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APPROPRIATE USE CRITERIA

ACC/AAP/AHA/ASE/HRS/SCAI/SCCT/SCMR/SOPE 2014 Appropriate Use Criteria for Initial Transthoracic Echocardiography in Outpatient Pediatric Cardiology

A Report of the American College of Cardiology Appropriate Use Criteria Task Force, American Academy of Pediatrics, American Heart Association, American Society of Echocardiography, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Cardiovascular Computed Tomography, Society for Cardiovascular Magnetic Resonance, and Society of Pediatric Echocardiography

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ABSTRACT

The American College of Cardiology (ACC) participated in a joint project with the American Society of Echocardiography, the Society of Pediatric Echocardiography, and several other subspecialty societies and organizations to establish and evaluate Appropriate Use Criteria (AUC) for the initial use of outpatient pediatric echocardiography. Assumptions for the AUC were identified, including the fact that all indications assumed a first-time transthoracic echocardiographic study in an outpatient setting for patients without previously known heart disease. The definitions for frequently used terminology in outpatient pediatric cardiology were established using published guidelines and standards and expert opinion. These AUC serve as a guide to help clinicians in the care of children with possible heart disease, specifically in terms of when a transthoracic echocardiogram is warranted as an initial diagnostic modality in the outpatient setting. They are also a useful tool for education and provide the

infrastructure for future quality improvement initiatives as well as research in healthcare delivery, outcomes, and resource utilization.

To complete the AUC process, the writing group identified 113 indications based on common clinical scenarios and/or published clinical practice guidelines, and each indication was classified into 1 of 9 categories of common clinical presentations, including palpitations, syncope, chest pain, and murmur. A separate, independent rating panel evaluated each indication using a scoring scale of 1 to 9, thereby designating each indication as "Appropriate" (median score 7 to 9), "May Be Appropriate" (median score 4 to 6), or "Rarely Appropriate" (median score 1 to 3). Fifty-three indications were identified as Appropriate, 28 as May Be Appropriate, and 32 as Rarely Appropriate.

PREFACE

In an effort to respond to the need for the rational use of services in the delivery of high quality care, the ACC has undertaken a process to determine the appropriate use of cardiovascular imaging and procedures for selected patient indications.

AUC publications reflect an ongoing effort by the ACC to critically and systematically create, review, and categorize clinical situations where diagnostic tests and procedures are utilized by physicians caring for patients with known or suspected cardiovascular diseases. The process is based on current understanding of the technical capabilities of the imaging modalities and procedures examined. Although not intended to be entirely comprehensive due to the wide diversity of clinical disease, the indications are meant to identify common scenarios encountered by the majority of contemporary practices. Given the breadth of information they convey, the indications do not directly correspond to the International Classification of Diseases (ICD) system.

The ACC believes that careful blending of a broad range of clinical experiences and available evidence-based information will help guide a more efficient and equitable allocation of health care resources in cardiovascular imaging. The ultimate objective of AUC is to improve patient care and health outcomes in a cost-effective manner, but they are not intended to ignore ambiguity and nuance intrinsic to clinical decision-making. Local parameters, such as the availability or quality of equipment or personnel, may influence the selection of certain tests or procedures. AUC thus should not be considered substitutes for sound clinical judgment and practice experience.

1. INTRODUCTION

Improvements in cardiovascular imaging technologies and their application, particularly with increasing therapeutic options for cardiovascular disease, have led to an increase in the utilization of such technologies. As these imaging technologies and clinical applications continue to advance, the healthcare community needs to understand how best to incorporate these options into daily clinical care and how to choose between new and long-standing, established imaging technologies. In an effort to respond to this need and to ensure the effective use of advanced diagnostic imaging tools and procedures, the AUC project was initiated. The AUC in this document have been developed in order to promote effective patient care, better clinical outcomes, and improved resource utilization. This set of AUC should be useful not only for pediatric cardiologists, but also for general pediatricians and family practitioners, who are frequently the first clinicians to consider the need for this modality.

Although AUC have been established for echocardiography in adult patients (1-3), a similar document for pediatric patients has not yet been published. This is partly because the scope of such a document would require an impossibly extensive list, if criteria were developed for each congenital cardiac malformation and its variants before and after intervention. Guidelines and standards for performing a pediatric echocardiogram, as well as recommendations for quantification methods, have already been published (4,5). However, the questions often raised by AUC of "when to do" and "how often to do" a pediatric echocardiogram still remained.

To address these concerns, the American College of Cardiology initiated an AUC document on pediatric echocardiography in the outpatient setting, since outpatient care is an important component of clinical pediatric cardiology. Children with heart disease represent a widely varied group of patients, frequently characterized by complex anatomic malformations requiring lifelong follow-up. While echocardiography is the primary diagnostic modality for children with established congenital and acquired heart disease, the scope of the current document has been limited to first-time outpatient transthoracic echocardiographic studies in patients without previously known cardiac abnormalities. This narrower set of clinical presentations has been chosen because of the high volume of such testing within pediatric cardiology. In addition, this initiative has established the infrastructure to develop additional AUC for pediatric and congenital echocardiography in other settings.

2. METHODS

This document covers a wide array of potential signs and symptoms associated with cardiovascular disease in pediatric patients. A standardized approach was used to create different categories of indications with the goal of capturing actual clinical scenarios, without making the list of indications excessively long. Indications were created

to represent most of the possible uses of echocardiography in the outpatient pediatric setting rather than limiting the AUC to indications for which evidence was available.

To identify and categorize the indications, a writing group of pediatric echocardiography experts was formed of representatives from a variety of organizations and societies. Wherever possible during the writing process, the group members would map the indications to relevant clinical guidelines and key publications or references (See Online Appendix). Once the indications were formed, they were reviewed and critiqued by the parent AUC Task Force and numerous external reviewers representing all pediatric cardiovascular specialties and primary care. After the writing group incorporated this initial feedback, the indications were sent to an independent rating panel comprised of additional experts in the pediatrics and pediatric cardiology realm, before being sent back to the writing group for additional vetting. Each indication was then rated and classified as either "Appropriate care", "May Be Appropriate care", or "Rarely Appropriate care" based on these multiple rounds of review and revision (see **Figure 1**).

A detailed description of the methods used for rating the selected clinical indications is found in a previous publication, "ACCF Proposed Method for Evaluating the Appropriateness of Cardiovascular Imaging," (6) as well as the updated version, "Appropriate Use of Cardiovascular Technology: 2013 ACCF Appropriate Use Criteria Methodology Update: A Report of the American College of Cardiology Foundation Appropriate Use Criteria Task Force" (7). Briefly, this process combines evidence-based medicine and practice experience and engages a rating panel in a modified Delphi exercise. Other steps are convening a formal writing group with diverse expertise in pediatric imaging and clinical care, circulating the indications for external review prior to being sent to the rating panel, ensuring an appropriate balance of expertise and practice areas among the rating panelists, developing a standardized rating package that includes relevant evidence, and establishing formal roles for facilitating panel interaction at the face-to-face meeting.

The rating panel first evaluated the indications independently. Then, the panel was convened for a face-to-face meeting for discussion of each indication. At this meeting, panel members were given their scores and a blinded summary of their peers' scores. After the meeting, panel members were then asked to independently provide their final scores for each indication (See Online Appendix).

