

Original Article

Appropriate use criteria in myocardial perfusion imaging in a tertiary care hospital in South India: An audit

ABSTRACT

Myocardial perfusion imaging (MPI) is an important investigative tool in the diagnosis and management of coronary artery disease. This investigation has seen a manifold increase in number in past decades as compared to other investigations such as cardiac magnetic resonance imaging/positron emission tomography or computed tomography. In 2005, "Appropriate use criteria (AUC) in cardiac radionuclide imaging" was formulated by the American College of Cardiology Foundation and the American Society of Nuclear Cardiology for effective use of this investigation, later revised in 2009. We assessed the appropriateness of indications for MPI in patients presenting to the nuclear medicine department of a tertiary care hospital according to the latest AUC for cardiac radionuclide imaging. This is a retrospective analysis of all cardiac perfusion scans performed from June 2019 to January 2020 in a tertiary care teaching hospital in South India. All patients' indications for MPI were assessed for appropriateness using AUC 2009 as appropriate, inappropriate, and uncertain indications by two experienced nuclear medicine physicians blinded for results of the test and hospital stay of the patients. A total of 1015 cardiac scans were performed in the given period, which were analyzed. This included 613 males and 402 females, with most of the patients aged above 60 years ($n = 640$; males = 385, females = 255). Most of the patients had diabetes mellitus or hypertension or both except in 161 patients (15.8%) which did not have either of the comorbidities. Chest pain and/or shortness of breath were the most common presenting complaints. The appropriate indication for imaging was found in 784 patients (77.2%), inappropriate in 121 patients (12%), and uncertain in 110 patients (10.8%). Our results showed appropriate indication to be 77.2% and inappropriate indications as 12% for MPI referrals in a tertiary care teaching hospital, similar to Western literature but can be improved further by continued teaching and awareness campaigns.

Keywords: Appropriate use criteria, Choosing Wisely® campaign, inappropriate indication, myocardial perfusion imaging, uncertain indication

INTRODUCTION

Myocardial perfusion imaging (MPI) is an important investigative tool in the diagnosis and management of coronary artery disease (CAD). Its incremental value in the diagnosis of CAD has led to a manifold increase in the number of investigations in the past decade. The growth of advanced cardiac imaging techniques such as cardiovascular magnetic resonance, positron emission tomography, and cardiac computed tomography had also occurred during this period, but the growth in the number of MPI and echocardiography has been tremendous.^[1] In the USA, there had been a mean annual increase in the number of cardiac stress imaging tests by 6.1% when the increase in cardiac catheterization was 2% and percutaneous coronary interventions was <1%, in individuals

with acute myocardial infarction (MI),^[2] and the number of MPI scans doubled from 4 million to 8 million in a decade.^[3] With an increase in the number of tests, there was an overall increase in the cost of treatment. There was felt, a need for criteria to

MADHUR KUMAR SRIVASTAVA, RAM MANOHAR PAGALA, VINODH KENDARLA, KAVITHA NALLAPAREDDY

Department of Nuclear Medicine, Nizams Institute of Medical Sciences, Hyderabad, Telangana, India

Address for correspondence: Dr. Madhur Kumar Srivastava, Department of Nuclear Medicine, Nizams Institute of Medical Sciences, Hyderabad, Telangana, India.
E-mail: drmadhur77@yahoo.co.in


Submitted: 05-Jun-2020, **Revised:** 23-Jun-2020,

Accepted: 18-Jul-2020, **Published:** 14-Sep-2020

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: WKHLRPMedknow_reprints@wolterskluwer.com

How to cite this article: Srivastava MK, Pagala RM, Kendarla V, Nallapareddy K. Appropriate use criteria in myocardial perfusion imaging in a tertiary care hospital in South India: An audit. World J Nucl Med 2021;20:281-5.

