Budget impact of applying appropriateness criteria for myocardial perfusion scintigraphy: The perspective of a developing country

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Myocardial perfusion imaging is widely used for the risk stratification of coronary artery disease. In view of its cost, besides radiation issues, judicious evaluation of the appropriateness of its indications is essential to prevent an unnecessary economic burden on the health system. We evaluated, at a tertiary-care, public Brazilian hospital, the appropriateness of myocardial perfusion scintigraphy indications, and estimated the budget impact of applying appropriateness criteria. An observational, cross-sectional study of 190 patients with suspected or known coronary artery disease referred for myocardial perfusion imaging was conducted. The appropriateness of myocardial perfusion imaging indications was evaluated with the Appropriate Use Criteria for Cardiac Radionuclide Imaging published in 2009. Budget impact analysis was performed with a deterministic model. The prevalence of appropriate requests was 78%; of inappropriate indications, 12%; and of uncertain indications, 10%. Budget impact analysis showed that the use of appropriateness criteria, applied to the population referred to myocardial perfusion scintigraphy within 1 year, could generate savings of $ 64,252.04 dollars. The 12% inappropriate requests for myocardial perfusion scintigraphy at a tertiary-care hospital suggest that a reappraisal of MPI indications is needed. Budget impact analysis estimated resource savings of 18.6% with the establishment of appropriateness criteria for MPI.

Key Words: Myocardial perfusion imaging: SPECT • coronary artery disease • diagnostic and prognostic application • cost effectiveness

Abbreviations

AUC	Appropriate Use Criteria for Cardiac Radionuclide Imaging
BIA	Budget impact analysis
CPET	Cardiopulmonary exercise testing
CABG	Coronary artery bypass grafting
CAD	Coronary artery disease
CHD	Coronary heart disease
ECG	Electrocardiogram
ET	Exercise test
MPI	Myocardial perfusion imaging
PCI	Percutaneous coronary intervention

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INTRODUCTION

The evolution of medical imaging, while improving disease detection, has also generated escalating increases in spending for patients, health insurances and governments. Requests for imaging tests grew at a double-digit rate per year in the last decade,[1] creating an unmitigated problem face to the disseminated budget constraints seen globally in recent years. In this scenario, discussion on the proper use of medical imaging has also grown, as well as a search for solutions to balance cost, benefit, and accessibility to more complex procedures in both developed and developing countries.

Myocardial perfusion imaging (MPI) one of the most employed tests for the diagnosis and risk stratification of coronary artery disease (CAD) worldwide. In Brazil, Pozzo et al[2] showed that 54% of the outpatient Nuclear Medicine procedures are MPI studies. This translates into a significant burden for the public health system, for 2 main reasons—there is free, universal access to tests and procedures and a very limited number of public Nuclear Medicine facilities. Thus, the identification of inappropriate MPI indications may be a step toward reducing costs, which in its turn may favor a more equitable distribution of health spendings. This study aimed to evaluate, at tertiary-care, public Brazilian hospital, specialized in cardiovascular disease, the appropriateness of MPI indications and to estimate the budget impact of inappropriate indications.

METHODS

This was a cross-sectional study of 190 patients with suspected or known CAD referred for MPI (2-day protocol, with either exercise or pharmacologic stress), recruited at the Nuclear Medicine department of a public, tertiary-care Cardiology hospital in Rio de Janeiro, Brazil, from October 2013 to March 2014. Demographic and clinical data were obtained during patient interview for MPI. MPI indications were classified, according to the Appropriate Use Criteria for Cardiac Radionuclide Imaging (AUC) published in 2009,[3] as appropriate, inappropriate, or uncertain. Among 67 clinical indications present in the AUC, the most frequent in the study population were selected.

Budget Impact Analysis

Budget impact analysis (BIA) was performed using static modeling, which consists of multiplying the individual cost of the new intervention by the number of individuals with indication for its use.[4] A time horizon of 2 years was set for incorporation of AUC, and the rate of incorporation was estimated to be 50% each year. The population undergoing BIA was the number of patients referred to the Nuclear Medicine department from January 1, 2013 to December 31, 2013 (1284 patients). The results found in the study sample (190 patients) were then projected to the 1284 patients. AUC implementation was compared to the reference scenario, defined as performing MPI without considering the AUC. The costs considered in the BIA were calculated according to reference values provided by the Management Procedures Table of the Brazilian Public Health System.[5] Incremental budget impact was calculated as the cost difference between the use of the AUC and the reference scenario at the end of the implementation time of AUC.

In addition, alternative scenarios were created, as recommended by guidelines for BIA of health technologies.[4,6] The alternative scenarios aim to study other patterns of the use of technology; in the current study, for example, they simulate how the AUC might guide the use of other diagnostic methods for patients with inappropriate MPI indications by AUC, as exercise test (ET) or cardiopulmonary exercise testing (CPET) and even no testing when diagnostic stratification is not indicated. Three alternative scenarios, comprising the most frequent indications of MPI at our institution, were created: (1) asymptomatic patients evaluated for coronary heart disease (CHD); (2) symptomatic patients without known CAD; and (3) patients with known CAD. In alternative scenario 3, asymptomatic patients <5 years post-coronary artery bypass grafting surgery (CABG) or <2 post-percutaneous coronary intervention (PCI) were also considered inappropriate indications for the purpose of BIA in this study.

