities on MPI appropriateness use criteria. These occurred during scheduled hospitalist education series: practice exercises and clinical examples illustrated the relationship between Bayes Theorem, pretest, and post-test probability of coronary artery disease (CAD).[6] Additionally, local experts were invited to discuss guidelines for exercise and pharmacologic MPIs (eg, do not perform MPI for pretest probability of CAD <10% or if certain electrocardiographic criteria are met).[4,7] All education materials were made available electronically to the hospitalist division for future reference.

Statistical Analysis

For the primary outcome of group MPI rate, we used χ^2 testing to examine the change in MPI rate before and after the intervention. We compared each postintervention year to the baseline period. For the subgroup of hospitalists caring for cardiac floor patients, we calculated baseline and postintervention MPI rates for each individual. To determine whether their MPI rate had changed significantly after the intervention, we used a random-effects model. The outcome variable was the MPI rate of each physician: the physician was treated as a random effect and the time period as a fixed effect. To see if our educational interventions had an effect on inappropriate MPI ordering, we reviewed cases involving exercise tolerance MPIs; pharmacologic MPIs were excluded because alternative testing for patients unable to exercise is not available at our institution. A chart review was performed to calculate the pretest probability of CAD for each case based on established guidelines.[6] Using the χ^2 test, we calculated the change in the group's rate of inappropriate exercise MPI ordering (ie, pretest CAD probability <10% [the postintervention period for this calculation was July 2011–March 2013]).

RESULTS

The change in group MPI rate over time can be seen in Table 1. Comparing each postintervention year to baseline, we noted that a statistically significant 1.1% absolute reduction in the MPI rate for postintervention year 1 ($P = 0.009$) was maintained a year later ($P = 0.004$) and became more pronounced in postintervention year 3, a 2.1% absolute reduction ($P < 0.00001$).

A similar decline was seen in the MPI rate in the subgroup of patients cared for on the cardiac floor. In the baseline period, 20 hospitalists ordered 204 MPI tests on 2458 cardiac discharges, an average utilization rate 8.3 MPIs per 100 discharges (individual ranges, 4.0%–11.7%). In the postintervention period, 23 hospitalists ordered 173 MPI studies on 2629 cardiac discharges, which is an average utilization rate of 6.6 MPIs per 100 discharges (individual ranges, 3.4%–11.3%). Because there was variability in individual rates and no hospitalist's decrease was statistically significant, we used random-effects modeling to compare the magnitude of change for this entire subgroup of hospitalists. We found that their MPI rate decreased statistically significantly from 8.0% in the baseline period to 6.7% in the postintervention period ($P = 0.039$).

Table 2 shows volumes and rates for all stress-testing modalities employed at our hospital; there was

TABLE 2. Volume (and Rate per 100 Discharges) of Different Cardiac Stress-Testing Modalities for the Periods Studied

Intervention	Baseline Period	Postintervention Year 1	Postintervention Year 2	Postintervention Year 3
ETT volume (rate)	275 (4.7)	259 (4.1)	289 (4.6)	299 (4.7)
MPI volume (rate)	357 (6.1)	312 (5.0)	310 (4.9)	249 (3.9)
Stress ECHO volume (rate)	16 (0.027)	9 (0.014)	16 (0.029)	22 (0.035)

NOTE: **Abbreviations:** ETT, exercise tolerance test; MPI, myocardial perfusion imaging; Stress ECHO, stress echocardiography.

