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Research paper

Appropriateness and subsequent management of inpatient echocardiograms: An evaluation of low value care

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ARTICLE INFO

Keywords:

Echocardiography
 Appropriate use
 Clinical management
 Cardiac imaging
 Diagnostic testing

ABSTRACT

Study objective: Transthoracic echocardiograms (TTE) are perceived to be overused and multiple TTEs are often ordered within one inpatient visit with unclear utility. This study identified inpatients who received multiple TTEs to determine the appropriateness, results, and subsequent management of repeat TTEs.

Design: Retrospective Cohort Study.

Setting: Single academic medical center.

Participants: Subjects over age 18 who underwent >1 TTE during hospitalization in 2020.

Interventions: N/A

Main outcome measures: Appropriateness of TTE, TTE results, subsequent changes in management.

Results: Of the 875 subjects, the average age was 60 years old with a male predominance (57.8%). In comparing the first and second TTE results, the frequency of new abnormal findings decreased significantly from 44.7% to 15.1% ($p < .0001$). Changes in clinical management in relation to the TTEs decreased from 47.1% to 32.5% ($p < .0001$), of which medication changes were most common. The majority of tests were appropriate, with a slight increase of inappropriate TTEs from 0.6% to 1.8% ($p < .0001$) between first and second TTEs.

Conclusions: While the rate of inappropriate TTE use increased after the initial TTE, the overall rate of inappropriate use was very small indicating that stricter adherence to AUC would not appreciably reduce duplication of inpatient TTEs. The non-negligible frequency of new abnormal findings for the repeat TTEs at 15% cannot be ignored. Our data suggests that the assumption that repeat TTEs are in large part unnecessary is more complicated than originally thought.

1. Introduction

Multiple estimates suggest that 20–30% of medical tests are unnecessary or low-value care, offering no benefits to the patient. Transthoracic echocardiograms (TTE) are frequently ordered for patients admitted to the hospital to evaluate a variety of signs and symptoms, including both cardiac and noncardiac conditions. On occasion these studies are repeated, with or without a change in the patient's clinical status. The clinical benefit of repeated inpatient TTEs has not been well described and physicians often perceived them to be overused [1].

Professional societies have developed Appropriate Use Criteria (AUC) to help establish which indications for tests and procedures are most important for patient outcomes, and which do not necessitate

testing [2–4]. These criteria are intended to be used *a priori* to guide decision making at the point of care. Limited data have been published correlating appropriateness ratings with novel clinical findings and subsequent patient management [5–7].

We conducted this investigation to evaluate the appropriateness and clinical utility of multiple TTEs being performed during a single hospitalization. We hypothesized that echocardiograms that were repeated would be less likely to be appropriate or to uncover new abnormalities that warranted a change in management.

Abbreviations: AUC, Appropriate Use Criteria; TTE, Transthoracic Echocardiogram.

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<https://doi.org/10.1016/j.ahjo.2021.100070>

Received 6 October 2021; Received in revised form 27 October 2021; Accepted 4 November 2021

Available online 22 November 2021

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2. Methods

2.1. Study design

We performed a cohort study of subjects who underwent >1 TTE during a single hospitalization between January 1 and December 31 of 2020. Data were extracted from our electronic medical record system in June 2021. Subjects were identified from our Integrated Data Repository based on Current Procedural Terminology codes for TTE (codes 99,306-8). All subjects meeting this criterion and over the age of 18 were included, no exclusion criteria were applied.