Although panel members were not provided explicit cost information to help determine their appropriate use ratings, they were asked to implicitly consider cost as an additional factor in their evaluation of appropriate use. In rating these criteria, the AUC Rating Panel was asked to assess whether the use of the test for each indication should be categorized as Appropriate care, May Be Appropriate care, or Rarely Appropriate care, and was provided the following definition of appropriate use:

An appropriate imaging study is one in which the expected incremental information, combined with clinical judgment, exceeds the expected negative consequences[1] by a sufficiently wide margin for a specific indication that the procedure is generally considered acceptable care and a reasonable approach for the indication.

The rating panel scored each indication as follows:

Median Score 7 to 9: *Appropriate test* for specific indication (test **is** generally acceptable and **is** a reasonable approach for the indication).

An appropriate option for management of patients in this population due to benefits generally outweighing risks; effective option for individual care plans although not always necessary depending on physician judgment and patient specific preferences (i.e., procedure is generally acceptable and is generally reasonable for the indication).

Median Score 4 to 6: *May Be Appropriate test* for specific indication (test **may** be generally acceptable and **may** be a reasonable approach for the indication). May Be Appropriate also implies that more research and/or patient information is needed to classify the indication definitively.

At times an appropriate option for management of patients in this population due to variable evidence or lack of agreement regarding the benefits risks ratio, potential benefit based on practice experience in the absence of evidence, and/or variability in the population; effectiveness for individual care must be determined by a patient's physician in consultation with the patient based on additional clinical variables and judgment along with patient preferences (i.e., procedure may be acceptable and may be reasonable for the indication).

Median Score 1 to 3: *Rarely Appropriate test* for specific indication (test **is not** generally acceptable and **is not** a reasonable approach for the indication).

Rarely an appropriate option for management of patients in this population due to the lack of a clear benefit/risk advantage; rarely an effective option for individual care plans; exceptions should have documentation of the clinical reasons for proceeding with this care option (i.e., procedure is not generally acceptable and is not generally reasonable for the indication).

The division of the numerical scores into 3 levels of appropriateness is somewhat arbitrary and the numeric designations should be viewed as existing on a continuum. Further, there may be diversity in clinical opinion for particular clinical scenarios, such that scores in the

[1]Negative consequences include the risks of the procedure (i.e., radiation or contrast exposure) and the downstream impact of poor test performance such as delay in diagnosis (false negatives) or inappropriate diagnosis (false positives).

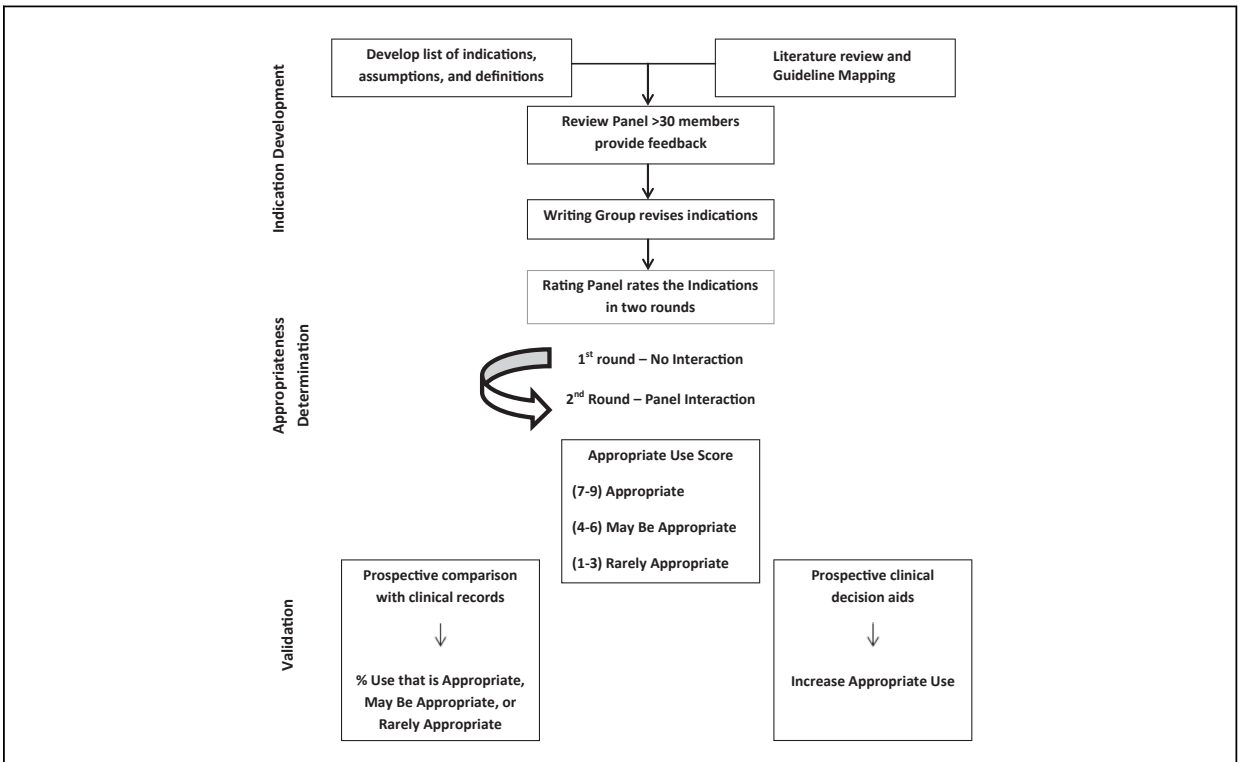

FIGURE 1 AUC Development Process

intermediate level of appropriate use should be labeled "May Be Appropriate," as critical patient or research data may be lacking or discordant. This designation should be a prompt to the field to carry out definitive research investigation whenever possible. It is anticipated that the AUC reports will continue to be revised as further data are generated and information from criteria implementation is accumulated.

To prevent bias in the scoring process, the rating panel, by design, included a minority of specialists in pediatric echocardiography. Specialists, while offering important clinical and technical insights, might have a natural tendency to rate the indications within their specialty as more appropriate than non-specialists. In addition, care was taken to provide objective, nonbiased information, including guidelines and key references, to the rating panel.

The level of agreement among panelists was analyzed based on the RAND Corporation's BIOMED Concerted Action on Appropriateness rule (8) for a panel of 14 to 16 members. As such, agreement was defined as an indication where 4 or fewer panelists' ratings fell outside the 3-point region containing the median score.

Disagreement was defined as occurring when at least 5 panelists' ratings fell in both the Appropriate and the Rarely Appropriate categories. Any indication having disagreement was categorized as May Be Appropriate regardless of the final median score.

3. GENERAL ASSUMPTIONS

1. This document will address the initial use of outpatient transthoracic echocardiography (TTE) during pediatric (≤ 18 years of age) outpatient care. Although TTE is also an essential tool in hospitalized patients, discussion of indications for this use is beyond the scope of this document.
2. This AUC document will not address the use of TTE in patients with previously known structural, functional, or primary electrical cardiac abnormalities.
3. A comprehensive TTE examination may include 2-dimensional, M-mode, and 3-dimensional imaging as well as spectral and color Doppler evaluation, all of which are important elements (9–11) to evaluate relevant cardiac structures and hemodynamics. A comprehensive TTE report includes interpretation of all aspects of the TTE.
4. The use of transesophageal or stress echocardiography will not be addressed in this document.
5. This document assumes that any other more definitive diagnostic test, including but not limited to electrocardiogram (ECG), chest X-ray, or genetic testing, when appropriate will be considered prior to ordering a TTE.
6. All standard TTE techniques for image acquisition are available for each indication and have a sensitivity