The Institutional Ethics Committee approved the study and all patients signed a written informed consent.

Statistical Analysis

Categorical variables were expressed as number and percentage and compared with the Fisher's exact test. Continuous values were expressed as mean and standard deviation and compared with the Student's t, ANOVA, or Kruskal-Wallis tests. A P value <.05 was considered statistically significant. The EPIINFO™ software version 7 (7.1.3) was employed for all analyses.

RESULTS

Among 190 patients, 10% were asymptomatic, undergoing evaluation for suspected CHD, 28% were symptomatic without prior CAD, and 62% had known CAD. Baseline characteristics are shown in Table 1.

The overall percentages of appropriate, inappropriate, and uncertain indications for MPI were 78%, 12%, and 10%, respectively. When stratified by clinical categories, the rates of inappropriate indications were

Table 1. Demographic and clinical characteristics

Age, years (mean ± SD)	62.4 ± 10.6
Men	111 (58%)
BMI (mean ± SD)	28.0 ± 5.1
Hypertension	151 (79%)
Diabetes	58 (34%)
Dyslipidemia	97 (52%)
Obesity	50 (26%)
Sedentary	148 (78%)
Smoking	21 (11%)
Asymptomatic	73 (38%)
Suspected CAD	53 (28%)
Known CAD	118 (62%)
MI	88 (46%)
CABG	23 (12%)
PCI	48 (25%)
Medical management	40 (21%)

Data presented as number (percentage) for categorical variables, and as median ± SD - standard deviation for continuous variables; *BMI*, body mass index; *MI*, myocardial infarction; *CABG*, coronary artery bypass grafting; *CAD*, coronary artery disease; *PCI*, percutaneous coronary intervention

53% for asymptomatic patients evaluated for CHD risk, 5.7% for symptomatic without prior CAD, and 8.5% for known CAD. The most frequent clinical scenarios with inappropriate indications are shown in Table 2. Performing MPI in asymptomatic individuals who underwent PCI in the previous 2 years was the most frequent inappropriate indication. The percentage of MPI studies referred from primary or secondary care was 16.8%. There was no difference between the rates of inappropriate requests from other units of the public health system compared to those from the tertiary-care center (9.7% versus 13.0%, $P = .4$).

Table 3. Cost of the reference scenario

	Population (*n*)
Reference scenario	1284
Intervention	MPI (100%)
Cost of intervention	$ 268.34
	Total value
Cost of reference scenario	$ 344,548.56

In the BIA, alternative scenario 1 comprised 128 asymptomatic patients (10.0%) referred to MPI to evaluate CHD risk. ET would be applicable to patients with intermediate CAD risk according to the Framingham score, able to exercise, and with interpretable electrocardiogram (ECG), comprising 26.0% of the patients from this scenario. CPET would be applicable to patients undergoing preoperative evaluation for abdominal aortic aneurysm repair without clinical risk factors or active cardiac conditions (26.0%). MPI would be used for the remaining 48.0%.

Alternative scenario 2 had 360 patients (28.0%) who were symptomatic without prior CAD. MPI would be suited for 94.0% of the patients, and ET for the remaining 6.0% with low pretest probability of CAD, able to exercise, and with interpretable ECG.

Alternative scenario 3 comprised 796 patients (62.0%) with known CAD. ET would be suited for those who were asymptomatic, with interpretable ECG, and able to exercise, who comprised 7.0%; no testing, for 13% of asymptomatic individuals for whom diagnostic stratification was not indicated, while the remaining 80.0% would perform MPI.

Table 3 depicts the cost of the reference scenario. The budget impact of applying the AUC, considering all scenarios, would determine a $ 64,252.04 savings, a

Table 2. Most frequent inappropriate clinical indications

	Inappropriate indications (*n*)	**% total of indications**
Preoperative evaluation for vascular surgery, without clinical risk factors	5	2.4
Asymptomatic with intermediate risk of CHD, interpretable ECG, and able to exercise	5	2.4
Symptomatic with low pretest probability of CAD, interpretable ECG, and able to exercise	3	1.4
Asymptomatic individuals submitted to PCI <2 years	6	2.9
Known CAD, stable; MPI performed <2 years	3	1.4

Table 4. Incremental budget impact

	Year 1	Year 2
Scenario 1 vs reference	$ −8,341.36	$ −16,790.40
Scenario 2 vs reference	$ −2,727.64	$ −5,326.49
Scenario 3 vs reference	$ −21,056.84	$ −42,135.15
Total	$ −32,125.84	$ −64,252.04

decrease of 18.6% compared to the reference scenario (Table 4).

