Rev Port Cardiol. 2015;34(12):713–718

Revista Portuguesa de Cardiologia
Portuguese Journal of Cardiology
www.revportcardiol.org

ORIGINAL ARTICLE

Appropriate use criteria for transthoracic echocardiography at a tertiary care center

Paulo Fonseca*, **Francisco Sampaio, José Ribeiro, Helena Gonçalves, Vasco Gama**

Serviço de Cardiologia, Centro Hospitalar de Vila Nova de Gaia/Espinho, Vila Nova de Gaia, Portugal

Received 24 April 2015; accepted 12 June 2015
Available online 26 November 2015

KEYWORDS
Echocardiography;
Transthoracic echocardiogram;
Appropriate use criteria

Abstract
Introduction and Objectives: The American College of Cardiology and American Society of Echocardiography have developed appropriate use criteria for echocardiography. The objective of this study was to assess the rate of appropriate requests for transthoracic echocardiography at a Portuguese tertiary care center and to identify the factors associated with lower adherence to the appropriate use criteria.
Methods: All transthoracic echocardiograms (in- and outpatient) performed over a period of one month were analyzed by two independent imaging cardiologists, who matched each request to a specific indication in the appropriate use criteria document.
Results: Overall, 799 echocardiograms were included in the analysis. In 97.5% of cases it was possible to determine an indication listed in the criteria, according to which 78.7% of classifiable echocardiograms were appropriate, 15.3% inappropriate and 6.0% of uncertain appropriateness. The most common appropriate indication (111 echocardiograms) was initial evaluation of patients with symptoms or conditions potentially related to cardiac etiology, while the main inappropriate indication (59 echocardiograms) was routine surveillance of ventricular function in patients with known coronary artery disease and no change in clinical status or cardiac exam. The proportion of inappropriate echocardiograms was significantly higher among outpatients than among inpatients (18.8 vs. 4.3%, $p<0.05$) and among cardiologists compared to other specialties (19.3% vs. 10.9%, $p<0.05$).
Conclusions: The majority of requests for transthoracic echocardiograms at a Portuguese tertiary care center were appropriate. Requests by cardiologists and outpatient referrals presented the highest rates of inappropriateness.

* Corresponding author.
E-mail address: paulobarbosafonseca@hotmail.com (P. Fonseca).

PALAVRAS-CHAVE
Ecocardiografia;
Ecocardiograma transtorácico;
Critérios de utilização apropriada

Critérios de adequação para ecocardiografia transtorácica num centro terciário

Resumo
Introdução e objetivos: O *American College of Cardiology* e a *American Society of Echocardiography* desenvolveram critérios de utilização adequada da ecocardiografia. O objetivo deste estudo foi avaliar a taxa de pedidos apropriados de ecocardiograma transtorácico num centro terciário português e identificar os fatores associados à baixa adesão aos critérios de adequação.
Métodos: Todos os ecocardiogramas transtorácicos realizados durante um mês (internamento e ambulatório) foram analisados por dois cardiologistas independentes que estabeleceram a correspondência entre os pedidos e as indicações específicas dos critérios de adequação.
Resultados: Foram incluídos no estudo um total de 799 ecocardiogramas. Em 97,5% dos casos foi possível definir uma indicação específica. De acordo com os critérios de adequação, 78,7% dos ecocardiogramas classificáveis eram adequados, 15,3% inadequados e 6,0% de adequação incerta. A indicação adequada mais frequente (111 ecocardiogramas) foi a avaliação inicial de doentes com sintomas ou condições potencialmente relacionadas com etiologia cardíaca, enquanto a principal indicação inadequada (59 ecocardiogramas) foi a vigilância de rotina da função ventricular em doentes com doença coronária conhecida e sem alteração do seu estado clínico. A proporção de ecocardiogramas inadequados foi significativamente superior nos doentes de ambulatório comparativamente aos doentes internados (18,8 *versus* 4,3%, $p < 0,05$) e entre os cardiologistas comparativamente às restantes especialidades (19,3 *versus* 10,9%, $p < 0,05$).
Conclusões: Num centro terciário português a maioria dos pedidos de ecocardiograma transtorácico foram apropriados. Os pedidos realizados por cardiologistas e em regime de ambulatório apresentaram as taxas mais elevadas de inadequação.