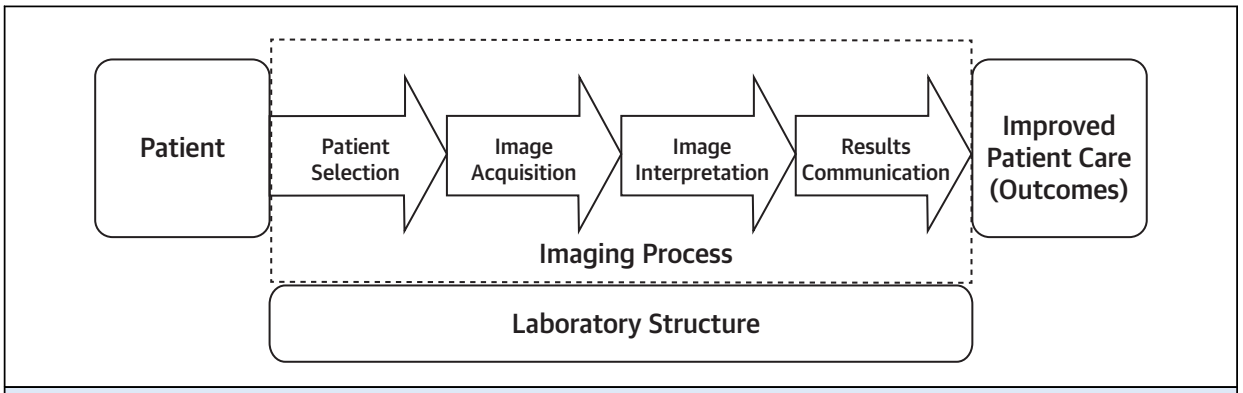

FIGURE 2 Factors Influencing Outcomes of an Imaging Study (16)

and specificity similar to those found in the published literature.

7. The test is performed and interpreted by qualified individual(s) in a facility that is in compliance with national standards for performing pediatric echocardiograms (4).
8. AUC is one aspect of quality for imaging procedures occurring at the time of patient selection. Several additional factors should be addressed to support high-quality results (see **Figure 2**). These other factors are important but are not covered in this document.
9. The range of potential indications for echocardiography is quite large, particularly in comparison with other cardiovascular imaging tests. Thus, the indications are, at times, purposefully broad to cover an array of cardiovascular signs and symptoms and to account for the ordering physician's best judgment as to the presence of cardiovascular abnormalities. Additionally, there are likely clinical scenarios that are not covered in this document.
10. A qualified clinician has obtained a complete clinical history and performed the physical examination such that the clinical status of the patient can be assumed to be valid as stated in the indication (e.g., an asymptomatic patient is truly asymptomatic for the condition in question and sufficient questioning of the patient has been undertaken).
11. Some indications address whether or not an ECG has been obtained and whether or not it reveals any abnormalities as influencing the appropriateness of additional echocardiographic assessment. It is beyond the scope of this document to define every possible clinical scenario involving specific ECG abnormalities. Therefore, the term "abnormal ECG" refers to only clinically pertinent ECG findings. Criteria for "abnormal ECG" will be based upon standard published ECG normal values in pediatric patients (12–15).
12. If the reason for a test can be assigned to more than one indication, it is classified under the most clinically significant indication.
13. The term family history in this document refers to first-degree relatives only.
14. Cost is considered implicitly in the appropriate use determination. Clinical benefits should always be considered first, and costs should be considered in relationship to these benefits in order to better convey net value. For example, a procedure with moderate clinical efficacy for a given AUC indication should not be scored as more appropriate than a procedure with high clinical efficacy solely due to its lower cost. When scientific evidence exists to support clinical benefit, cost efficiency and cost effectiveness should be considered for any indication.
15. For each indication, the rating reflects whether the echocardiogram is reasonable for the patient according to the appropriate use definition, not whether the test is preferred over another modality. It is not assumed that the decision to perform a diagnostic test has already been made. The level of appropriateness also does not consider issues of local availability or skill for any modality.
16. The category of May Be Appropriate is used when insufficient data are available for a definitive categorization or when there is substantial disagreement regarding the appropriateness of that indication. The designation May Be Appropriate should not be used as grounds for denial of reimbursement.
17. This manuscript does not address whether a cardiology consultation is required prior to the echocardiogram unless specified in the indication.

4. DEFINITIONS

Abnormal electrocardiogram (ECG): Electrocardiographic findings regarded as probably or definitely abnormal

according to age as well as clinically significant, and including but not limited to ventricular hypertrophy, atrial enlargement, complete bundle branch block, atrioventricular block, prolonged QTc, abnormal T waves or ST-T wave segments, Wolff-Parkinson-White syndrome, premature atrial contractions (PACs), premature ventricular contractions (PVCs), supraventricular tachycardia, ventricular tachycardia, and Brugada syndrome

Arrhythmia: Documented irregular and/or abnormal heart rate or rhythm (Patients with palpitations do not necessarily have an arrhythmia, and patients with an arrhythmia do not necessarily experience palpitations)

Cardiomyopathy: Disease affecting the structure and/or function of the myocardium, including but not limited to hypertrophic, dilated, or restrictive cardiomyopathy, left ventricular non-compaction, or arrhythmogenic right ventricular cardiomyopathy

Channelopathy: A clinical syndrome involving a genetic mutation or acquired malfunction of the proteins forming the myocardial ion channels (including but not limited to $Na+$, $K+$, and $Ca^{2}+$) of the cardiovascular electrical system, including but not limited to long QT syndrome, short QT syndrome, catecholaminergic polymorphic ventricular tachycardia, and Brugada syndrome

Chest pain: Physical discomfort in the anterior thoracic region

Congestive heart failure: A condition in which the heart is unable to pump enough blood to meet the body's metabolic demands

Cyanosis: Bluish discoloration of the skin and mucous membranes

Desaturation: For pediatric patients other than newborns, an oxygen saturation <95% as measured by pulse oximeter; for newborns ≥24 hours of age, an oxygen saturation that is (a) <90% in the initial screen or in repeat screens, (b) <95% in the right hand and foot on 3 measures, each separated by 1 hour, or (c) a >3% absolute difference in oxygen saturation between the right hand and foot on 3 measures, each separated by 1 hour (17)

Echogenic focus: Small bright spot(s) frequently seen on a fetal echocardiogram, usually related to the ventricular papillary muscles and chordae and generally considered a benign finding

Hypertension: Average systolic and/or diastolic blood pressure that is ≥95th percentile for gender, age, and height on 3 or more occasions

Murmur: Additional heart or vascular sound due to normal or abnormal turbulent blood flow heard during auscultation

> *Innocent murmur*: Murmur that is consistent with normal blood flow and is determined not to be related to any structural abnormalities of the heart or great vessels, including but not limited to Still's murmur, pulmonary flow murmur, physiologic peripheral pulmonary stenosis, supraclavicular arterial bruit, and venous hum; most innocent murmurs are soft (less than or equal to grade 2/6), heard in early systole, characterized as crescendo-decrescendo type, and may vary with position
>
> *Pathologic murmur*: Murmur that is suggestive of the presence of a cardiovascular abnormality (not clearly innocent sounding), including but not limited to diastolic murmurs, holosystolic murmurs, late systolic murmurs, grade 3/6 systolic murmur or louder, continuous murmurs other than venous hums, harsh murmurs, and murmurs that are provoked or become louder with changes in position (from squatting to standing) or during the strain phase of a Valsalva maneuver

Neonate: A child that is less than or equal to 28 days old

Neurocardiogenic syncope: A type of syncope typically occurring in the upright position, in which the triggering of a neural reflex results in a usually self-limited episode of systemic hypotension and/or bradycardia or asystole

Palpitations: An unpleasant sensation of rapid, irregular, and/or forceful beating of the heart

