Appropriateness of Outpatient Echocardiograms Ordered by Pediatric Cardiologists or Other Clinicians

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Objective To assess the appropriateness and diagnostic yield of TTEs ordered by various pediatric providers according to the pediatric appropriate use criteria (AUC) for outpatient transthoracic echocardiography (TTE) before its release.

Study design Clinic notes of patients aged ≤18 years who underwent initial outpatient TTE between April and September 2014 were reviewed to determine the AUC indication, and appropriateness was assigned based on the AUC document. Ordering physicians were categorized into cardiologists, primary care physicians (PCPs; including pediatricians and family practitioners [FPs]), and noncardiology subspecialists.

Results Of the 1921 TTEs ordered during the study period, 84.6% were by cardiologists, 9.2% by pediatricians, 3.4% by FPs, and 2.8% by noncardiology subspecialists. The appropriateness rate for cardiologists was higher than that for PCPs (86% vs 64%; $P < .001$) but not noncardiology subspecialist (86% vs 87%; $P = .80$). PCPs had a significantly higher proportion of studies that could not be classified compared with cardiologists (35% vs 5%; $P < .001$) and noncardiology subspecialists (35% vs 11%; $P < .001$), owing primarily to a lack of adequate clinical information. The likelihood of an abnormal finding was higher in TTEs ordered by a cardiologist vs those ordered by a noncardiologist (OR, 4.8; 95% CI, 2.1-10.9; $P < .001$).

Conclusions Compared with PCPs, cardiologists ordered more TTEs, had the highest yield of abnormal findings, and had greater appropriateness of TTE orders. A large proportion of TTEs ordered by PCPs were unclassifiable owing to insufficient information. This study lays a framework for provider education and improvement in the TTE order intake process. *(J Pediatr 2017;184:137-42).*

Transthoracic echocardiography (TTE) has been widely used to assess cardiac structure and function not only by cardiologists, but also by primary care providers (PCPs) and noncardiology subspecialists. Given the rising healthcare costs due to excessive use of imaging procedures, the American College of Cardiology established the Appropriate Use Criteria (AUC) Task Force in 2005.[1] Since its inception, this task force has released several documents applicable to adult cardiology patients, and the first pediatric AUC document, published in 2014, addresses the use of initial outpatient TTE.[2] This document consists of assumptions and definitions of terms applicable to the document and 113 indications for TTE that have been rated as appropriate (A), may be appropriate (M), or rarely appropriate (R). The document stratifies TTE indications so that an appropriate indication is one in which TTE is reasonable to consider, because it is expected to add information to the clinical judgment in such a way that the benefit exceeds the cost for the patient.

The first pediatric AUC implementation study was recently published.[3] This large multicenter study included only pediatric cardiologists, owing to a lack of details on clinical indications for TTE ordered by noncardiologists. Nonetheless, the AUC document is intended to serve all providers and is not restricted to pediatric cardiologists. Studies in adult cardiology have reported variable differences in the appropriateness rate of cardiologists and noncardiologists, but no such data exist for pediatric patients undergoing initial outpatient TTE.[4-6] We sought to determine the proportion of studies ordered by noncardiologists, and to compare their appropriateness and diagnostic yield with those ordered by cardiologists before publication of the AUC document. In addition, we aimed to determine the proportion of studies that could not be classified based on the AUC document, and the reasons for the inability to do so. This information will aid the design of educational interventions to improve the appropriate use of TTE and improve the intake process for TTE orders.

A	Appropriate
AUC	Appropriate use criteria
EMR	Electronic medical record
FP	Family practitioner
M	May be appropriate
PCP	Primary care physician
R	Rarely appropriate
TTE	Transthoracic echocardiography

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Methods

We reviewed medical records of patients aged <18 years who underwent initial outpatient TTE at our center during a 6-month period (April 1, 2014, to September 30, 2014) before publication of the pediatric AUC document. All patients seen by the pediatric cardiologists had a clinic encounter associated with the order and details of the clinical indication readily available. These patients were included in the previously published AUC implementation study.[6] The noncardiology providers were either primary care physicians (PCPs), comprising pediatricians and family practitioners (FPs), or noncardiac pediatric subspecialists. Because of the relatively small number of TTEs ordered by pediatricians and FPs and the similarity of the indications for these providers, they were grouped together for some of the statistical analyses. Patients referred by these providers for only a TTE in the clinic did not always have a clinic encounter available in our electronic medical record (EMR) system to provide the details needed for assigning the AUC indication. For example, many were referred with a single word indication such as "murmur," "palpitations," or "syncope," with no further details and thus could not be classified. The indication for TTE was determined by a single reviewer after reviewing the TTE order and clinical encounter, when available. The corresponding appropriateness rating (A, M, or R) was then assigned using the AUC document.[2] The reviewer's patients were excluded from the study. The reviewer attempted to remain blinded to the results of the TTE before assigning the AUC indication, though these results were included in the clinic notes. Studies were deemed "unclassifiable" for 1 of 2 reasons: either there was incomplete information in the referral from which an indication could be assigned, or the indication was unavailable in the AUC document.

