Metric #: 001
Effective: 4.15.2016

Complete Aortic Evaluation for Adults with Repaired COA	
Measure Description: Proportion of adults, > 18 years of age, with repaired coarctation of the aorta (rCOA) who have undergone a complete aortic evaluation.	
Numerator	Number of patients who have had a complete aortic evaluation[1] ordered or performed during the measurement period, in the 3 years prior to the clinic visit[2], or after turning 18 years old.
Denominator	Number of patients, > 18 years old, who had a rCOA[3] and an outpatient cardiology clinic visit during the measurement period.
Denominator Exclusions	• Documentation of gadolinium AND dye allergy • Patient refusal • Pregnant women
Denominator Exceptions	None
Definitions/Notes	1. **Complete aortic evaluation** is defined as having undergone at least one of the following: thoracic CMR, CT scan, or angiography 2. **Clinic Visit:** If the patient has had multiple visits during the measurement period, use the most recent visit (i.e. last visit in the measurement period). 3. **Repaired coarctation of the aorta** can either be surgical or catheter-based.
Measurement Period	Quarterly
Sources of Data	Retrospective medical or electronic record review
Attribution	Pediatric Cardiologists, Internal Medicine Cardiologists, ACHD Cardiologists (Clinician, practice or institution)
Care Setting	Outpatient

Rationale

Adults with rCOA may develop aortic aneurysm/pseudoaneurysm proximal, distal, or at the coarctation repair site and may be asymptomatic until aortic dissection or rupture. CMR/CT is superior to physical examination and echocardiography for surveying the entire thoracic aorta for complicated vascular anatomy and future comparison

Clinical Recommendation(s)

ACC/AHA Guidelines:
Class 1

Every patient with coarctation (repaired or not) should have at least 1 cardiovascular MRI or CT scan for complete evaluation of the thoracic aorta and intracranial vessels. (Level of Evidence: B)

Warnes C, Williams, R, Bashore T, et al. ACC/AHA guidelines for the management of adults with congenital heart disease. JACC 2008:52:e143-263.

Other guidelines:

All patients should have a periodic MRI or angiogram following repair of the aortic coarctation to document the post-repair anatomy and mechanical complications (restenosis or aneurysm formation)
Grade: Consensus

Therrien J, Gatzoulis M, Graham T, Bink-Boelkens M, Connelly M, Niwa K, Mulder B, Pyeritz R, Perloff J, Somerville J, Webb GD. Canadian Cardiovascular Society Consensus Conference 2001 update: Recommendations for the Management of Adults with Congenital Heart Disease--Part II. Can J Cardiol. 2001 Oct;17(10):1029-50.

Challenges to Implementation

Some institutions without electronic medical records and proper coding of CHD diagnoses may find difficulty identifying rCOA patients from their cardiology outpatient charts.

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Metric #: 002
Effective: 9.15.2016

Appropriate counseling among pediatric cardiac patients with BMI greater than 85 %	
Measure Description: Proportion of patients, 3-18 years old, with a BMI greater than 85% who received appropriate counseling.	
Numerator	Number of patients who received appropriate counseling[1] for elevated BMI[2] during the measurement period or in the 12 months prior to the outpatient visit[4].
Denominator	Number of patients, 3-18 years old, with a BMI[2] greater than the 85% percentile[3] (within the past 12 months) and at least one pediatric cardiology outpatient visit during the measurement period.
Denominator Exclusions	• Patients in whom an accurate height and weight cannot be obtained for medical reasons • Patients who are actively enrolled/engaged in obesity program
Denominator Exceptions	None
Definitions / Notes	**1. Appropriate counseling is defined as:** BMI ≥ 85th percentile (a) Patient education and self-help materials for weight reduction via diet and exercise **OR** (b) Referral to a registered dietician **2. Measurement of BMI should be done as follows:** Body mass index (BMI): a measure derived from the division of the square of the height in meters into the weight in kilograms. **3. BMI percentile should be calculated as follows:** A patient's BMI percentile is determined from plotting the BMI on CDC growth charts 4. **Clinic Visit:** If the patient has had multiple visits during the measurement period, use the most recent visit (i.e. last visit in the measurement period).
Measurement Period	Quarterly
Sources of Data	Retrospective medical record review, electronic medical record
Attribution	Clinician, practice or institution
Care Setting	Outpatient
Rationale	
Obesity has become one of the most important public health problems in the United States. One third of the children are overweight (BMI >= 85th percentile). BMI is the single most important predictor of cardiovascular morbidity. Monitoring	

