High Prevalence of Clinically Important Echocardiographic Abnormalities in Patients with a Normal Electrocardiogram Referred for Transthoracic Echocardiography

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Background: Normal electrocardiographic (ECG) results have been reported to be associated with a low prevalence of structural heart disease and thus may preclude the need for transthoracic echocardiographic (TTE) imaging. The goal of this study was to determine the prevalence of important TTE abnormalities in patients with a normal ECG referred for TTE imaging.

Methods: Consecutive electrocardiograms over 6 months were reviewed. Patients with a normal ECG who underwent TTE imaging within 30 days formed the study group. TTE indication and appropriateness designation were determined. TTE findings were noted, including a composite, ''major TTE abnormalities'' (Maj TTE ABNs).

Results: Of 26,254 electrocardiograms reviewed, 3,955 (15%) were normal, 522 with qualifying TTE studies. Maj TTE ABNs were common (27%). The most common TTE indication was signs or symptoms of congestive heart failure (17%), 35% of which had Maj TTE ABNs. Two echocardiographic indications were found to have significantly fewer of Maj TTE ABNs: palpitations (4%, $P < .01$) and preoperative evaluation before noncardiac surgery (6%, $P < .01$). A majority of TTE studies were appropriate (76%), with only 14% rarely appropriate. Maj TTE ABNs were less common in rarely appropriate compared with appropriate TTE studies (13% vs 30%, $P < .01$), with a very low prevalence of Maj TTE ABNs in outpatient rarely appropriate TTE studies (4%).

Conclusions: Clinically important TTE abnormalities in patients with a normal ECG are common, suggesting that normal ECG results should not routinely preclude TTE imaging to identify structural heart disease. However, recognition of common clinical indications and application of the appropriate use criteria may identify patients with a normal ECG in whom TTE imaging is of very low yield. (J Am Soc Echocardiogr 2018;■:■-■.)

Keywords: Normal, Electrocardiogram, Transthoracic echocardiography, Appropriateness, Prevalence

Transthoracic echocardiographic (TTE) imaging is the most widely used noninvasive imaging modality for the evaluation of suspected structural heart disease.[1,2] Although the indications for TTE are generally well established, rising health care costs and expanding use of echocardiography over the past two decades have spawned efforts to limit and optimize the practice of echocardiography.[2-5] One example of this is the appropriate use criteria (AUC) developed by the American College of Cardiology Foundation, in conjunction with subspecialty societies including the American Society of Echocardiography, to help guide the use of cardiac imaging procedures in the delivery of high-quality medical care.[6,7] Despite improvements in use with these efforts, additional investigation regarding appropriate and optimal use of echocardiography is warranted.[4,5,8]

Electrocardiography is inexpensive, office based, and commonly the initial diagnostic tool to evaluate cardiovascular signs and symptoms. Although electrocardiography is performed to exclude cardiac arrhythmias as a cause for cardiac symptoms, electrocardiographic (ECG) abnormalities may prompt concern for underlying structural heart disease. As a result, abnormal ECG results are a frequent and appropriate indication for echocardiography. On the contrary, it is unclear whether normal ECG results suggest an absence of structural heart disease. Recent small studies in selected populations have reported that normal ECG results are associated with a low prevalence of structural heart disease.[9-11] Thus, it has been suggested that normal ECG results may preclude the need for additional assessment with TTE imaging.[9,10] However, the true prevalence of echocardiographic abnormalities in patients with normal ECG results has not been studied systematically.

Our goal was to determine the prevalence of clinically significant TTE abnormalities in patients with normal ECG results. In addition, we sought to investigate the relationship between appropriateness designation according to the AUC for echocardiography and the prevalence of clinically significant TTE abnormalities in patients with a normal ECG.

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Abbreviations

AUC = Appropriateness use criteria

CHF = Congestive heart failure

ECG = Electrocardiographic

LV = Left ventricular

LVEF = Left ventricular ejection fraction

Maj TTE ABN = Major transthoracic echocardiographic abnormality

TTE = Transthoracic echocardiographic

METHODS

Study Design

In this retrospective observational study, the study group was identified from a database of consecutive ECG studies performed over a 6-month period (January 1 to June 20, 2016) at University of Chicago Medicine. All subjects with normal ECG results who were ≥18 years of age and also underwent complete TTE examinations performed at University of Chicago Medicine within 30 days of electrocardiography were eligible for inclusion. Normal ECG results were defined by the automated interpretation performed by the Marquette 12SL ECG Analysis Program,[12] with confirmation by an attending cardiologist at the time of clinical study. Electronic medical records were reviewed, and subjects were excluded if they had any clinical events that might alter the TTE findings in the interval between electrocardiography and TTE imaging (e.g., new symptoms, acute coronary syndrome, new signs or symptoms of heart failure).