Extracted data elements included the dates of hospitalization and echocardiograms, the total number of TTEs completed during the hospitalization, the primary diagnosis on admission (based on chart review, not coding), and medical history including coronary artery disease (defined as prior myocardial infarction or revascularization), chronic kidney disease (Stage 3, 4, or 5), stroke, diabetes (treated with insulin or oral hypoglycemic agents), hypertension, moderate/severe valvular disease, heart failure, and atrial fibrillation were collected. The results of each echocardiogram were extracted, and studies were categorized as normal, abnormal, or newly abnormal (e.g. abnormal findings were observed that were not previously known). Abnormal findings included: ejection fraction <55%, moderate/severe valvular disease, or moderate or greater pericardial effusion. TTEs that were normal or had only mild abnormalities (such as mild valvular abnormalities or minimal/physiological effusions) were grouped together. Each TTE was categorized based on the AUC from 2011² and 2017 [8]. Each AUC document was created by a diverse group of clinicians and imaging experts and spans hundreds of indications for obtaining a TTE. Each indication is scored on a scale from 1 to 9. A median score between 7 and 9 indicated appropriate use, a median score between 4 and 6 indicated uncertain/maybe appropriate use, and a median score between 1 and 3 indicated inappropriate/rarely appropriate use. Studies that were “appropriate” and “maybe appropriate” were grouped together and compared to the proportion that were “inappropriate.” Appropriateness determination was made through a comprehensive review of the TTE report, the indicated reason for the TTE, and the progress notes of the ordering clinicians. The notes temporally following the TTE report were reviewed to determine if any changes in management were made based on the results of the study which included: cardiology consultation, additional cardiac testing, and changes to medications.

The primary outcome of our investigation was to compare first and subsequent TTEs for the proportion that had newly abnormal findings. Secondary outcomes included a comparison of changes in management based on TTE results and the proportion of TTEs rated as appropriate/maybe appropriate. Our Institutional Review Board reviewed the study and waived the requirement for informed consent.

2.2. Statistical analysis

All data were recorded and stored in a custom Research Electronic Data Capture database [9]. Statistical analysis was conducted using the SPSS version 28 (IBM, Armonk, NY). Proportions were compared using the chi-square test and a significant difference was predefined as *p* value of <0.05. Because the proportion of studies with new abnormal findings was not known *a priori*, no power calculations were performed.

3. Results

3.1. Baseline characteristics

We evaluated 875 subjects who had >1 TTEs during their inpatient stay; the average age of the subjects was 60 years old with a predominance of males (57.8%). Most subjects (56.0%) had only 2 TTEs during their hospitalization and 95% of subjects had 7 TTEs or less. The maximum number of TTEs within one hospitalization was 33. The

majority of subjects were admitted for a noncardiac diagnosis (56.8%). The subjects' most common baseline conditions were hypertension (66.4%), diabetes (31.7%), and coronary artery disease (24.6%); moderate/severe valve disease was present in 15.8%.

3.2. Outcomes

In comparing the first and second TTE results for our primary outcome, we found that the presence of new abnormal findings significantly decreased from 44.7% to 15.1% ($p < .0001$). In contrast, persistent abnormal findings increased from 18.5% to 44.3%, and normal findings slightly increased from 36.1% to 40.0% (Fig. 1). We found that 47.1% of the first TTEs yielded a change in management compared to 32.5% of the second TTEs (Fig. 2). Of these changes in management, medication changes were the most common at 43.7% for the first TTE, increasing to 56.3% for the second TTE. Cardiology consultation decreased from 25.2% to 10.2%, while other cardiac tests ordered decreased from 16.5% to 11.3% (Fig. 3).

3.3. Appropriateness

The TTEs in this cohort spanned 26 AUC clinical scenarios, of which, nearly all were rated as appropriate. Only 0.6% of first TTEs were rated as inappropriate, increasing slightly to 1.8% for second TTEs and 6.1% for third TTEs (if done, $p < .0001$). Acute heart failure was the most prevalent reason for obtaining a TTE at 18.5% for the first TTE and 16.9% for the second. Hypotension was the second most common, decreasing slightly from 9.4% to 9.1% between the first and second TTE. Suspected pericardial disease was third, slightly increasing from 8.8% to 9.9%, followed by evaluation of suspected pulmonary hypertension (8.9%, 10.9%), suspected cardiomyopathy (7.4%, 8.1%), and signs and symptoms of heart disease (5.1%, 4.9%). The remaining, infrequent clinical scenarios included, but were not limited to pre-operative cardiac assessment, post-operative assessment of prosthetic valves, unexplained murmur, and monitoring rejection in a heart transplant patient.