Pre-Syncope: A state of experiencing lightheadedness, dizziness, weakness, visual changes (such as spots, tunnel vision, or loss of vision), auditory changes (ringing, buzzing, or muffled hearing), or feeling hot or cold without loss of consciousness

Syncope: Sudden temporary loss of consciousness associated with a loss of postural tone and with spontaneous recovery that does not require electrical or chemical cardioversion

5. ABBREVIATIONS

AUC = Appropriate Use Criteria
ECG = electrocardiogram
PAC = premature atrial contraction
PVC = premature ventricular contraction
TTE = transthoracic echocardiogram

6. RESULTS

The final ratings for pediatric echocardiography are listed by indication in Tables 1 to 9. The final score for each indication reflects the median score of the 15 Rating Panel members and has been labeled according to the categories of Appropriate (median 7 to 9), May Be Appropriate (median 4 to 6), or Rarely Appropriate (median 1 to 3). In the tables, the final score for each indication is shown in parentheses with the ratings. Out of 113 total indications, 53 were considered Appropriate

(47%), 28 were considered May Be Appropriate (25%), and 32 were considered Rarely Appropriate (28%). To see the indications listed by Appropriate Use rating, see the Online Appendix. The Discussion section highlights further trends in scoring.

Figures 3, 4, 5, and 6 illustrate flow diagrams based on common patient symptoms (chest pain, syncope, palpitations and arrhythmias, and murmur) that the clinician can use to narrow down patient information until the AUC score is attained. Likewise, Figure 7 (a-d) in the Online Appendix shows flow diagrams grouped by clinical presentation, such as family history and test findings.

7. TRANSTHORACIC ECHOCARDIOGRAPHY IN OUTPATIENT PEDIATRIC CARDIOLOGY: APPROPRIATE USE CRITERIA (BY INDICATION)

TABLE 1 Palpitations and Arrhythmias

Indication		Appropriate Use Rating
	Palpitations	
1.	Palpitations with no other symptoms or signs of cardiovascular disease, a benign family history, and no recent ECG	**R (2)**
2.	Palpitations with no other symptoms or signs of cardiovascular disease, a benign family history, and a normal ECG	**R (1)**
3.	Palpitations with abnormal ECG	**M (6)**
4.	Palpitations with family history of a channelopathy	**R (3)**
5.	Palpitations in a patient with known channelopathy	**M (4)**
6.	Palpitations with family history at a young age (before the age of 50 years) of sudden cardiac arrest or death and/or pacemaker or implantable defibrillator placement	**A (7)**
7.	Palpitations with family history of cardiomyopathy	**A (9)**
8.	Palpitations in a patient with known cardiomyopathy	**A (9)**
	ECG Findings	
9.	PACs in the prenatal or neonatal period	**R (3)**
10.	PACs after the neonatal period	**R (3)**
11.	Supraventricular tachycardia	**A (7)**
12.	PVCs in the prenatal or neonatal period	**M (6)**
13.	PVCs after the neonatal period	**M (6)**
14.	Ventricular tachycardia	**A (9)**
15.	Sinus bradycardia	**R (2)**
16.	Sinus arrhythmia	**R (1)**

The number in parentheses next to the rating reflects the median score for that indication.

Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = electrocardiogram; PACs = premature atrial contractions; PVCs = premature ventricular contractions.

TABLE 2 Syncope

Indication		Appropriate Use Rating
17.	Syncope with or without palpitations and with no recent ECG	**R (3)**
18.	Syncope with no other symptoms or signs of cardiovascular disease, a benign family history, and a normal ECG	**R (2)**
19.	Syncope with abnormal ECG	**A (7)**
20.	Syncope with family history of channelopathy	**M (5)**
21.	Syncope with family history at a young age (before the age of 50 years) of sudden cardiac arrest or death and/or pacemaker or implantable defibrillator placement	**A (9)**
22.	Syncope with family history of cardiomyopathy	**A (9)**
23.	Probable neurocardiogenic (vasovagal) syncope	**R (2)**
24.	Unexplained pre-syncope	**M (4)**
25.	Exertional syncope	**A (9)**
26.	Unexplained post-exertional syncope	**A (7)**
27.	Syncope or pre-syncope with a known non-cardiovascular cause	**R (2)**

The number in parenthesis next to the rating reflects the median score for that indication.

Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = Electrocardiogram.

TABLE 3 Chest Pain

Indication		Appropriate Use Rating
28.	Chest pain with no other symptoms or signs of cardiovascular disease, a benign family history, and a normal ECG	**R** (2)
29.	Chest pain with other symptoms or signs of cardiovascular disease, a benign family history, and a normal ECG	**M** (6)
30.	Exertional chest pain	**A** (8)
31.	Non-exertional chest pain with no recent ECG	**R** (3)
32.	Non-exertional chest pain with normal ECG	**R** (1)
33.	Non-exertional chest pain with abnormal ECG	**A** (7)
34.	Chest pain with family history of sudden unexplained death or cardiomyopathy	**A** (8)
35.	Chest pain with family history of premature coronary artery disease	**M** (4)
36.	Chest pain with recent onset of fever	**M** (6)
37.	Reproducible chest pain with palpation or deep inspiration	**R** (1)
38.	Chest pain with recent illicit drug use	**M** (6)

The number in parenthesis next to the rating reflects the median score for that indication.
Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = Electrocardiogram.

TABLE 4 Murmur

Indication		Appropriate Use Rating
39.	Presumptively innocent murmur with no symptoms, signs, or findings of cardiovascular disease and a benign family history	**R** (1)
40.	Presumptively innocent murmur with signs, symptoms, or findings of cardiovascular disease	**A** (7)
41.	Pathologic murmur	**A** (9)

The number in parenthesis next to the rating reflects the median score for that indication.
Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = Electrocardiogram.

TABLE 5 Other Symptoms and Signs

Indication		Appropriate Use Rating
42.	Symptoms and/or signs suggestive of congestive heart failure, including but not limited to respiratory distress, poor peripheral pulses, feeding difficulty, decreased urine output, edema, and/or hepatomegaly	**A** (9)
43.	Chest wall deformities and scoliosis pre-operatively	**M** (6)
44.	Fatigue with no other signs and symptoms of cardiovascular disease, a normal ECG, and a benign family history	**R** (3)
45.	Signs and symptoms of endocarditis in the absence of blood culture data or a negative blood culture	**A** (8)
46.	Unexplained fever without other evidence for cardiovascular or systemic involvement	**M** (5)
47.	Central cyanosis	**A** (8)
48.	Isolated acrocyanosis	**R** (1)

The number in parenthesis next to the rating reflects the median score for that indication.
Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = Electrocardiogram.

TABLE 6 Prior Test Results

Indication		Appropriate Use Rating
49.	Known channelopathy	M (4)
50.	Genotype positive for cardiomyopathy	A (9)
51.	Abnormal chest X-ray findings suggestive of cardiovascular disease	A (9)
52.	Abnormal ECG without symptoms	A (7)
53.	Desaturation based on pulse oximetry	A (9)
54.	Previously normal echocardiogram with no change in cardiovascular status or family history	R (1)
55.	Previously normal echocardiogram with a change in cardiovascular status and/or a new family history suggestive of heritable heart disease	A (7)
56.	Elevated anti-streptolysin O titers without suspicion for rheumatic fever	R (3)
57.	Chromosomal abnormality known to be associated with cardiovascular disease	A (9)
58.	Chromosomal abnormality with undefined risk for cardiovascular disease	M (5)
59.	Positive blood cultures suggestive of infective endocarditis	A (9)
60.	Abnormal cardiac biomarkers	A (9)
61.	Abnormal barium swallow or bronchoscopy suggesting vascular ring	A (7)

The number in parenthesis next to the rating reflects the median score for that indication.
Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = Electrocardiogram.