Access this article online	
Website: www.wjnm.org	Quick Response Code 
DOI: 10.4103/wjnm.WJNM_77_20	

regulate this leading to the formulation of “Appropriate use criteria (AUC) in cardiac radionuclide imaging” by American College of Cardiology Foundation and the American Society of Nuclear Cardiology in 2005, which were later revised in 2009.^[4] An appropriate study was described as “one in which the expected incremental information, combined with clinical judgment, exceeds the expected negative consequences by a sufficiently wide margin for a specific indication that the procedure is generally considered acceptable care and a reasonable approach for the indication”.^[4] Since then, there had been many studies done in various parts of the world to look for the appropriateness of these guidelines to improve the referrals for MPI and formulating strategies for further improvement. A recent meta-analysis by Ladapo *et al.*^[5] showed stress MPI appropriate testing rates as 72.0% (67.6%–76.3%) and inappropriate/rarely appropriate testing rates as 15.7% (12.4%–19.1%) using AUC, 2009. Studies showed that more inappropriate referrals for MPI came from noncardiovascular specialists than cardiac specialists.^[6] However, other studies do not confer with this result.^[5] It is also shown that there is a resource saving of up to 18.6% by the use of these AUC for cardiac radionuclide imaging.^[7] There is a paucity of literature over the use of these AUC criteria from India. The aim was to assess the appropriateness of referrals for MPI to the nuclear medicine department of a tertiary care hospital according to AUC for cardiac radionuclide imaging proposed by the American Medical Association in 2009.

MATERIALS AND METHODS

The study is a retrospective analysis of all myocardial perfusion scans done from June 2019 to January 2020 in a tertiary care teaching hospital in South India. All patients were referred from the Department of Cardiology and Department of Internal Medicine for MPI, and MPI scans were performed in the Department of Nuclear Medicine on Symbia T6 and Symbia EvoExcel dual-head Gamma camera manufactured by Siemens® Medical Solutions, Erlangen, Germany. History and demographic data were collected after retrieving the case records from the medical records’ department. Based on Hendel *et al.*’s recommendations, each indication was scored as appropriate study (scores 7–9), uncertain study (scores 4–6), and inappropriate study (scores 1–3); an appropriate study is considered acceptable and a reasonable approach for a given indication, an inappropriate study is considered not acceptable and not a reasonable approach to the given indication, and uncertain test is considered may be acceptable and may be a reasonable approach.^[4] The appropriateness of the criteria was determined by two experienced nuclear medicine physicians (MKS and KN) using the most recent

AUC for MPI. They were blinded to the results of the test and subsequent hospital course of the patient.

RESULTS

A total of 1015 myocardial perfusion studies were performed from June 2019 to January 2020, and their records were retrieved from the medical records’ department. In this, there were 613 males (60.4%) and 402 females (39.6%), with a mean age of 61.7 ± 11.4 years. Majority of the patients were above 60 years of age ($n = 640$; males = 385, females = 255), followed by those in the fifth decade ($n = 240$; males = 152, females = 88). In the fourth decade, there were 98 patients (males = 51, females = 47) and below 40 years, there were 37 patients (males = 25, females = 12) [Figure 1]. With regard to comorbidities, both hypertension (HTN) and diabetes mellitus (DM) were seen in 499 patients (49.2%), while only HTN was present in 213 patients (21%) and only DM was present in 142 patients (14%). A total of 161 patients (15.8%) did not have either HTN or DM.

There was quite an overlap in the presenting symptoms in the patients such as patients with normal MPI test 1 year back, now presented for preoperative evaluation for major noncardiac surgery based on comorbidities. For this, we used prioritization of tables as suggested by Gibbons *et al.*,^[2] in which post revascularization was order 1 indication followed by preoperative evaluation (order 2), postacute coronary syndrome/MI (order 3), prior test results (order 4), symptomatic patients (order 5), and the asymptomatic patients (order 6). Based on the above prioritization, the above patients were classified as appropriate as the preoperative evaluation is considered order 2 compared to prior test results (order 4). Overall, chest pain and/or shortness of breath were present in 775 patients, who presented for MPI. The cardiac preoperative evaluation was an indication for 240 patients. A prior intervention such as percutaneous coronary intervention (PCI) and coronary artery bypass grafting (CABG) was present in 243 patients. Of these 243 patients, 119 presented with new onset of symptoms.