4. Conclusions

4.1. Summary of findings

In this retrospective cohort study of subjects with multiple TTEs during hospitalization, we observed complicated trends between the rate of abnormal findings, change in clinical management, and appropriateness. While repeated TTEs were less likely to uncover new abnormalities, the non-negligible frequency of new abnormal findings for the repeat TTEs at 15% cannot be ignored. The rate of inappropriate TTE use increased after the initial TTE, however, the overall rate of inappropriate use was very small indicating that even if clinicians strictly adhered to AUC, it would not appreciably reduce duplication of inpatient TTEs. Our findings show that the assumption that repeat TTEs are in large part unnecessary is more complicated than originally thought.

4.2. Similar study findings

Prior studies have reported a substantial range in the proportion of inpatient TTEs rated as inappropriate. Similar to our findings, a cohort study by Banihashemi found that inpatient TTEs in their facility were inappropriate only 0.9% of the time [1]. Contrastingly, Ballo examined appropriateness in an inpatient community setting and found that 14.7% of TTEs were inappropriate [10].

When appropriateness is paired with results or clinical management, an inpatient cohort reported by Ghatak et al. found 73.4% of repeat TTEs to be appropriate and that 52% of repeat TTEs resulted in new abnormal findings [11], a substantially higher portion than we observed. Lang et al. examined the use of first-time TTEs in the pediatric inpatient population, specifically looking at the frequency of new abnormal

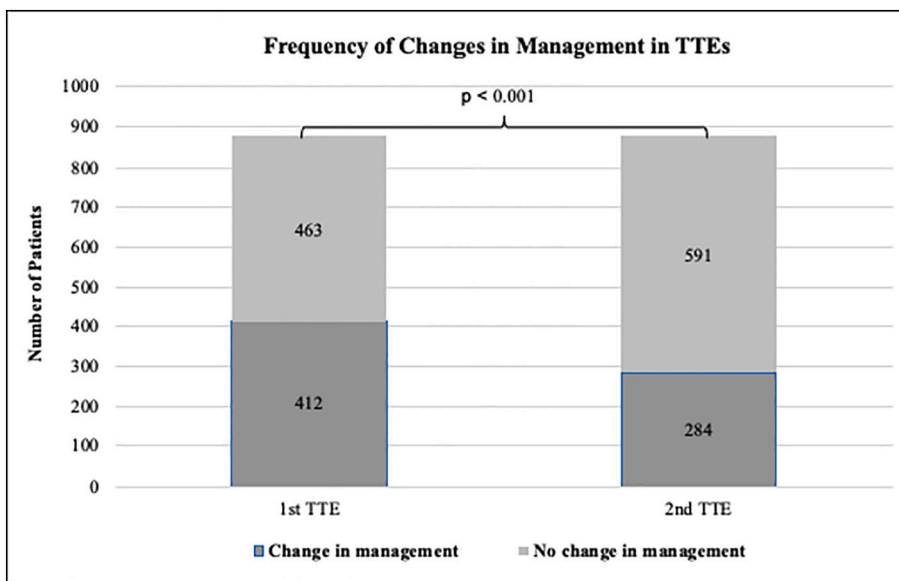


Fig. 1. This figure shows how often patient management changed as a result of the TTE results, with one column for the first patient’s and the another column for the second results. Abbreviation: TTE transthoracic echocardiogram.