TABLE 7 Systemic Disorders

Indication		Appropriate Use Rating
62.	Cancer without chemotherapy	M (5)
63.	Prior to or during chemotherapy in cancer	A (8)
64.	Sickle cell disease and other hemoglobinopathies	A (8)
65.	Connective tissue disorder such as Marfan, Loeys Dietz, and other aortopathy syndromes	A (9)
66.	Suspected connective tissue disorder	A (7)
67.	Clinically suspected syndrome or extracardiac congenital anomaly known to be associated with congenital heart disease	A (9)
68.	Human immunodeficiency virus infection	A (8)
69.	Suspected or confirmed Kawasaki disease	A (9)
70.	Suspected or confirmed Takayasu arteritis	A (9)
71.	Suspected or confirmed acute rheumatic fever	A (9)
72.	Systemic lupus erythematosis and autoimmune disorders	A (7)
73.	Muscular dystrophy	A (9)
74.	Systemic hypertension	A (9)
75.	Renal failure	A (7)
76.	Obesity without other cardiovascular risk factors	R (2)
77.	Obesity with obstructive sleep apnea	M (6)
78.	Obesity with other cardiovascular risk factors	M (6)
79.	Diabetes mellitus	R (3)
80.	Lipid disorders	R (3)
81.	Stroke	A (8)
82.	Seizures, other neurologic disorders, or psychiatric disorders	R (2)
83.	Suspected pulmonary hypertension	A (9)
84.	Gastrointestinal disorders, not otherwise specified	R (2)
85.	Hepatic disorders	M (4)
86.	Failure to thrive	M (5)
87.	Storage diseases, mitochondrial and metabolic disorders	A (8)
88.	Abnormalities of visceral or cardiac situs	A (9)

The number in parenthesis next to the rating reflects the median score for that indication.
Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

TABLE 8 Family History of Cardiovascular Disease in Patients Without Signs or Symptoms and Without Confirmed Cardiac Diagnosis

Indication		Appropriate Use Rating
89.	Unexplained sudden death before the age of 50 years	**M** (6)
90.	Premature coronary artery disease before the age of 50 years	**R** (2)
91.	Channelopathy	**R** (3)
92.	Hypertrophic cardiomyopathy	**A** (9)
93.	Non-ischemic dilated cardiomyopathy	**A** (9)
94.	Other cardiomyopathies	**A** (8)
95.	Unspecified cardiovascular disease	**R** (3)
96.	Disease at high risk for cardiovascular involvement, including but not limited to diabetes, systemic hypertension, obesity, stroke, and peripheral vascular disease	**R** (2)
97.	Genetic disorder at high risk for cardiovascular involvement	**A** (7)
98.	Marfan or Loeys Dietz syndrome	**A** (7)
99.	Connective tissue disorder other than Marfan or Loeys Dietz syndrome	**M** (6)
100.	Congenital left-sided heart lesion, including but not limited to mitral stenosis, left ventricular outflow tract obstruction, bicuspid aortic valve, aortic coarctation, and/or hypoplastic left heart syndrome	**M** (6)
101.	Congenital heart disease other than the congenital left-sided heart lesions	**M** (5)
102.	Idiopathic pulmonary arterial hypertension	**M** (5)
103.	Heritable pulmonary arterial hypertension	**A** (8)
104.	Pulmonary arterial hypertension other than idiopathic and heritable	**R** (3)
105.	Consanguinity	**R** (3)

The number in parenthesis next to the rating reflects the median score for that indication.
Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

TABLE 9 Outpatient Neonates Without Post-Natal Cardiology Evaluation

Indication		Appropriate Use Rating
106.	Suspected cardiovascular abnormality on fetal echocardiogram	**A** (9)
107.	Isolated echogenic focus on fetal ultrasound	**R** (2)
108.	Maternal infection during pregnancy or delivery with potential fetal/neonatal cardiac sequelae	**A** (7)
109.	Maternal diabetes with no prior fetal echocardiogram	**M** (6)
110.	Maternal diabetes with a normal fetal echocardiogram	**M** (4)
111.	Maternal phenylketonuria	**A** (7)
112.	Maternal autoimmune disorder	**M** (5)
113.	Maternal teratogen exposure	**M** (6)

The number in parenthesis next to the rating reflects the median score for that indication.
Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

8. FLOW DIAGRAMS FOR COMMON PATIENT SYMPTOMS

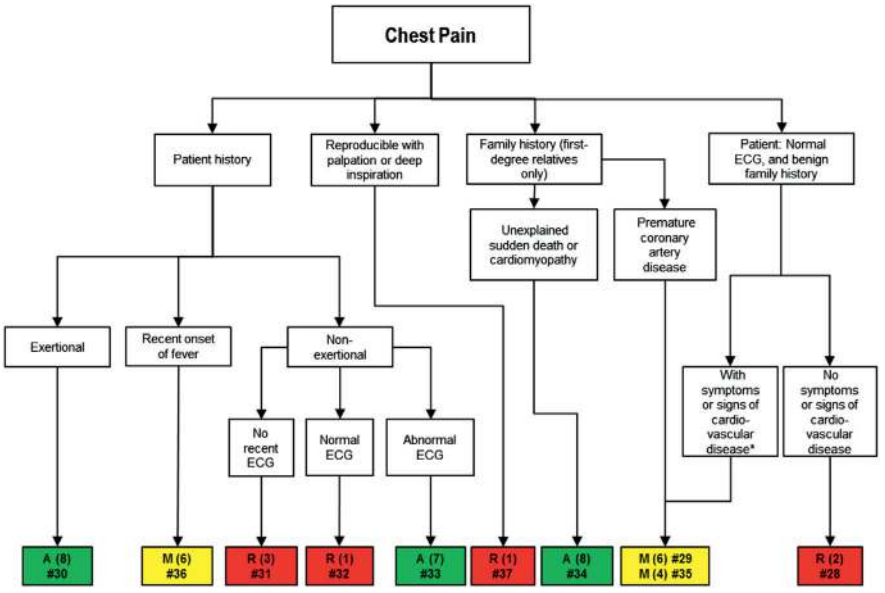

FIGURE 3 **Chest Pain**

Each indication is preceded with a number sign. The rating of A, M, or R is then followed by the median score in parenthesis for that particular indication. *See Discussion section. Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = Electrocardiogram.

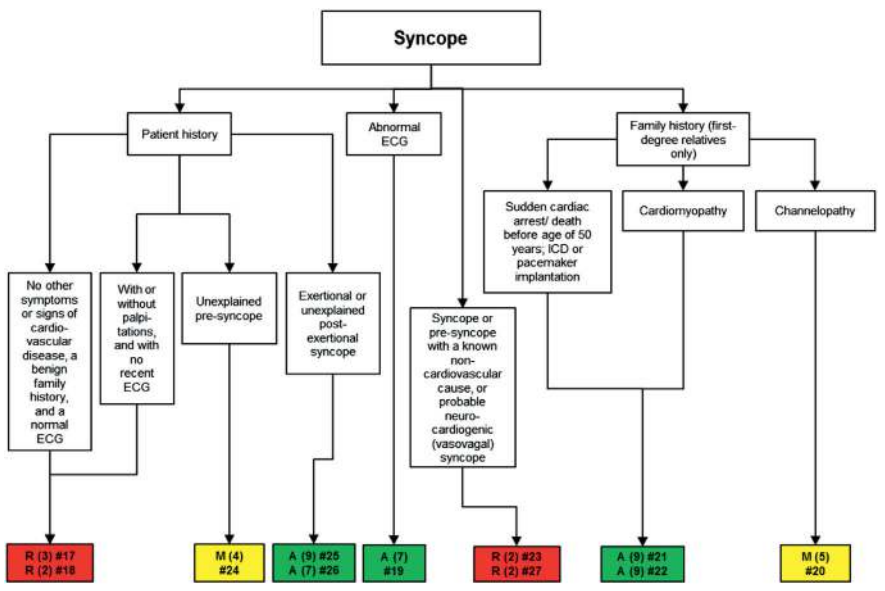

FIGURE 4 **Syncope**

Each indication is preceded with a number sign. The rating of A, M, or R is then followed by the median score in parenthesis for that particular indication. Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = Electrocardiogram; ICD = Implantable Cardioverter Defibrillator.