Clinical Recommendation(s)
ACC/AHA Guidelines: None available Other guidelines/references: None available
Challenges to Implementation
Some clinicians may not have electronic systems to support BMI documentation. Documentation of BMI may be viewed as time consuming, and not a sub-specialty problem. This problem is exacerbated by the perception that family and patients may not comply with recommendations and because the impact of intervention is delayed with no perceived immediate reward.
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Metric #: 003
Effective: 10.9.2015

BMI measurement in ambulatory pediatric cardiac patients	
Measure Description: Proportion of patients, ≥ 3 years old, who had their BMI measured and BMI percentile calculated.	
Numerator	Number of patients who had documentation of BMI[1] measurement and percentile[2] calculated during the measurement period or in the 12 months prior to the outpatient visit[3].
Denominator	Number of patients, ≥ 3 years old, with at least one pediatric outpatient visit during the measurement period.
Denominator Exclusions	• Patients in whom an accurate height and weight cannot be obtained for medical reasons.
Denominator Exceptions	None
Definitions / Notes	**1. Measurement of BMI should be done as follows:** Body mass index (BMI): a measure derived from the division of the square of the height in meters into the weight in kilograms **2. BMI percentile should be calculated as follows:** A patient's BMI percentile is determined from plotting the BMI on CDC growth charts 3. **Clinic Visit:** If the patient has had multiple visits during the measurement period, use the most recent visit (i.e. last visit in the measurement period).
Measurement Period	Quarterly
Sources of Data	Retrospective medical record review, electronic medical record
Attribution	Clinician, practice or institution
Care Setting	Outpatient
Rationale	
Obesity has become one of the most important public health problems in the United States. One third of the children are overweight (BMI >= 85th percentile). BMI is the single most important predictor of cardiovascular morbidity.	
Clinical Recommendation(s)	
ACC/AHA Guidelines: None available **Other guidelines/references:** Pediatric Cardiovascular Risk Reduction Initiative by NHLBI http://www.nhlbi.nih.gov/guidelines/cvd_ped/index.htm	

Challenges to Implementation
Some clinicians may not have electronic systems to support BMI documentation. Documentation of BMI may be viewed as time consuming, and not a sub-specialty problem. This problem is exacerbated by the perception that family and patients may not comply with recommendations and because the impact of intervention is delayed with no perceived immediate reward.
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Metric #: 004
Effective: 12.3.2015

Critical Results Reporting in Pediatric Echocardiography		
Measure Description: Median time between study completion and referring provider notification for all pediatric exams with critical results AND Proportion of critical results reported within recommended timeframes. **Note:** *This metric includes <u>three</u> parts including (1) median time reporting critical test results (2) proportion of results communicated with 60 mins and (3) proportion of results communicated within 120 mins. The denominator should be the same number for ALL three parts.*		
Part I	**Median**	Median time[1] between study completion[2] and referring provider (or member of care team) notification for all pediatric exams with critical test[4] results during the measurement period.
	Denominator	Total number of pediatric echocardiograms for which critical results[4] were reported and communicated[3] during the measurement period.
Part II	**Numerator**	Number of pediatric echocardiograms for which critical results were reported and communicated in less than <u>60 mins</u>
	Denominator	Total number of pediatric echocardiograms for which critical results were reported and communicated during the measurement period.
Part III	**Numerator**	Number of pediatric echocardiograms for which critical results were reported in less than <u>120 mins</u>
	Denominator	Total number of pediatric echocardiograms for which critical results were reported and communicated during the measurement period.
Denominator Exclusions		Patients for whom the critical test result is not a new finding (i.e. Patients with previous documentation of the same critical result, previously communicated within the past 30 days of the most recent test result in the measurement period).
Denominator Exceptions		None
Definitions / Notes		**1. Median time (in minutes)** can be calculated by arranging all the observations from lowest value to highest value and picking the middle value. If there is an even number of observations (and no single middle value), the median is average of the two middle values. 2. **Study completion** is defined as the time the last image was obtained (typically time-stamped on the digital image). 3. **Documentation of completion** should include the time and method of communication, and specifically name the person to whom the information was communicated. **4. Critical Results** include any of the following: o New critical congenital heart disease (CHD), including duct-dependent lesions (such as critical aortic or pulmonary stenosis, critical aortic coarctation, functional single ventricle