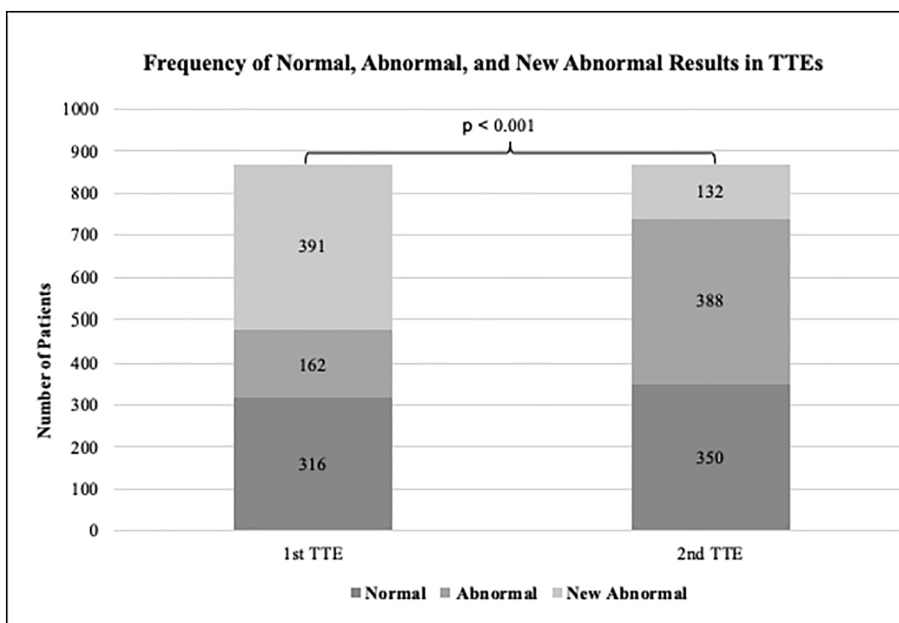


Fig. 2. This figure demonstrates how often TTE results were normal, abnormal, or newly abnormal divided between the first and second TTEs. Abbreviation: TTE transthoracic echocardiogram.

results and appropriate use. They found that while the vast majority of TTEs performed were appropriate, most often for pathologic murmurs, only 25% of these resulted in abnormal findings [12]. While this study examined the pediatric population with only first-time TTEs, their findings parallel the high rate of appropriateness and the non-negligible frequency of new abnormal results observed in our study.

While overuse is a common target for studies evaluating the AUC, an equally important consideration is the degree to which tests are underused. Papalos et al. evaluated appropriateness, underuse, and outcomes in a study with data from the Nationwide Inpatient Sample (NIS). They found that receiving a TTE was associated with a lower mortality risk for inpatients with the most common cardiac diagnoses and that underuse of appropriate TTEs is common. Specifically, only 8% of patients with indications considered appropriate by AUC received a TTE.

They speculate on several reasons for this degree of underuse including a shift from inpatient to outpatient post-discharge testing, discretion by physicians, and cost bundling agreements. The authors did not have any way of knowing if local efforts to reduce unnecessary TTEs or the AUC as a whole contributed to the avoidance of any appropriate testing [10,13]. Together, these studies and ours illustrate the primary challenge of AUC; how to balance concerns about overuse without compromising testing that may be valuable for alteration of clinical management.

We additionally note that the data in our study was collected from inpatient encounters during the first waves of the COVID-19 pandemic which substantially disrupted most health care systems and introduced fluctuations in supply and demand for all sorts of testing [14]. COVID-19 drove some facilities to adopt new triage protocols for which TTEs to perform and which to defer, which was especially crucial in the early

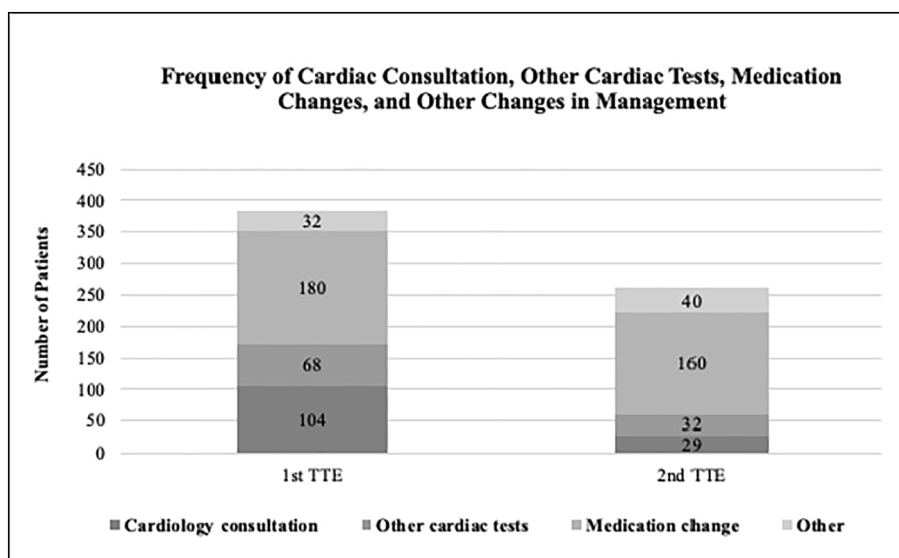


Fig. 3. This figure shows that additional tests, consults, and medication changes were more commonly observed after the first TTE compared to the second. Abbreviation: TTE transthoracic echocardiogram.