TABLE 3. Change in Inappropriate Stress Test Ordering

	ETT-MPIs with Pretest CAD Probability <10%	Total ETT-MPIs Performed	Proportion of Inappropriate ETT-MPIs	ARR	RRR	*P* Value
Baseline period	22	133	16.5%			
Postintervention years 1 and 2	19	212	9%	7.5% (1.9–15)	46% (3.9–70)	0.034

NOTE: **Abbreviations:** ARR, absolute risk reduction; CAD, coronary artery disease; ETT-MPI, exercise tolerance test-myocardial perfusion imaging; RRR, relative risk reduction.

no significant difference in either our ETT or stress echocardiography rates over the years. We include these figures because our intervention could have caused hospitalists, in an effort to avoid radiation exposure, to redirect ordering to other modalities. Finally, the influence of continuing education on appropriate ordering can be seen in Table 3. The rate of inappropriate exercise MPIs on patients with a pretest CAD probability <10% dropped almost in half, from 16.5% in the baseline period to 9.0% in the subsequent 20 months. This difference also reached statistical significance ($P = 0.034$) and underlies a trend of even greater clinical impact—a decrease in a test clearly not indicated for the patient's condition.

DISCUSSION

In this prospective study of MPI ordering variation among hospitalists at a community teaching hospital, we found a statistically significant, sustained decline in the group MPI rate; a statistically significant decrease in the MPI rate for cardiac floor patients; and no corresponding increases in the use of other stress-testing modalities. Finally, and perhaps most relevant clinically, the proportion of inappropriately ordered MPIs decreased almost by half following our intervention.

Variation in physician practice has been the subject of research for decades,[8] with recent studies looking into geographical and physician variation in performing coronary angiography[9] or electrocardiograms.[10] We sought to determine whether examining variation among hospitalists was a viable strategy to influence their MPI ordering behavior. Our findings reveal that sharing individual MPI rates, coupled with educational initiatives on appropriateness use criteria, led to a continuous decline in group MPI rate for 3 consecutive years following our intervention. This sustainability of change is among our study's most encouraging findings. Education-based quality improvement projects can sometimes fizzle out after an impressive start. The persistent decline in MPI utilization suggests that our efforts had a long-lasting impact on MPI ordering behavior without affecting the utilization of stress tests not employing ionizing radiation. We have no evidence of any other secular trends that could have accounted for these changes. There were no other programs at our institution addressing MPI use, nor was there a change in hospital or physician reimbursement during the study period.

Inappropriate stress testing has long been a concern in low-risk chest pain admissions; over two-thirds of such patients undergo stress testing prior to discharge,[11] and physicians rarely consider the patient's CAD pretest probability, resulting in an alarming number of stress tests performed without clinical indications.[12] Our finding of a statistically significant 46% decline in inappropriate exercise MPI ordering was thus particularly illuminating. With a number of 13 needed to treat or prevent 1 unnecessary MPI, education on appropriateness use criteria makes a compelling case for an effective strategy to reduce unwarranted imaging. To further reinforce its benefits, we have started periodically updating the hospitalist division on any changes in appropriateness use guidelines and on its ongoing MPI rate.

Decreased MPI utilization has certain cost implications as well. On average, 67 fewer MPIs are performed yearly in our hospital following our intervention. With charges of $3585 for ETT-MPIs and $4378 for pharmacological MPIs, which constitute 55% of all MPIs, this would result in yearly cost savings of $269,536, or $35,850 annually if only looking at inappropriately ordered ETT-MPIs. Such cost savings may become particularly relevant in a new risk-sharing environment where such studies may not be reimbursed.

Our study has several limitations. It was a small, single-center, pre- and postintervention study, thereby limiting its generalizability to other settings. MPI attribution was based on the discharging hospitalist who sometimes did not admit the patient. MPI figures were obtained from billing rather than ordering database; occasionally the cardiologist interpreting the stress test would change a nonimaging test to an MPI affecting the hospitalist rate. About half of our patients are on teaching services where tests are ordered by housestaff, also potentially influencing the group MPI rate. Finally, we did not study any clinical measures to see whether our intervention had any influence on patient outcomes.

Despite the above limitations, our examination of MPI ordering variation in a hospitalist division revealed that in an age of increasing scrutiny of high-cost imaging, such an approach can be extremely productive. In our experience, hospitalists are receptive to the continuous evaluation of their ordering behavior and to educational activities on appropriateness use criteria. It is our opinion that similar interventions could be applied to other high-cost imaging modalities under the daily purview of hospitalists such as computed tomography and magnetic resonance imaging.

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