	with severe pulmonary stenosis or pulmonary atresia, hypoplastic left heart syndrome) and total anomalous pulmonary venous return (infradiaphragmatic or other type with obstruction) ○ New moderate or severe-ventricular systolic dysfunction (as defined by lab-specific criteria) ○ New severe valvular regurgitation or stenosis ○ New moderate or large pericardial effusion ○ New intracardiac vegetation or mass ○ New pulmonary hypertension with pulmonary arterial pressure greater than two-thirds systemic pressure
Measurement Period	Quarterly
Sources of Data	Prospective worksheet (see attached Worksheet Template), retrospective medical record review, electronic medical record, echo reports, echo database
Attribution	Communication and documentation of critical results should be performed by the interpreting physician. Information communicated should include: patient name, medical record number, test completed, and result(s). When verbally communicated, the receiver of the information should confirm their own understanding of key findings from the individual who gave them the critical test result information by writing down, reading back, and seeking confirmation of patient name, medical record number, and critical results. Communication of critical results should be documented in the echocardiography report, and should include: • Critical result • Date, time, and method of communication • Name of person to whom the communication was delivered When unable to reach the ordering provider (or their designee), the process should be escalated by contacting the provider on call for the ordering provider's practice, or by using alternative institutional electronic communication methods. If electronic communication is used, a receipt request should be used to ensure confirmation of communication.
Care Setting	Outpatient

Rationale

Health care organizations should ensure critical diagnostic findings are communicated in a timely and appropriate manner. Failure to communicate abnormal diagnostic test results can lead to errors, adverse events, and liability claims.

This quality metric will evaluate timely communication of critical pediatric echocardiography results to referring providers who are not the interpreting echocardiographer. The metric will be calculated as the mean time between study completion and referring provider (or any member of the care team) notification for all pediatric exams with critical results.

Clinical Recommendation(s)

American College of Radiology Guidelines

Non-routine communications: Routine reporting of imaging findings is communicated through channels established by the hospital or diagnostic imaging facility. However, in emergent or other non-routine clinical situations, the interpreting physician should expedite the delivery of a diagnostic imaging report (preliminary or final in a manner that reasonably ensures timely receipt of the findings.

Situations that may require non-routine communication

- Findings that suggest a need for immediate or urgent intervention. Generally, these cases may occur in the emergency and surgical departments or critical care units and may include pneumothorax, pneumoperitoneum, or a significantly misplaced line or tube.
- Findings that are discrepant with a preceding interpretation of the same examination and where failure to act may adversely affect patient health. These cases may occur when the final interpretation is discrepant with a preliminary report or when significant discrepancies are encountered upon subsequent review of a study after a final report has been submitted.
- Findings that the interpreting physician reasonably believes may be seriously adverse to the patient's health and are unexpected by the treating or referring physician. These cases may not require immediate attention but, if not acted on, may worsen over time and possibly result in an adverse patient outcome.

Documentation of non-routine communications

- Interpreting physicians should document all non-routine communications and include the time and method of communication and specifically name the person to whom the communication was delivered. Documentation is best placed in the radiology report or the patient's medical record but may be entered in a department log and/or personal journal. Documentation preserves a history for the purpose of substantiating certain findings or events. Documentation may also serve as evidence of such communication, if later contested.