epidemic when vaccines were nonexistent and personal protective equipment was in short supply [15]. Ultimately, we cannot be sure how COVID-19 affected the appropriateness of TTEs ordered in our facility during the study period.

While the level of utilization of TTEs remains controversial, it is important to consider the potential for inaccurate utilization rates. One study found that ICD-9 procedure codes that are based on hospital reimbursement are not sensitive to actual TTE utilization, with variations between different diagnoses. Using the Premier Healthcare Informatics database, which obtains information via “hospital internal cost-accounting systems,” [16] they reported a high utilization rate for appropriate TTEs, revealing a discrepancy with the NIS study. As such, they do not recommend the use of ICD-9 codes to determine the use of TTEs. Our study utilized CPT codes, which may reflect a more accurate picture of TTE frequency and subsequent outcomes.

4.3. Future directions

Many interventions have been implemented to improve the utilization of TTEs and minimize inappropriate tests [17]. AUC-based educational interventions have been developed and were found to minimize the frequency of “rarely appropriate” TTEs [18]. Another study showed that upon completion of this intervention and in the absence of continued education, the frequency of rarely appropriate TTEs reverted to what it had been *a priori* [19]. Moreover, ordering clinicians may not reliably apply AUC identically in every situation.

As repeat TTEs within 1 year constitute a large portion of TTEs performed and often do not result in new findings, the development and implementation of solutions to this issue remains an outstanding challenge. One study designed an algorithm, the CAVES score, and successfully predicted the likelihood of finding abnormal results on repeat TTEs. While this algorithm warrants further validation, the study's findings show the potential for predictive algorithms that could minimize the frequency of unnecessary repeat TTEs.

While our results showed a very low frequency of inappropriate tests, efforts to further minimize the incidence of inappropriate or unnecessary tests are still critical. In order to minimize unnecessary tests, looking at who is receiving the test in addition to who is ordering it is pertinent. A study of stratifying repeat TTEs by insurance status found that patients with Medicaid coverage were more likely to have inappropriate tests, compared to patients with Medicare or private insurance [20]. Regardless of intention, this illustrates how the monetary burden

of the present health care system disproportionately impacts patients of lesser financial means. Further studies that investigate whether this association is correlated with the rate of abnormal findings or changes in clinical management are needed.

5. Limitations

While the number of TTEs within one inpatient visit ranged from 1 to 33, we only extracted results and changes in management for the first 3 TTEs for any given patient. It could be argued that the analysis of greater than three TTEs could yield different information.

Additionally, we were limited by the scope of this single center study, and despite the ample sample size, our study lacks external validation. While our study focused on changes in medications, cardiac consultation, and other cardiac testing, it remains to be seen what metrics are the most useful indicators of patient outcomes. Furthermore, we inferred changes in management to be associated with the TTE findings and could not confirm all to be truly related.

While the vast majority of repeat TTEs were appropriate based on AUC, 15.1% yielded new abnormal findings and 32.5% resulted in a change in patient management. Our findings illustrate the need for better methods to optimize efficient and appropriate utilization of TTEs without compromising value-based patient care.

Funding source

This work is supported by NIH T35 Training Grant: 5T35HL007489-37. Dr. Winchester is supported by VHA HSR&D CDA-2 13-023. The views expressed in this article are those of the authors and do not necessarily reflect the position or policy of the Department of Veterans Affairs or the United States Government.

Disclosures

Dr. Winchester and Alexandria Danyluk do not have any financial or other disclosures to report.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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