DISCUSSION

The indisputable diagnostic and prognostic value of MPI have led to such a growth of its use in past decades[1] that the inappropriate use of the test would be somewhat predictable in the midst of millions of test orders. Anywhere, but especially in countries with universal free access to health services, such as Brazil, the efficient use of resources is vital to keep the ability to adequately provide the services. In addition, data from the Brazilian Health System show that of all MPI services, only 9.0% are public,[2] hindering access to MPI for users of public health system. In this scenario, budget management based on appropriateness criteria is even more relevant. This study therefore tried to evaluate the frequency of inappropriate indications for MPI at a tertiary-care, Cardiology hospital, with the use of AUC, and estimate through budget impact analysis the resource savings of their application.

In our patient sample, there were 12% of inappropriate indications, similarly to what has been described in other studies (12% to 14%).[7-13] Many of these studies had their inadequacy rates influenced by requests of non-cardiologists, which may negatively influence the appropriateness of indications.[12,14-17] In the current study, there was no difference between the rates of inappropriate indications originating from other units of the public health system in relation to those originating at the Cardiology center itself. Therefore, the inappropriate indication rate of 12% likely reflects the actual local practice, suggesting the need for re-evaluation of these practices in light of the AUC. When the inappropriate indications were studied according to clinical categories, asymptomatic patients evaluated for CHD risk had the highest percentage of inappropriate indications (53%). A multicenter study of AUC[12] showed that asymptomatic status increased the odds of an inappropriate classification by 22.5-fold.

Among inappropriate indications, the most common were the evaluation of asymptomatic patients undergoing MPI less than 2 years after PCI, followed by the evaluation of asymptomatic patients with intermediate cardiovascular risk, able to exercise, and with interpretable ECG. These data are in line with the studies by Moralidis et al[14] and Medolago et al.[15]

Another purpose of our study was to estimate resource savings of applying the AUC through the BIA. The BIA aims to provide the health manager an estimate of the financial impact of the adoption of a particular technology in a health system with finite resources.[4] It integrates into its analysis, among other variables, the current spending with a given health condition and the fraction of individuals eligible for a new intervention.[4] So, BIA is an important step toward better use of technology.

In the alternative scenarios, diagnostic methods beyond MPI were assigned for several patients. For patients undergoing CPTE, for example, as a preoperative test before abdominal aortic aneurysm evaluation, studies have shown that oxygen consumption at the anaerobic threshold <10 mL O2/kg/min is able to identify patients at higher risk of death and cardiovascular complications in the postoperative period.[18-22] This makes the CPTE an alternative for these patients, with lower cost.

For ET, we assigned symptomatic patients without previous CAD and low pretest probability, as well as asymptomatic individuals with intermediate CHD risk, and also patients ≥2 years post PCI. This last indication, classified as uncertain by the 2009 AUC, was considered inappropriate in the BIA model, as well as the asymptomatic patient <5 years post CABG, for whom no testing was assigned. In the 2013 multimodality AUC,[23] performing MPS or ET in asymptomatic individuals <5 years post CABG is considered rarely appropriate. Also asymptomatic patients submitted to PCI ≥2 years would be appropriate for both MPI and ET. In this scenario, the excellent negative predictive value and the low cost of the ET in patients with interpretable ECG and able to exercise would make it an acceptable choice for the initial stratification. Indeed, for either symptomatic patients without previous CAD or asymptomatic patients with interpretable ECG undergoing ET, studies suggest that clinical variables and exercise capacity are enough for risk stratification [23-27].

Patients with known CAD were the majority in our sample, comprising 62% of the total. Considering the 2013 multimodality AUC, 13% of these patients would not need a test and 7% could have the ET as the first test. From the percentage of inappropriately ordered tests ''taking the place'' of patients with appropriate indications for MPI in a saturated health system, we may hypothesize that the latter have long waiting times to have the test, or even may not have it at all. Another consequence would be the indirect cost increase, since the latter may undergo invasive tests and revascularization without prior noninvasive stratification. In that sense, Cerci et al have shown that, at 2 large Brazilian metropolitan areas, a substantial proportion of patients did not have any noninvasive evaluation test prior to cardiac catheterization, and in those cases the incidence of catheterization that did not result in revascularization was higher than in patients who underwent prior functional evaluation (assuming that patients who undergo the first are supposed to be the most likely candidates for the second, the rates of catheterization and of revascularization should ideally be similar). In that study, most of the revascularized patients (up to 87%) did not have any prior assessment of ischemic burden.[28] All this may reflect several problems, from noncompliance with guidelines to limitations of patient access to noninvasive tests. Anyway, along with the current study, this scenario reinforces the need for re-evaluation and improvement of patient management based on AUC.

NEW KNOWLEDGE GAINED

The budget impact analysis of the implementation of AUC for MPI demonstrates that it is able to generate substantial cost savings. The use of AUC will be especially vital for developing countries to preserve health-dedicated budgets.

CONCLUSIONS

In the Brazilian public health system, the use of appropriateness criteria for MPI results in cost savings of and may be a way to optimize health expenditure and access to more complex procedures. Furthermore, other diagnostic methods, more accessible and less expensive than MPI, may be acceptable alternatives for some patient populations, mainly asymptomatic patients.

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