Methods of communication

- Communication methods are dynamic and varied. It is important, however, that non-routine communications be handled in a manner most likely to reach the attention of the treating or referring physician in time to provide the most benefit to the patient. Communication by telephone or in person to the treating or referring physician or his/her representative is appropriate and assures receipt of the findings. This may be accomplished directly by the interpreting physician or, when judged appropriate, by the interpreting physician's designee. There are other forms of communication that provide documentation of receipt which may also suffice to demonstrate that the communication has been delivered and acknowledged.
- While other methods of communication may be considered, including text pager, facsimile, voice messaging and other nontraditional approaches, these methods may not assure receipt of the communication. Therefore, in these instances, the interpreting physician may consider initiating a system that explicitly requests confirmation of receipt of the report by the clinician. If confirmation or other response is not received within a time appropriate to the diagnosis after the initial communication, a staff person should notify the clinician to document follow-up. Regardless of the method selected, it must be in compliance with state and federal law.

(ACR PRACTICE GUIDELINE FOR COMMUNICATION OF DIAGNOSTIC IMAGING FINDINGS, 2010)

Other guidelines:

- Critical results of tests and diagnostic procedures fall significantly outside the normal range and may indicate a life-threatening situation. The objective is to provide the responsible licensed caregiver these results within an established time frame so that the patient can be promptly treated. *(Joint Commission National Patient Safety Goal NPSG.02.03.01)*
- Critical Values. Each laboratory should have a policy for reporting critical values and a method to communicate these findings to the referring physician. Possible critical values might include aortic dissection, a new large pericardial effusion, findings consistent with cardiac tamponade, a new cardiac mass or thrombus, new severe LV or RV dysfunction, new valvular vegetations, new severe valvular regurgitation or stenosis, and high-risk stress echocardiographic findings. Documentation of physician-to-physician communication of the critical values must be present in the report, an addendum, or the patient's medical record. The laboratory should have a procedure for tracking compliance of this reporting policy. (American Society of Echocardiography Recommendations for Quality Echocardiography Laboratory Operations. (2011). Picard, et al. *Journal of the American Society of Echocardiography, 24*(1), 1-10.
- Intersocietal Accreditation Commission – Echocardiography: The IAC Standards and Guidelines for Pediatric Echocardiography Accreditation (last revision August 2012).
    - Section 3.2A – Provisions must exist for the timely reporting of examination data.
    - Section 3.2.1A – There must be a policy in place for communicating critical results.

Automated Detection of Critical Results in Radiology Reports (a study presented at the Society for Imaging Informatics in Medicine 2011 Annual Meeting):
http://www.siim2011.org/abstracts/communication_ss_lakhani.html

Challenges to Implementation

Lab-specific definitions for critical results such as "new moderately or severely depressed right or left ventricular systolic function" or "significant change in existing ventricular or valvular function in comparison to previous studies" will be necessary to ensure uniform reporting of critical results.
Staff and referring providers will require education and training in the critical results process.
Data collection and auditing require dedicated time.

There may be issues with operational feasibility and workflow, especially in small centers where studies are not immediately reviewed. In this situation, it will be critical for the individuals performing the exams to immediately notify the interpreting physician.

Alternative methods for notification of the referring provider may vary depending on the clinical setting (hospital vs outpatient clinic), and will require complete contact information for referring providers. Determining the actual number of studies with critical results (including those that are not coded correctly as "critical") may be more difficult for labs without a central report database.

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Adverse Events with Sedated Pediatric Echocardiography	
Measure Description: Proportion of sedated echocardiograms associated with adverse events.	
Numerator	Number of moderate/deep sedated transthoracic echo procedures associated with minor[2], moderate[3], or severe[4] adverse events. ***Note:*** *Include only the adverse events that occur during the sedation episode[1].*
Denominator	Number of moderate or deep sedated transthoracic echocardiograms performed for children < 3 years of age during the measurement period. **Note**: *Include transthoracic echocardiograms performed by anyone completing a sedated echo (both anesthesiologist and non-anesthesiologists) and at any location, either an echocardiography lab or in partnership with echocardiography labs.*
Denominator Exclusions	Sedated echocardiographic studies where echocardiography is not the sole procedure for which sedation is performed, but which are performed in conjunction with additional procedures (Eg. patient having an echocardiogram performed under the same sedation as a minor urologic surgical procedure). These studies would be excluded from this metric as adverse events occurring may be related to the associated procedure rather than to the sedation requirements of the pediatric echocardiogram.
Denominator Exceptions	None
Definitions / Notes	1. **Sedation Episode**: time of receipt of sedation to discharge by the individual administering the sedation 2. **Minor events** o Desaturation – fall in saturation of 10% or more from baseline and/or unplanned oxygen use o Apnea more than 15 seconds requiring stimulation o Allergic reaction not requiring treatment o Vomiting o Prolonged sedation (greater than 2 hours from initial medication administration to completion of study OR per center's definition, dependent on agent used) o Prolonged recovery (greater than 2 hours from completion of echo to return to baseline OR per center's definition, dependent on agent used) o Inadequate sedation to perform study. 3. **Moderate events** o Oxygenation/ventilation compromise requiring non-invasive ventilation (includes bag and mask and CPAP) o Intubation o Use of reversal agents o Aspiration o Hemodynamic compromise requiring fluid resuscitation o Unplanned overnight observation