TTE findings were categorized based on the classification used in the first pediatric AUC implementation study, as normal, incidental, or abnormal.[3] Incidental findings included patent foramen ovale, tiny patent ductus arteriosus in a neonate, peripheral pulmonic stenosis, and a left superior vena cava. Abnormal findings were further classified as mild, moderate, or severe.[3] Mild findings were defined as those that might require follow-up but no intervention; moderate findings, as those that alter management but require no urgent intervention; and severe findings, those likely to require urgent hospitalization or intervention.

Statistical Analyses

Statistical analyses were performed using SAS 9.4 (SAS Institute, Cary, North Carolina), and figures were created using Excel 2013 (Microsoft, Redmond, Washington). Statistical significance was assessed at the $P < .05$ level. Descriptive statistics were calculated for all variables of interest as count and percentage. Frequency counts of TTEs ordered were compared between groups using the χ^2 test. ORs and 95% CIs were calculated using noncardiologists as the reference group unless noted otherwise.

Results

The 1921 initial outpatient TTE evaluations performed during the study period included 1625 (84.8%) ordered by cardiologists, 176 (9.2%) ordered by pediatricians, 66 (3.4%) ordered by FPs, and 54 (2.8%) ordered by noncardiology subspecialists. These orders were from 38 different cardiologists, 127 pediatricians, 51 FPs, and 18 noncardiology subspecialists. These subspecialists included otolaryngologists (n = 3), pediatric surgeons (n = 3), endocrinologists (n = 2), gastroenterologists (n = 2), hematologists/oncologists (n = 3), obstetricians (n = 2), a geneticist (n = 1), a pulmonologist (n = 1), and a neurologist (n = 1).

Appropriateness by Provider Type

The percentage of TTEs rated A was significantly higher for cardiologists compared with PCPs (77.3% vs 40.9%; $P < .001$) but similar to that for noncardiology subspecialists (77.3% vs 66.7%; $P = .068$) (**Figure 1**). The number of total unclassifiable studies was significantly higher for PCPs compared with cardiologists (34.7% vs 5.3%; $P < .001$) and noncardiology subspecialists (34.7% vs 11.1%; $P < .001$). The vast majority of unclassifiable studies for PCPs were because of incomplete clinical information in the referral (85.7%), which included 59 reports of murmurs, 5 reports of chest pain, and 8 reports of syncope (**Figure 2**). Note that PCPs are split into pediatricians and FPs in **Figure 2**, but were analyzed together to improve statistical power. All of the unclassifiable studies for cardiologists were due to unavailability in the AUC document. For noncardiology subspecialists, 5 studies (9.2%) were unclassifiable due to lack of availability in the AUC document, and 1 study (1.9%) was unclassifiable because of incomplete clinical information.

Common Indications for TTE by Provider Type

The most common indication for TTE ordered by cardiologists was a murmur (n = 526; 32.4%), followed by chest pain (n = 355; 21.8%) and then systemic disorder (n = 194; 11.9%). The most common types of systemic disorders were systemic hypertension (n = 98), suspected connective tissue disorder (n = 32), and clinically suspected syndrome or extracardiac congenital abnormality known to be associated with congenital heart disease (n = 29). Other significant indications included previous test results (n = 166; 10.2%) and family history of cardiovascular disease (n = 131; 8.1%). For PCPs, the most common indications were systemic disorders (n = 81; 33.5%), murmur (n = 59; 24.4%), and family history of cardiovascular disease (n = 47; 19.4%). The most common systemic disorders for which PCPs ordered TTE were sickle cell disease or other hemoglobinopathies (n = 17) and suspected pulmonary hypertension in patients with obstructive sleep apnea (n = 15). Of the 47 indications for family history, 42 were for a family history of congenital left-sided lesions, which includes lesions ranging from hypoplastic left heart syndrome to bicuspid aortic valve. For noncardiology subspecialists, the most common indications were systemic disorders (n = 39; 72.2%). The most common systemic disorders for this group