Introduction

Over the past decade, expenditure on cardiovascular imaging in general, and echocardiography in particular, have increased significantly,[1] which has raised concerns about the sustainability of this growth and potential overuse or misuse of imaging tests. In order to improve clinical practice, reduce unnecessary tests and enhance overall cost-effectiveness, the American College of Cardiology in partnership with the American Society of Echocardiography and other subspecialty societies developed appropriate use criteria (AUC) for transthoracic echocardiography (TTE). This document, first published in 2007[2] and updated in 2011,[3] contains recommendations for the rational use of TTE, rating the grade of appropriateness of various clinical indications. Since then, there have been studies of the appropriateness of clinical requests for TTE in different settings in the USA[4–8] and Europe.[9,10]

The aim of this study was to assess whether TTE requests comply with the 2011 AUC at a Portuguese tertiary care center. In addition, we aimed to identify the factors associated with lower adherence to the AUC.

Methods

Study population

The study included all TTE studies (in- and outpatient) performed over a period of one month (February 2014) at a non-university tertiary care center that provides health services to a population of 334 000. We excluded from the analysis studies with insufficient clinical information to assign an indication and TTE performed for research purposes.

Data collection and determination of indications

Patient information was collected from request forms, medical records, previous TTE and other previous tests. The data on each patient were then analyzed by two independent imaging cardiologists, who matched each clinical scenario to a specific indication in the 2011 AUC document. If the reason for a TTE could be assigned to more than one indication, it was classified under the most appropriate indication. In patients who underwent more than one TTE study during the study period, each study was included independently in the analysis.

Statistical analysis

Continuous variables are described as means with standard deviation and categorical variables as frequencies and percentages. Comparisons were performed using the chi-square test using a p value of 0.05 for statistical significance. Analyses were performed using SPSS software (version 19.0, SPSS, Inc., Chicago, IL).

Table 1 Major classes of indications according to appropriate use criteria category.

	Appropriate	Inappropriate	Uncertain	Total
General evaluation of cardiac structure and function	213	87	1	301
Cardiovascular evaluation in an acute setting	53	4	3	60
Evaluation of valvular function	175	21	7	203
Evaluation of intracardiac and extracardiac structures and chambers	25	0	0	25
Evaluation of aortic disease	8	0	0	8
Evaluation of hypertension, heart failure or cardiomyopathy	134	6	35	175
Adult congenital heart disease	5	1	1	7

Results

General characteristics

During the period under review, a total of 824 TTE studies were performed. We excluded twenty exams due to insufficient clinical information and five that were performed for research purposes. Overall, 799 exams were included in the analysis. The study population consisted of 784 patients, predominantly male (56.1%), with a mean age of 66.0±14.7 years. The majority were outpatients (75.1%). Most of the echocardiograms were requested by the cardiology department (52.1%), followed by internal medicine (21.7%), pneumology (8.9%), cardiothoracic surgery (6.6%), oncology (2.0%), neurology (1.9%) and nephrology (1.6%).

Appropriateness of indications

In 97.5% of cases it was possible to determine an indication listed in the 2011 AUC. According to the AUC, 78.7% of the classifiable exams were appropriate, 15.3% inappropriate and 6.0% of uncertain appropriateness (Table 1). Table 2 shows the distribution of TTE requests in major classes of indications and respective appropriateness. More than 80% of requested exams fell into one of the three following major classes: general evaluation of cardiac structure and function; evaluation of valvular function; and evaluation of hypertension, heart failure or cardiomyopathy.