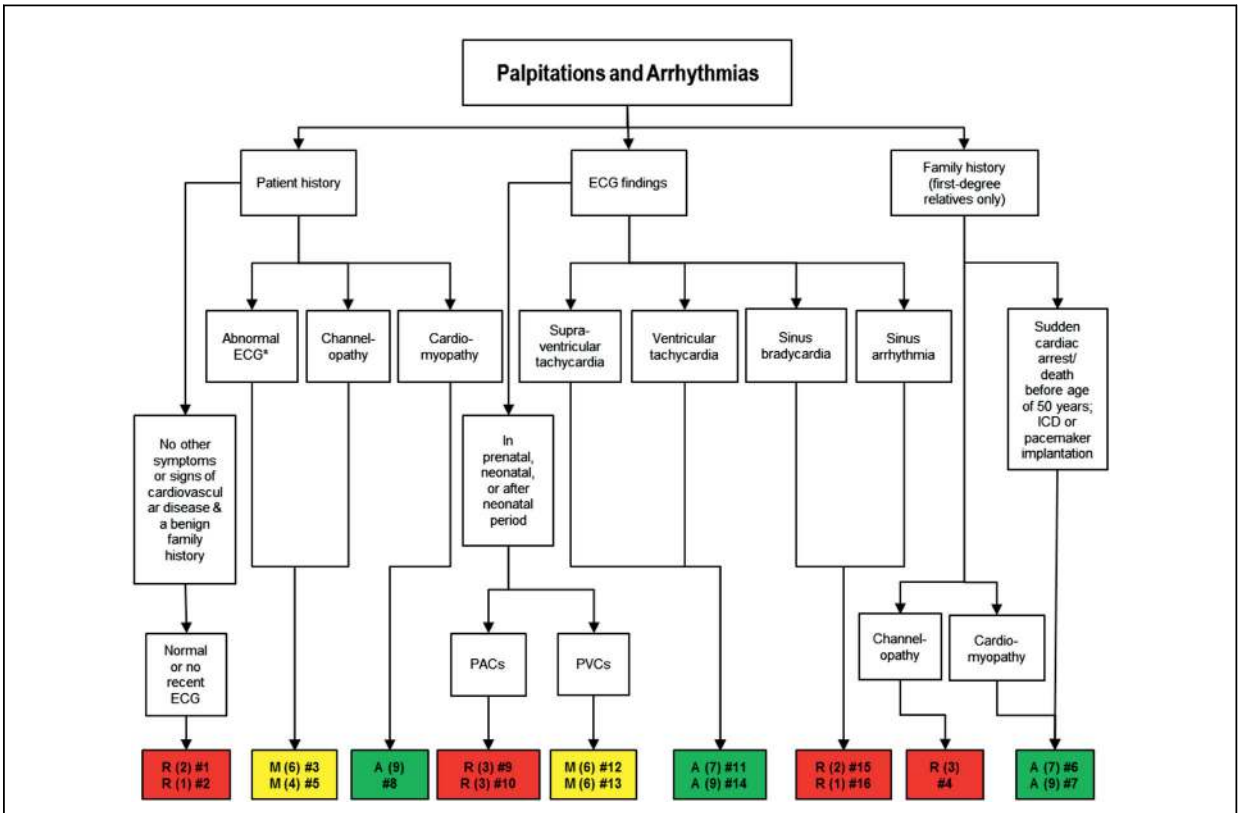

FIGURE 5 **Palpitations and Arrhythmias**

Each indication is preceded with a number sign. The rating of A, M, or R is then followed by the median score in parenthesis for that particular indication. *See Discussion section. Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate; ECG = Electrocardiogram; ICD = Implantable Cardioverter Defibrillator; PACs = Premature Atrial Contractions; PVCs = Premature Ventricular Contractions.

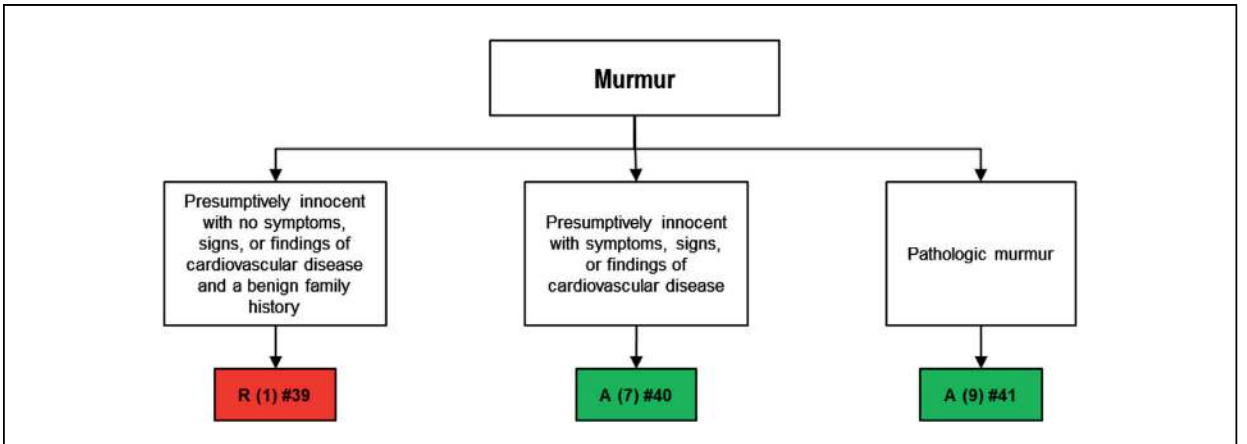

FIGURE 6 **Murmur**

Each indication is preceded with a number sign. The rating of A, M, or R is then followed by the median score in parenthesis for that particular indication. Abbreviations: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate.

9. DISCUSSION

This is the first report by the American College of Cardiology addressing appropriate use in the field of pediatric cardiology. Although the use of AUC for various areas of cardiovascular imaging in adult cardiology has been established since 2005, there has not been a tool to guide practice in pediatric cardiology (1,18). Given the high level of utilization of echocardiography in the outpatient setting, this topic was chosen as the subject for the first pediatric AUC, and was intentionally restricted to initial, outpatient, and transthoracic echocardiographic evaluation. Of the various diagnostic modalities, echocardiography remains the most readily available, non-invasive and highly diagnostic tool for assessing cardiac structure, function and hemodynamics in those with suspected cardiac disease. This report will help us establish the infrastructure precedent for expanding AUC for echocardiography in pediatric patients as well as AUC for other diagnostic modalities and procedures used in this field.