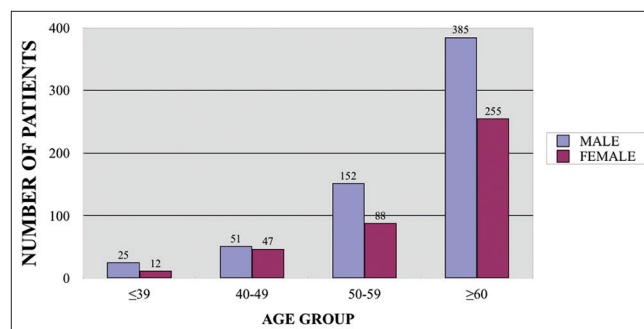


Figure 1: Age-wise distribution of the patients

As per the AUC criteria for radionuclide imaging^[4] and review of all the available information such as age, sex, comorbidities, and indication of MPI scan, out of 1015 patients, 784 had an appropriate indication for the scan (77.2%), 121 had inappropriate indication (12%), while 110 were classified as uncertain indications (10.8%). In the appropriate indications, the most common was AUC no. 43, i.e., preoperative risk assessment in intermediate-risk surgery with risk factors and poor performance score (*n* = 140) followed by AUC no. 15, i.e., asymptomatic high pretest CHD risk (*n* = 119) and AUC no. 62, i.e., assessment of viability (*n* = 103) [Table 1]. In the inappropriate indications, the most common was AUC no. 1, i.e., unstable angina in patients with low pretest probability (*n* = 33) followed by AUC no. 40–42 and 44, i.e., preoperative evaluation in low/intermediate risk with moderate or good performance and asymptomatic post PCI/PTCA (*n* = 28) and AUC no. 12, i.e., asymptomatic with low pretest probability (*n* = 25) [Table 2]. In the uncertain indications, the most common was AUC no. 57 and 60, i.e., asymptomatic <5 years post-CABG or ≥2 years after PCI (*n* = 53) [Table 3].

DISCUSSION

Since the publishing of AUC in radionuclide imaging in 2005 and its revision in 2009, there had been multiple articles published to observe the effectiveness of these criteria in their hospital settings. Few meta-analyses have also been done to give a clear picture of AUC in clinical settings. There is a huge variation noted in the appropriateness of a test indication ranging from 62% to 91%, the inappropriate test indications in 5%–18%, and uncertain test indications in 4%–20%.^[5–11] Dos Santos *et al.*^[7] in their study of 190 patients showed an appropriate test indication in 78%, inappropriate test indication in 12%, and uncertain test indication in 10%. Our results are very similar to those of this study. When the meta-analysis done by Ladapo *et al.* was compared,^[5] they found an appropriate test in 71.1%, inappropriate in 10.7%,

and uncertain in 18.2%, which again is similar to our study, with our study showing appropriate indications in 77.2%, inappropriate indications in 12%, and uncertain indications in 10.8% [Table 4]. Perhaps, slightly better appropriate criteria in our study could be due to institutional referrals, which accounts for >90% of our referrals.

Studies have also shown that with the use of AUC criteria, there is a cost saving of up to 18.6%;^[7] even though the number of scans has increased over time, there are more and more referrals for appropriate indications. Although our study did not look into the cost saving from these scans, the authors agree that in the long run, AUC would result in significant cost cutting by the reduction in inappropriate tests. There is a discrepancy in the appropriateness of the MPI test in patients who are referred from cardiovascular specialists as compared to internists,^[6] however, few other studies did not find similar results.^[5] Gertz *et al.*^[12] looked into AUC in inpatient settings but did not find any difference when compared to ambulatory settings. Few studies also compared the appropriateness of tests using AUC 2005^[13] and 2009 but did not find any significant difference in the appropriate use of imaging.^[14,15]

With the use of AUC, 2009, and recently Choosing Wisely[®] campaign^[16] started by the American Board of Internal Medicine Foundation in which the Society of Nuclear Medicine and Molecular Imaging gave the recommendation for cardiac imaging that “Don’t perform routine annual stress testing after coronary artery revascularization,” there has been more awareness on the appropriate use of imaging, and the authors believe that there would be a decrease in inappropriate cardiac imaging.