The most common appropriate specific indication (Table 2) was initial evaluation of patients with symptoms or conditions of suspected cardiac etiology (indication 1). Stroke or transient ischemic attack (TIA) (43.6%), chest pain (21.8%) and dyspnea (15.5%) were the main reasons for TTE performed under this indication. Other frequent appropriate indications were for initial evaluation of patients with known or suspected heart disease, including heart failure (indication 70), hypertensive heart disease (indication 67) and valvular or structural heart disease (indication 34).

The main inappropriate indication, responsible for 61 (51.3%) of inappropriate exams, was routine surveillance of ventricular function in patients with known coronary artery disease (CAD) and no change in clinical status or cardiac exam (indication 11) (Table 3). Other frequent inappropriate indications were evaluation of patients with no symptoms or signs suggesting cardiac disease, either as screening (indication 10) or as perioperative evaluation (indication 13), responsible for 14 and 6 exams, respectively.

Requests of uncertain appropriateness were mainly related to routine surveillance (≥1 year) of known cardiomyopathy without a change in clinical status (indication 89, 13 exams), initial evaluation for cardiac resynchronization therapy device optimization after implantation (indication 77, 12 exams) and routine surveillance (<1 year) of moderate or severe valvular regurgitation without a change in clinical status (indication 45, six exams).

In- vs. outpatients

The proportion of appropriate TTE was significantly higher among inpatients than in outpatients (93.0% vs. 74.2%, $p<0.05$) (Table 4). The most frequent appropriate indications for TTE in inpatients was evaluation of patients with conditions of suspected cardiac etiology, in particular stroke (indication 1) and evaluation of ventricular function following an acute coronary syndrome (indication 24), each responsible for 34 exams (16.6% of all inpatient studies). In outpatients, indication 1 was also the most frequent appropriate indication (12.8% of all outpatient studies), mainly due to dyspnea and chest pain. The most frequent inappropriate indication among inpatients was routine

Table 2 Most common appropriate indications.

	Appropriate indications	n (% of appropriate)
1	Symptoms or conditions of suspected cardiac etiology	111 (18.1)
70	Initial evaluation of known or suspected heart failure	43 (7.0)
67	Initial evaluation of suspected hypertensive heart disease	35 (5.7)
24	Initial evaluation of ventricular function following ACS	33 (5.4)
34	Initial evaluation of suspected valvular or structural heart disease	28 (4.6)
15	Evaluation of suspected pulmonary hypertension	28 (4.6)

ACS: acute coronary syndrome.

Table 3 Most frequent inappropriate indications.

Inappropriate indications		n (% of inappropriate)
11	Routine surveillance of ventricular function with known CAD and no change in clinical status or cardiac exam	61 (51.3)
10	Initial evaluation of ventricular function (e.g., screening) with no symptoms or signs of cardiovascular disease	14 (11.8)
13	Routine perioperative evaluation of ventricular function with no symptoms or signs of cardiovascular disease	6 (5.0)
48	Routine surveillance (<3 years after valve implantation) of prosthetic valve if no known or suspected valve dysfunction	5 (4.2)

CAD: coronary artery disease.

Table 4 Rates of appropriateness in different settings.

	Appropriate, n (%)	Inappropriate, n (%)	Uncertain, n (%)
In- vs. outpatients			
Inpatients	174 (93.0)	8 (4.3)	5 (2.7)
Outpatients	439 (74.1)	111 (18.8)	42 (7.0)
Ordering specialty			
Cardiology	291 (72.2)	77 (19.1)	35 (8.7)
Internal medicine	149 (86.6)	17 (9.9)	6 (3.5)
Pneumology	60 (85.7)	9 (12.9)	1 (1.4)
Cardiothoracic surgery	45 (90.0)	5 (10.0)	0 (0.0)
Oncology	16 (100.0)	0 (0.0)	0 (0.0)
Neurology	15 (100.0)	0 (0.0)	0 (0.0)
Nephrology	8 (72.7)	1 (9.1)	2 (18.2)
Other	29 (69.0)	10 (23.8)	3 (7.1)

perioperative evaluation of ventricular function with no symptoms or signs of cardiovascular disease (indication 13, four exams, 2.1% of all inpatient studies), while in outpatients it was routine surveillance of ventricular function with known CAD and no change in clinical status or cardiac exam (indication 11, 61 exams, 10.3% of all outpatient studies).