It is important to note the differences between clinical practice guidelines and AUC (19). The American College of Cardiology guidelines have been developed by leaders in the field of cardiovascular medicine using evidence-based documents and expert opinion and are in general quite broad. Even though AUC are evidence based, they are created around possible clinical scenarios that are encountered in everyday practice rather than starting with options based on current evidence. Echocardiography is the most common imaging modality used in cardiology, but there is evidence that it may not be a cost-effective or high-yield diagnostic test for some indications included in this document (20–29). The AUC address a reasonable role of echocardiography. Each individual patient is unique and the possible use of echocardiography deserves to be considered in full clinical context. It is noteworthy that there are no recent practice guidelines for indications of echocardiography in pediatric patients and this report may become a clinically useful guide for practitioners (30).

Assumptions and Definitions

Some of the assumptions used while writing this report are important to emphasize. It is assumed that a thorough history and physical examination has been performed by a qualified clinician and that use of other more diagnostic tests has been considered prior to ordering an echocardiogram. It is also assumed that the echocardiogram is performed and interpreted by qualified individuals. Although the AUC ratings listed in this report provide general guidance for when transthoracic echocardiography may be useful in a specific patient population, the role of clinical judgment in ordering the test for an individual patient should not be undermined because there may be reasons other than those listed in this document that preclude application of the AUC. The AUC may also not be applicable if another diagnostic modality has already proven the diagnosis for which an echocardiogram was intended. For example, if a vascular ring is confirmed by cardiac magnetic resonance imaging (MRI), then an echocardiogram will not provide any additional critical information. Even though this indication is rated as Appropriate in this document, clinical judgment in such scenarios will definitely supersede the AUC rating.

The definitions provided in this document were finalized by the writing group after it had given due consideration to the current literature and views provided by the external reviewers and the rating panel. The users of this document should be well versed in these assumptions and definitions prior to implementing the AUC.

Indications and Ratings

The indications presented in this report were finalized after incorporating the suggestions by the external reviewers, and the members of the rating panel rated the indications independently. The median score for each indication became the final rating. In general, the indications rated as Appropriate included evaluation of new cardiac symptoms or clinical scenarios known to be associated with congenital or acquired heart disease in the pediatric population. The indications ranked as Rarely Appropriate clustered around broad systemic diseases and family history of conditions that are generally not known to be associated with structural or functional abnormalities detectable by echocardiography. Scenarios that were rated as May Be Appropriate, in general, involved uncertainty or required additional clinical information to better define the appropriateness of the test.

In the pediatric population, chest pain, syncope and murmur are 3 common reasons for referral of an echocardiogram in the outpatient setting. For this reason, tables dedicated to each of these conditions with various clinical scenarios were included in the current report. Although a murmur is one of the most common indications for obtaining an echocardiogram in the pediatric population, it is well known that a large number of patients are referred with an innocent murmur that does not require evaluation with an echocardiogram. The current document presumes that the clinician has made every effort to determine whether the murmur is innocent or not prior to considering the use of an echocardiogram (21,31). Echocardiographic screening for presumably or clearly innocent murmur has been rated as Rarely Appropriate in this document. This rating is supported by prior publications reporting that examination

by a pediatric cardiologist is quite accurate in distinguishing between innocent and pathologic murmurs (21,32,33). Pathologic murmurs (including those that are not clearly innocent after evaluation), along with presumably innocent murmurs with other signs, symptoms or findings of cardiovascular disease, were found to be Appropriate for an echocardiogram, since these situations suggest the possibility of a cardiovascular abnormality as their underlying cause. Of course, the ability to make a final diagnosis of innocent murmur after an echocardiogram for patients meeting either of these appropriate indications does not imply that the rationale for using an echocardiogram to rule out a cardiovascular abnormality was not appropriate.

Chest pain and syncope are 2 other common presentations in the pediatric age group. The etiology for these is generally benign and echocardiography has been shown to be low-yield, unlike in adult patients (25-29). For this reason, the indications and their ratings related to chest pain in this document are very different from those in the adult AUC. Syncope with no other symptoms or signs of cardiac disease has been rated as Appropriate in the adult AUC (3), but rated as Rarely Appropriate for pediatric patients (Indication #18), albeit with additional qualifiers of a benign family history and a normal ECG. The reasonableness of using an echocardiogram as a primary screen versus using an echocardiographic assessment only after a pediatric cardiology consultation for evaluation of a murmur, chest pain, syncope, or any other indication, depends on many factors and needs to be given due consideration on a case-by-case basis.

Given the complexity of clinical presentations, it is likely that there will be some overlap between the indications in this document. Several indications share identical accompanying findings, signs or symptoms, but differ as to the primary patient complaint. As such, the ratings were driven in these scenarios by the prevalence of the primary presentation and the likelihood of it being cardiac-related. For example, non-exertional chest pain with abnormal ECG (A [7] #33) and palpitations with abnormal ECG (M [6] #3) have been rated slightly differently by the panel even though they both relate to an abnormal ECG. Given the broad definition of an abnormal ECG described in this paper, it is not unexpected that the ratings for palpitations that may accompany more benign ECG findings were a bit lower. Similarly, ratings for indications related to symptoms or signs of cardiovascular disease changed slightly depending on other presenting factors described in the scenarios (#29 - chest pain and signs and symptoms - M [6], #40 - presumptively innocent murmur with signs and symptoms - A [7], and #42 - congestive heart failure with signs and symptoms - A [9]). In applying the AUC, if more than one indication listed in this document could be applied, clinicians need to use their judgment in picking the scenario that most closely fits the individual patient.

Comparison With the Adult Cardiology AUC

The current adult cardiology AUC for echocardiography includes initial and follow-up evaluation in the inpatient and outpatient setting using transthoracic, transesophageal, and stress echocardiography (3). In contrast, this current document is limited to initial outpatient transthoracic echocardiography. The initial adult cardiology AUC for transthoracic and transesophageal echocardiography were published in 2007 (1). After practical application of these AUC, a revised version was published in 2011. This revised version which is currently in use included many more indications and now provides a more complete range of clinical scenarios (3). Studies comparing the application of these two AUC in adult cardiology clinical practice have demonstrated significant improvement in the ability to classify the various clinical scenarios using the revised version (34,35). This current report for pediatric patients has certainly benefited from the maturational process and experience gained by the AUC in adults (36). Implementation studies in the pediatric population will help us to identify any missing or ambiguous indications that could be addressed in future revisions.

In comparing the ratings of various indications in the current document with those in the adult AUC, there were many indications that were rated similarly (3). For example, isolated PACs and sinus bradycardia were rated as Rarely Appropriate indications in both documents, while SVT, VT, pathologic murmurs, initial evaluation of suspected pulmonary hypertension, systemic hypertension, and suspected endocarditis were rated as Appropriate in both. However, there were some striking differences in the ratings of some indications such as syncope and chest pain due to variations in the most common underlying causes in pediatric versus adult patients.

There are also differences in format. In this report, prior test results for which a subsequent echocardiogram may be ordered are listed separately in **Table 7** with individual ratings; but in the adult AUC report they are lumped together under one indication ('Prior testing that is concerning for heart disease or structural abnormality including but not limited to chest X-ray, baseline scout images for stress echocardiogram, ECG, or cardiac biomarkers' (3)), and are rated as Appropriate. The current report also includes a broad list of systemic disorders (**Table 7**) and scenarios related to family history (**Table 8**) that are not covered in the adult AUC report.