Data Collection

TTE indication and all TTE findings were recorded for all studies. All TTE studies were interpreted at the time of clinical study by full-time faculty echocardiographers applying all guidelines and standards as outlined by the American Society of Echocardiography. A composite end point of "major TTE abnormalities" (Maj TTE ABNs) was determined for each study. A Maj TTE ABN was defined as left ventricular (LV) dysfunction (LV ejection fraction [LVEF] < 45%), right ventricular dysfunction, moderate or greater valvular regurgitation, any valve stenosis, any regional wall motion abnormality, pulmonary hypertension (estimated right ventricular systolic pressure > 35 mm Hg), moderate or severe diastolic dysfunction, or pericardial effusion at least small in size. Primary clinical indication for TTE imaging, inpatient versus outpatient status, and whether the study was the patient's initial TTE examination or a repeat examination were also recorded. The primary clinical indication for TTE imaging was determined on the basis of review of the written indication and the diagnostic International Classification of Diseases, Ninth Revision, code entered in the electronic order by the ordering clinician at the time of clinical study and confirmed by review of the electronic medical record.

Classification of appropriateness was performed according to the 2011 AUC for echocardiography.[6] Since publication of the 2011 AUC, the nomenclature of appropriateness designations (previously appropriate, uncertain, and inappropriate) has changed. In this study, we have applied the new recommended nomenclature such that each study was determined to be appropriate, maybe appropriate, or rarely appropriate.[6,7] Two investigators, blinded to echocardiographic results, independently reviewed the electronic order and medical record and selected the 2011 AUC indication that best fit the clinical reason for the study. For studies in which the appropriateness determination (appropriate, maybe appropriate, or rarely appropriate) for the indication selected by the two investigators agreed (97% of studies), this served as the consensus appropriateness designation of the study. For studies in which there was not agreement in the appropriateness level of between the two investigators (3% of studies), a third investigator independently reviewed the data and selected one of the initial two selections as the final primary consensus appropriateness designation of the study.

Comparisons between study indications, echocardiographic findings, and appropriateness designations were performed using χ^2 tests; a P value < .05 was considered to indicate statistical significance.

RESULTS

Of 26,254 consecutive electrocardiograms obtained in the 6-month study period, 3,955 (15%) were confirmed to be normal. Of these, 522 subjects (13%) underwent qualifying TTE examinations within 30 days of electrocardiography and formed the study group.

TTE findings are listed in Table 1. Overall, 27% were found to have Maj TTE ABNs. Individual TTE findings included 3% with LV dysfunction (LVEF < 45%), 32% with diastolic dysfunction, 8% with right ventricular dysfunction, 9% with pulmonary hypertension, and 5% with regional wall motion abnormalities (Table 1).

The practice setting of TTE examinations in the study group was nearly evenly divided, with 280 (54%) performed as inpatient studies and 242 (46%) performed as outpatient studies (Table 2). Maj TTE ABNs were significantly less frequent among outpatient compared with inpatient TTE examinations (21% vs 32%, $P < .01$). A majority of subjects had no prior TTE examinations ($n = 349$ [67%]). Compared with subjects who had undergone prior TTE studies, those with no prior studies were less likely to have Maj TTE ABNs (22% vs 38%, $P < .01$). Among subjects who had no prior TTE examinations, outpatients had significantly fewer Maj TTE ABNs (15% vs 28%, $P < .05$) compared with inpatients. Among patients with prior TTE studies, there was no significant difference in the prevalence of Maj TTE ABNs in outpatients compared with inpatients (33% vs 41%, P = NS).

Indication for Echocardiography

The most common indications for TTE were signs or symptoms of congestive heart failure (CHF; 17%), followed by dyspnea (11%), stroke or transient ischemic attack (10%), and syncope (8%; Table 3). The highest prevalence of Maj TTE ABNs was found in TTE examinations with an ordering indication of known valve disease (75%), followed by respiratory failure or arrest (50%), known arrhythmia (37%), and signs or symptoms of CHF (35%). Maj TTE ABNs were significantly more likely to be found in TTE studies ordered for signs or symptoms of CHF (35%, $P < .05$), respiratory failure or arrest (50%, $P < .01$), and known valve disease (75%, $P < .01$), compared with the rest of the study group. Two TTE indications were found to have a significantly lower prevalence of Maj TTE ABNs compared with the rest of the study group: palpitations (4% [$n = 1$], $P < .01$) and preoperative evaluation before noncardiac surgery (6% [$n = 2$] $P < .01$; Table 2). The one patient with a referral indication for TTE imaging of palpitations found to have a Maj TTE ABN was a 79-year-old man with an LVEF of 44%. Only two patients with a referral indication of preoperative evaluation before noncardiac surgery were found to have Maj TTE ABNs. One was a 59-year-old woman with a history of hypertension referred for laparotomy for an abdominal mass who was found to have moderate diastolic dysfunction. The second was a 77-year-old woman referred for lower extremity vascular surgery and found to have an LVEF of 40%.