Cardiologists vs. non-cardiologists

Cardiologists ordered inappropriate TTE more frequently than other specialties (19.3% vs. 10.9%, p<0.05). Our cardiology department is composed of 22 cardiology specialists, four of whom have an advanced echocardiography level and read TTE. Comparison of TTE readers with non-readers revealed no difference in rates of inappropriate requests (21.5% vs. 20.0%, p=0.81). Among cardiologists, 10.8% of exams were ordered by residents. Comparing cardiology residents with cardiology specialists showed a tendency for higher rates of inappropriate TTE in the residents (30.2% vs. 20.1%, p=0.13). The most frequent inappropriate indication was routine surveillance of ventricular function with known CAD and no change in clinical status or cardiac exam (indication 11).

In non-cardiology specialties, all TTE exams requested by oncologists and neurologists were appropriate. The sole indication for requesting an exam by oncologists was baseline and serial re-evaluations in patients undergoing therapy with cardiotoxic agents (indication 91), while neurologists requested TTE for evaluating patients with stroke or TIA (indication 1).

Unclassifiable studies

Twenty exams were considered unclassifiable because they did not match any clinical indication listed in the AUC document. Exams performed after invasive procedures (pulmonary vein isolation or percutaneous closure of atrial septal defect or left atrial appendage) accounted for 50% of unclassifiable studies. Echocardiographic follow-up of patients who had undergone transcatheter aortic valve implantation (TAVI) was responsible for 35%. The other cases were for postoperative assessment of cardiac tumor resection (two cases) and repair of right ventricular perforation by a pacemaker lead (one case).

Discussion

We found that, according to the 2011 AUC document, 78.7% of TTE requests were appropriate, 15.3% were inappropriate and 6.0% were of uncertain appropriateness. These results are similar to those reported by other studies, in which appropriateness rates range from 71.0% to 96.5%.[5,6,9,10] Several factors may influence these results, such as the setting in which the study is carried out (university vs.

non-university center, tertiary vs. non-tertiary center, in- vs. outpatients), the characteristics of the study population and the specialty of the requesting physician.

Given that in 2013 about 10 000 TTE exams were performed at our echocardiography laboratory (echo lab), the sample included in this study probably reflects the usual pattern of TTE requests at our center. A significant proportion of appropriate exams were performed to evaluate symptoms or conditions potentially related to cardiac etiology, in particular stroke or TIA. Other common appropriate indications were related to initial evaluation of patients with known or suspected heart failure, hypertensive heart disease or valvular or structural heart disease. A few scenarios account for the majority of inappropriate studies. The most significant was routine surveillance of ventricular function in patients with known CAD and no change in clinical status or cardiac exam, which is also reported in other studies as a frequent inappropriate indication.[9,10]

The study population was mainly composed of outpatients. We found that inappropriate requests were more frequent in outpatients than in inpatients. This is not unexpected, since inpatients commonly present new symptoms or signs suggesting cardiac disease or worsening of known cardiovascular disease, and both scenarios are rated as appropriate. On the other hand, outpatient requests usually refer to routine TTE in patients with no change in clinical status, which is normally rated as inappropriate. Previous studies have also reported a higher proportion of inappropriate exams among outpatients.[4,5]

Surprisingly, cardiologists presented a higher rate of inappropriateness (19.1%) than most other specialties. This was mainly related to routine evaluation of outpatients with known CAD and no change in clinical status. These findings conflict with other studies, in which cardiologists' requests were more often appropriate than other specialties.[9,10] At our center, cardiologists have close contact with the echo lab and easier access to the scheduling system than other specialties, which could explain some of the overuse of the technique. Interestingly, we found that cardiologists who read TTE had similar rates of inappropriate requests to other cardiologists.