Limitations

The current AUC report is not fully inclusive of all possible clinical scenarios and does not include indications for follow-up or inpatient echocardiography. In addition, it is restricted to the first use of transthoracic echocardiography and does not include indications for fetal or transesophageal echocardiography. Some of the indications have been purposefully kept broad either because it was beyond the scope of this report to list each and every possible scenario, or because they were considered fairly uncommon in routine practice. Examples of these broad indications include use of illicit drugs, chest wall deformities, chromosomal abnormalities with undefined risk of cardiovascular disease, suspected connective tissue disorders, neurologic or psychiatric disorders, gastrointestinal and hepatic disorders and several indications related to family history.

Though we have attempted to cover a broad range of clinical scenarios in this document, we realize that by no means is this list exhaustive. Given the experience with the adult cardiology AUC, it would not be surprising for us to have missed some common indications. We also recognize that this document does not address the appropriateness, or lack thereof, of *not* performing echocardiograms. This underutilization of echocardiography could result from a lack of availability (equipment, sonographer or interpreting cardiologist), denial by payers or lack of insurance, alteration of the management plan following expert consultation, or lack of sound clinical judgment.

Use of AUC to Improve Care

We foresee several important applications of these AUC in the pediatric population. The most obvious use of this document will be to support the clinical decision making of a provider as to the appropriateness of care that they deliver to an individual pediatric patient. It is important to keep in mind that an Appropriate rating in this document should not be misinterpreted as a recommendation to perform an echocardiogram in every patient that meets the indications described herein. Rather, it should be interpreted as something that would be reasonable to do if the information obtained will help in caring for the patient. On the other hand, a Rarely Appropriate rating should not be misinterpreted as one in which an echocardiogram should absolutely not be performed. This category was termed as "Inappropriate" in the initial AUC documents, but due to significant misperceptions, the AUC Task Force changed the terminology from Inappropriate to Rarely Appropriate to emphasize that individual patient circumstances do exist where an echocardiogram would be reasonable to perform. Instead of precluding an echocardiogram in an individual patient, the importance of this category lies more in recognition of a pattern of ordering where a significantly higher number of echocardiograms are requested for the Rarely Appropriate indications by an individual provider compared with their peers. Indications rated as May Be Appropriate could be considered reasonable for obtaining an echocardiogram, particularly if the physician taking care of the patient determines that it would provide helpful information. These two categories should not be considered as the basis for denying insurance coverage or reimbursement for the procedure, as individual decision making is required to determine what is best for each patient. Nevertheless, it is important for the clinicians taking care of pediatric patients to recognize that healthcare facilities, accreditation bodies, or payers for these tests may use this document to ensure quality care and appropriate use of financial resources.

Ideally, this document will also serve as an educational and quality improvement tool for addressing the high number of Rarely Appropriate referrals for echocardiograms by individual providers. Experience with the adult echocardiography AUC has shown that physician engagement in quality improvement programs, and tracking and benchmarking of test ordering behavior, has reduced the percentage of inappropriate testing (37). Further, lab accreditation organizations such as the Intersocietal Accreditation Commission (IAC) require attention to AUC as part of their quality improvement process (38). Finally, the AUC may provide the basis for evaluation of the impact of using AUC, especially as accessed by online tools, instead of more onerous and less physician-driven administrative controls on imaging use.

10. CONCLUSIONS

This AUC report provides a helpful guide to clinicians in determining the reasonable role of initial transthoracic echocardiography in the evaluation of pediatric patients in an outpatient setting. It also lays the foundation for developing AUC in other areas of pediatric cardiology. Furthermore, it can form the basis of designing educational and quality improvement projects to improve quality of care. Future studies to evaluate implementation of these AUC in clinical care will be helpful not only in identifying any deficiencies in the current document, but also in defining ordering patterns for individual practitioners and understanding variations in delivery of care. We expect that there will be a continued need for refinement of these AUC based on any gaps identified through this initial effort, changes in evidence-based medicine, and availability of technical and financial resources.

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APPENDIX A. APPROPRIATE USE CRITERIA FOR INITIAL TRANSTHORACIC ECHOCARDIOGRAPHY IN OUTPATIENT PEDIATRIC CARDIOLOGY: PARTICIPANTS

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APPENDIX B. RELATIONSHIPS WITH INDUSTRY (RWI) AND OTHER ENTITIES

The College and its partnering organizations rigorously avoid any actual, perceived, or potential conflicts of interest that might arise as a result of an outside relationship or personal interest of a member of the rating panel. Specifically, all panelists are asked to provide disclosure statements of all relationships that might be perceived as real or potential conflicts of interest. These statements were reviewed by the Appropriate Use Criteria Task Force, discussed with all members of the rating panel at the face-to-face meeting, and updated and reviewed as necessary. A table of relevant disclosures by the rating panel and oversight working group members can be found below. In addition, to ensure complete transparency, a full list of disclosure information—including relationships not pertinent to this document—is available in the Online Appendix.

Appropriate Use Criteria for Initial Transthoracic Echocardiography in Outpatient Pediatric Cardiology: Members of the Writing Group, Rating Panel, Indication Reviewers, and AUC Task Force—Relationships with Industry and Other Entities (Relevant)

Note: A standard exemption to the ACC RWI policy is extended to Appropriate Use Criteria writing groups, since they do not make recommendations but rather prepare background materials and typical clinical scenarios/indications that are rated independently by a separate panel of experts.

APPENDIX B. CONTINUED

Participant	Consultant	Speakers Bureau	Ownership/ Partnership/ Principal	Personal Research	Institutional, Organizational, or Other Financial Benefit	Expert Witness
Writing Group						
Robert M. Campbell	None	None	None	None	None	None
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Benjamin W. Eidem	None	None	None	None	None	None
Wyman W. Lai	None	None	None	None	None	None
Leo Lopez	None	None	None	None	None	None
Ritu Sachdeva	None	None	None	None	None	None
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Jeffrey R. Boris	None	None	None	None	None	None
Bryan Cannon	None	None	None	None	None	None
Gregory J. Ensing	None	None	None	None	None	None
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B. Kelly Han	None	None	None	• Siemens Medical Systems	None	None
Shabnam Jain	None	None	None	None	None	None
Mark B. Lewin	None	None	None	None	None	None
Richard H. Lockwood	None	None	None	None	• Excellus BCBS*	None
G. Paul Matherne	None	None	None	None	None	None
David Nykanen	None	None	None	None	None	None
Catherine L. Webb	None	None	None	None	None	None
Robert Wiskind	None	None	None	None	None	None
Reviewers						
Meryl S. Cohen	None	None	None	None	None	None
Mario J. Garcia	None	None	None	None	None	None
Michael Gewitz	None	None	None	None	None	None
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Alexander J. Javois	None	None	None	None	None	None
Walter H. Johnson	None	None	None	None	None	None
Ann Kavanaugh-McHugh	None	None	None	None	None	None
Hyun-Sook Helen Ko	None	None	None	None	None	None
Seema Mital	None	None	None	None	None	None
Andrew J. Powell	None	None	None	None	None	None
J. Carter Ralphe	None	None	None	None	None	None
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Julia Steinberger	None	None	None	None	None	None

(continued on the next page)

APPENDIX B. CONTINUED

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This table represents the relevant relationships with industry and other entities that were disclosed by participants at the time of participation. It does not necessarily reflect relationships with industry at the time of publication. A person is deemed to have a significant interest in a business if the interest represents ownership of 5% or more of the voting stock or share of the business entity, or ownership of $10,000 or more of the fair market value of the business entity; or if funds received by the person from the business entity exceed 5% of the person's gross income for the previous year. A relationship is considered to be modest if it is less than significant under the preceding definition. Relationships in this table are modest unless otherwise noted. Names are listed in alphabetical order within each category of review. Participation does not imply endorsement of this document.
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