ORIGINAL ARTICLE

Appropriate use criteria for transthoracic echocardiography at a tertiary care center

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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.

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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.

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

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 45, 63 exams) and routine surveillance (<1 year) of moderate or severe valvular regurgitation without a change in clinical status (indication 45, 63 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.

<table>
<thead>
<tr>
<th>Indication</th>
<th>n (% of appropriate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Symptoms or conditions of suspected cardiac etiology</td>
<td>111 (18.1)</td>
</tr>
<tr>
<td>70 Initial evaluation of known or suspected heart failure</td>
<td>43 (7.0)</td>
</tr>
<tr>
<td>67 Initial evaluation of suspected hypertensive heart disease</td>
<td>35 (5.7)</td>
</tr>
<tr>
<td>24 Initial evaluation of ventricular function following ACS</td>
<td>33 (5.4)</td>
</tr>
<tr>
<td>34 Initial evaluation of suspected valvular or structural heart disease</td>
<td>28 (4.6)</td>
</tr>
<tr>
<td>15 Evaluation of suspected pulmonary hypertension</td>
<td>28 (4.6)</td>
</tr>
</tbody>
</table>

ACS: acute coronary syndrome.
The table below shows the most frequent inappropriate indications.

<table>
<thead>
<tr>
<th>Inappropriate indications</th>
<th>n (% of inappropriate)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Routine surveillance of ventricular function with known CAD and no change in clinical status or cardiac exam</td>
<td>61 (51.3)</td>
</tr>
<tr>
<td>Initial evaluation of ventricular function (e.g., screening) with no symptoms or signs of cardiovascular disease</td>
<td>14 (11.8)</td>
</tr>
<tr>
<td>Routine perioperative evaluation of ventricular function with no symptoms or signs of cardiovascular disease</td>
<td>6 (5.0)</td>
</tr>
<tr>
<td>Routine surveillance (&lt;3 years after valve implantation) of prosthetic valve if no known or suspected valve dysfunction</td>
<td>5 (4.2)</td>
</tr>
</tbody>
</table>

**CAD**: coronary artery disease.

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### 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%. 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 per-
formed at our echocardiography laboratory (echo lab), the
sample included in this study probably reflects the usual pat-
ttern of TTE requests at our center. A significant propor-
tion of appropriate exams were performed to evaluate symptoms or
conditions potentially related to cardiac etiology, in par-
ticular stroke or TIA. Other common appropriate indications
were related to initial evaluation of patients with known or
suspected heart failure, hypertensive heart disease or valvu-
lar 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 outpa-
ents. We found that inappropriate requests were more
frequent in outpatients than in inpatients. This is not unex-
pected, 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 inap-
propriate exams among outpatients.4,5

Surprisingly, cardiologists presented a higher rate of inap-
propriateness (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 inap-
propriate requests than cardiology specialists, although the
difference was not statistically significant. Recently, Bha-
tia 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 inpa-
tient academic medical service after implementation of a
simple educational program consisting of lectures, pocket
cards and feedback on ordering behavior via e-mail.7 How-
ever, some methodological caveats have been pointed out
regarding this study.13 Recently, the same group of investi-
gators 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 Interest-
ingly, 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 com-
mon 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 use-
ful than those with inappropriate indications (87% vs. 14%,
p<0.001).7 Clinical impact was defined as any change in diag-
nostic 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 result-
ing 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.10 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.4,15 Indeed, in this study
the AUC indications covered most of the clinical requests,
with only 2.5% being unclassifiable. Control TTE after car-
diovascular interventions and TAVI follow-up accounted for
the majority of unclassifiable tests. Recently, the European
Society of Cardiology and the European Association of Car-
diovascular 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 recom-
endations.

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 pro-
cess of determining the AUC indication is not free of bias
related to clinical factors not fully considered by the review-
ers. 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 num-
ber 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**