Cardiology residents presented a higher rate of inappropriate requests than cardiology specialists, although the difference was not statistically significant. Recently, Bhatia et al. reported similar rates of inappropriate TTE among cardiology fellows.[12]

The Portuguese National Health Service provides health coverage for all the population and is mainly funded through general taxation. Physicians are paid a fixed monthly wage, which is not related to services rendered. Despite constant monitoring of effectiveness and quality, the national public health surveillance system does not perform any systematic monitoring of appropriateness of requested tests. The strict application of AUC would have reduced the number of exams performed annually at our echo lab by around 1500.

There are few data on the best strategies to improve AUC compliance. Bhatia et al. reported a significant reduction in the proportion of inappropriate TTE exams in an inpatient academic medical service after implementation of a simple educational program consisting of lectures, pocket cards and feedback on ordering behavior via e-mail.[7] However, some methodological caveats have been pointed out regarding this study.[11] Recently, the same group of investigators reported the results of the first randomized control trial of an AUC-based educational and feedback intervention designed to reduce inappropriate outpatient TTE ordered by physicians-in-training, mainly cardiology fellows. After implementing an educational intervention (generally similar to that described above), they reported a significantly lower rate of inappropriate TTE in the intervention compared to the control group (13% vs. 34%, $p<0.001$).[12] Interestingly, in both in- and outpatient settings, there was an increase in inappropriate TTE during follow-up in the post-intervention period, suggesting the need for a continued program to achieve sustained improvement in physicians' ordering behavior.[12,13] Given the heterogeneity of most common inappropriate indications between centers, a strategy tailored to the specificities of each practice environment would be desirable.[7]

Information on the clinical impact of AUC compliance is scarce and inconsistent. In a multicenter community study, Ballo et al. showed that TTE exams with appropriate or uncertain indications were often clinically more useful than those with inappropriate indications (87% vs. 14%, $p<0.001$).[9] Clinical impact was defined as any change in diagnostic workup, therapeutic decisions or follow-up planning induced by TTE results. However, more recently, in a single academic center study, Matulevicius et al., using the same definition, found a markedly lower overall rate of clinical impact (32%).[8] In addition, the proportion of exams resulting in an active change in clinical care did not correlate with AUC classification. However, the use of retrospective review of electronic medical records to determine clinical significance has been identified as a major drawback of this study.[14] One of the main challenges in future studies will be to define more precise measures of the utility of appropriate vs. inappropriate TTE in clinical practice.

The 2011 update of the 2007 AUC increased the clinical indications for TTE from 59 to 98 and led to a significant reduction in unclassified studies.[5,15] Indeed, in this study the AUC indications covered most of the clinical requests, with only 2.5% being unclassifiable. Control TTE after cardiovascular interventions and TAVI follow-up accounted for the majority of unclassifiable tests. Recently, the European Society of Cardiology and the European Association of Cardiovascular Imaging announced the formation of a taskforce to define appropriateness criteria for cardiovascular imaging use in clinical practice in Europe.[16] Some of these missing clinical scenarios should be considered in future recommendations.

Limitations

This is a single tertiary center study, and therefore the results cannot be extrapolated to other settings. Despite extensive review of all patient information, there was no direct contact with the ordering physician, and so the process of determining the AUC indication is not free of bias related to clinical factors not fully considered by the reviewers. We did not collect data on TTE abnormalities or assess its impact on decision-making due to the lack of detailed electronically stored information. Finally, we had a low number of TTE exams in an acute setting, since in this context

cardiologists usually perform focused bedside echocardiography rather than complete TTE at the echo lab. This may result in some underestimation of the overall appropriateness of TTE, as in this group the rate of appropriateness is higher than in outpatients.