The retrospective nature of this study in a single institute is an important limiting factor. Moreover, we did not consider the cost-effectiveness on the use of these criteria and the referral base for imaging that whether the referral was from a

Table 1: Appropriate indication for myocardial perfusion imaging (*n*=784)

AUC number	Category	Incidence (%)
43	Preoperative risk assessment high-/intermediate-risk surgeries Risk factors and poor performance status	140 (17.8)
15	Asymptomatic high pretest CAD risk	119 (15.2)
62	Assessment of viability	103 (13.1)
58	Asymptomatic after ≥5 years after CABG	86 (11.0)
2	Symptomatic; ECG not interpretable and unable to exercise	77 (9.8)
32	Borderline stenosis on CAG (CT CAG/conventional CAG)	70 (8.9)
29	Asymptomatic; positive TMT	67 (8.5)
52	Asymptomatic; ECG - NSTEMI	54 (7.0)
-	Other indications	68 (8.7)

CAD: Coronary artery disease; CABG: Coronary artery bypass grafting; CT: Computed tomography; NSTEMI: Non-ST elevation myocardial infarction; AUC: Appropriate use criteria; ECG: Electrocardiography; CAG: Coronary angiography; TMT: Treadmill test

Table 2: Inappropriate indication for myocardial perfusion imaging (n=121)

AUC number	Category	Incidence (%)
1	Unstable angina; low pretest probability	33 (27.5)
40-42, 44	Preoperative assessment low/intermediate risk Moderate or good performance Asymptomatic post-PCI/PTCA	28 (23.2)
12	Asymptomatic; low pretest probability	25 (20.3)
59	Post-PTCA; asymptomatic <2 years	21 (17.4)
27	Prior abnormal imaging; no new symptoms <2 years	14 (11.6)

AUC: Appropriate use criteria; PCI: Percutaneous coronary intervention; PTCA: Percutaneous transluminal coronary angioplasty

Table 3: Uncertain indication for myocardial perfusion imaging (n=110)

AUC number	Category	Incidence (%)
57, 60	Asymptomatic; <5 years post-CABG or ≥2 years post-PCI	53 (48.2)
26, 31	Known CAD; risk assessment with prior normal stress imaging	38 (34.5)
14	Detection of CAD; asymptomatic; intermediate pretest probability	19 (17.3)

PCI: Percutaneous coronary intervention; CAD: Coronary artery disease; CABG: Coronary artery bypass grafting

Table 4: Comparison of various studies performed on appropriate use criteria

Study	Number of patients	Appropriate criteria (%)	Inappropriate criteria (%)	Uncertain criteria (%)
Ladapo et al. ^[5]	25,779	71.1	10.7	18.2
Dos Santos et al. ^[7]	190	78	12	10
Gimelli et al. ^[8]	251	87	7	6
Remfry et al. ^[9]	553	91	5	4
Aldweib et al. ^[10]	1199	62	18	20
Medolago et al. ^[11]	2134	84	7	9
Our study	1015	77.2	12	10.8

cardiac specialist or internist. A large multi-institutional study is required to study the various parameters. Moreover, the authors did not take into account the results of MPI and the stay of the patient in the hospital as this was an audit of indications for MPI.

CONCLUSION

This study showed the application of AUC with 77.2% appropriate indication, 12% inappropriate indications, and 10.8% uncertain indications for MPI in a tertiary care teaching hospital in South India. With awareness and Choosing Wisely® campaign, the inappropriate indications can be further brought down, thereby improving the quality of imaging, reducing cost, and subsequently increasing the efficiency of the health-care system.

Financial support and sponsorship

Nil.