Conclusions

The majority of TTE requests at a Portuguese tertiary care center were appropriate. Cardiologists' requests and outpatient referrals presented the highest rates of inappropriateness. Strategies to improve AUC compliance and evaluation of its impact on clinical outcomes should be explored in the near future.

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

Conflicts of interest

The authors have no conflicts of interest to declare.

References

1. Pearlman AS, Ryan T, Picard MH, et al. Evolving trends in the use of echocardiography: a study of Medicare beneficiaries. J Am Coll Cardiol. 2007;49:2283–91.
2. Douglas PS, Khandheria B, Stainback RF, et al. ACCF/ASE/ACEP/ASNC/SCAI/SCCT/SCMR 2007 appropriateness criteria for transthoracic and transesophageal echocardiography. J Am Coll Cardiol. 2007;50:187–204.
3. Douglas PS, Garcia MJ, Haines DE, et al. ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 appropriate use criteria for echocardiography. J Am Coll Cardiol. 2011;57:1126–66.
4. Patil HR, Coggins TR, Kusnetzky LL, et al. Evaluation of appropriate use of transthoracic echocardiography in 1820 consecutive patients using the 2011 revised appropriate use criteria for echocardiography. Am J Cardiol. 2012;109:1814–7.
5. Bhatia RS, Carne D, Picard M, et al. Comparison of the 2007 and 2011 appropriate use criteria for transthoracic echocardiography in various clinical settings. J Am Soc Echocardiogr. 2012;25:1162–9.
6. Bailey S, Mosteanu I, Tietjen P, et al. The use of transthoracic echocardiography and adherence to appropriate use criteria at a regional hospital. J Am Soc Echocardiogr. 2012;25:1015–22.
7. Bhatia RS, Milford CE, Picard MH, et al. An educational intervention reduces the rate of inappropriate echocardiograms on an inpatient medical service. J Am Coll Cardiol Imaging. 2013;6:545–55.
8. Matulevicius SA, Rohatgi A, Das SR, et al. Appropriate use and clinical impact of transthoracic echocardiography. JAMA Intern Med. 2013;173:1600–7.
9. Ballo P, Bandini F, Capecchi I, et al. Application of 2011 ACC/ASE appropriateness of use criteria in hospitalized patients referred for transthoracic echocardiography in a community setting. J Am Soc Echocardiogr. 2012;25:589–98.
10. Gurzun M, Ionescu A. Appropriateness of use criteria for transthoracic echocardiography: are they relevant outside the USA? Eur Heart J Cardiovasc Imaging. 2014;15:450–5.
11. Gibbons RJ, Askew JW. Quality improvement using the AUC: is it this easy? JACC Cardiovasc Imaging. 2013;6:556–8.
12. Bhatia RS, Dudzinski DM, Malhotra R, et al. Educational intervention to reduce outpatient inappropriate echocardiograms: a randomized control trial. J Am Coll Cardiol Imaging. 2014;7:857–66.
13. Bhatia RS, Dudzinski DM, Milford CE, et al. Educational intervention to reduce inappropriate transthoracic echocardiograms: the need for sustained intervention. Echocardiography. 2014;31:916–23.
14. Dudzinski DM, Bhatia RS, Weiner RB. Assessing the clinical impact of appropriate echocardiograms. JAMA Intern Med. 2014;174:1195–6.
15. Parikh P, Asheld J, Kort S. Does the revised appropriate use criteria for echocardiography represent an improvement over the initial criteria? A comparison between the 2011 and the 2007 appropriateness of use criteria for echocardiography. J Am Soc Echocardiogr. 2012;25:228–33.
16. Garbi M, Habib G, Plein S, et al. Appropriateness criteria for cardiovascular imaging use in clinical practice: a position statement of the ESC/EACVI taskforce. Eur Heart J Cardiovasc Imaging. 2014;15:477–82.