Conflicts of interest

There are no conflicts of interest.

REFERENCES

- Shaw LJ, Marwick TH, Zoghbi WA, Hundley WG, Kramer CM, Achenbach S, et al. Why all the focus on cardiac imaging? JACC Cardiovasc Imaging 2010;3:789-94.
- Gibbons RJ, Miller TD, Hodge D, Urban L, Araoz PA, Pellikka P, et al. Application of appropriateness criteria to stress single-photon emission computed tomography sestamibi studies and stress echocardiograms in an academic medical center. J Am Coll Cardiol 2008;51:1283-9.
- Bonow RO. Is appropriateness appropriate? J Am Coll Cardiol 2008;51:1290-1.
- 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. J Am Coll Cardiol 2009;53:2201-29.
- Ladapo JA, Blecker S, O'Donnell M, Jumkhawala SA, Douglas PS. Appropriate use of cardiac stress testing with imaging: A systematic review and meta-analysis. PLoS One 2016;11:e0161153.
- Druz RS, Phillips LM, Sharifova G. Clinical evaluation of the appropriateness use criteria for single-photon emission-computed tomography: Differences by patient population, physician specialty, and patient outcomes. ISRN Cardiol 2011;2011:798318.
- Dos Santos MA, Santos MS, Tura BR, Félix R, Brito AS, De Lorenzo A. Budget impact of applying appropriateness criteria for myocardial perfusion scintigraphy: The perspective of a developing country. J Nucl Cardiol 2016;23:1160-5.
- Gimelli A, Rovai I, Liga R, Pasanisi EM, Marzullo P. Appropriate use criteria in clinical routine practice: Implications in a nuclear cardiology lab. Int J Cardiovasc Imaging 2016;32:1003-9.
- Remfry A, Abrams H, Dudzinski DM, Weiner RB, Bhatia RS.

- Assessment of inpatient multimodal cardiac imaging appropriateness at large academic medical centers. *Cardiovasc Ultrasound* 2015;13:44.
10. Aldweib N, Negishi K, Seicean S, Jaber WA, Hachamovitch R, Cerqueira M, *et al.* Appropriate test selection for single-photon emission computed tomography imaging: Association with clinical risk, posttest management, and outcomes. *Am Heart J* 2013;166:581-8.
 11. Medolago G, Marcassa C, Alkraisheh A, Campini R, Ghilardi A, Giubbini R, *et al.* Applicability of the appropriate use criteria for SPECT myocardial perfusion imaging in Italy: Preliminary results. *Eur J Nucl Med Mol Imaging* 2014;41:1695-700.
 12. Gertz ZM, O'Donnell W, Raina A, Litwack AJ, Balderston JR, Goldberg LR. Application of appropriate use criteria to cardiac stress testing in the hospital setting: Limitations of the criteria and areas for improved practice. *Clin Cardiol* 2015;38:8-12.
 13. Brindis RG, Douglas PS, Hendel RC, Peterson ED, Wolk MJ, Allen JM, *et al.* ACCF/ASNC appropriateness criteria for single-photon emission computed tomography myocardial perfusion imaging (SPECT MPI): A report of the American College of Cardiology Foundation Quality Strategic Directions Committee Appropriateness Criteria Working Group and the American Society of Nuclear Cardiology endorsed by the American Heart Association. *J Am Coll Cardiol* 2005;46:1587-605.
 14. Oliveira AD, Rezende MF, Corrêa R, Mousinho R, Azevedo JC, Miranda SM, *et al.* Applicability of the appropriate use criteria for myocardial perfusion scintigraphy. *Arq Bras Cardiol* 2014;103:375-81.
 15. Fonseca R, Negishi K, Otahal P, Marwick TH. Temporal changes in appropriateness of cardiac imaging. *J Am Coll Cardiol* 2015;65:763-73.
 16. ABIM Foundation. Choosing Wisely: An Initiative of the ABIM Foundation. Available from: <http://www.choosingwisely.org>. [Last accessed on 2019 May 04].