	○ Allergic reaction requiring treatment ○ Agitation/delirium requiring treatment (includes use of additional medications) ○ IV related complication ○ Emergent anesthesia/sedation consultation required ○ Hypoglycemia requiring treatment ○ Hypothermia ○ Stridor ○ Wheezing ○ Laryngospasm 4. **Severe events** ○ Cardiopulmonary arrest ○ Permanent injury or disability (especially neurologic) ○ Death
Measurement Period	Quarterly
Sources of Data	Prospective flowsheet, retrospective medical record review, electronic medical records are all appropriate sources of data.
Attribution	This metric should be reported by each echocardiography laboratory performing sedated transthoracic echocardiography. Data will be assessed quarterly, by the laboratory director or his/her designate and reviewed with the laboratory staff involved in the ordering and provision of sedation and in the interpretation of echocardiograms performed under sedation. Some centers may wish to delegate responsibility for collection of data to a member of a sedation team if sedation is not provided directly by the cardiologists.
Care Setting	Outpatient

Rationale

This metric assesses the safety of administration of sedation in the population of vulnerable patients who require sedation for completion of a transthoracic echocardiogram as part of their care for complete delineation of anatomy and physiology. The need for sedated echocardiography in infants and small children whose cooperation cannot always be won is recognized in the pediatric cardiology community. Sedation has recognized potential complications, and there are numerous guideline documents recognizing the need for monitoring and responding to adverse events during sedation. Quality assurance processes should include periodic review of adverse events and consideration of changes in policy to minimize these events; physicians involved in the ordering and performance of these studies should be involved in quality assurance reviews of these procedures within their laboratories.

Clinical Recommendation(s)

ACC/AHA Guidelines
None

Other Guidelines:

References for need for quality assurance review processes:

1. American Academy of Pediatrics American Academy of Dentistry; Cote JC, Wilson S: Guidelines for monitoring and management of pediatric patients during and after sedation for diagnostic and therapeutic procedures. An update. *Pediatrics* 2006; 118; 2587

The essence of medical error reduction is a careful examination of index events and root-cause analysis of how the event could be avoided in the future. Therefore, each facility should maintain records that track adverse events such as desaturation, apnea, laryngospasm, the need for airway interventions including jaw thrust or positive pressure ventilation, prolonged sedation, unanticipated use of reversal agents, unintended or prolonged hospital admission, and unsatisfactory sedation/analgesia/anxiolysis.

Guidelines for monitoring for adverse events/presence of individuals skilled in resuscitation:

2. Guidelines and Standards for Performance of a Pediatric Echocardiogram: A Report from the Task Force of the Pediatric Council of the American Society of Echocardiography *JASE* 2006: 19:1413:

Written policies including, but not limited to, the type of sedatives, appropriate dosing for age and size, and proper monitoring of children during and after the examination should exist for the use of conscious sedation in children. Each laboratory should have a written procedure in place for handling acute medical emergencies in children. This should include a fully equipped cardiac arrest cart (crash cart) and other necessary equipment for responding to medical emergencies in pediatric patients of all sizes.

3. THE JOINT COMMISSION, COMPREHENSIVE ACCREDITATION MANUAL FOR HOSPITALS (CAMH). (2012).
Provision of Care, Treatment, and Services Standards PC.03.01.01, PC.03.01.05, PC.03.01.03, PC.03.01.07
Record of Care Standard: RC.02.01.03
Performance Improvement Standard: PI.01.01.01

Individuals administering moderate or deep sedation and anesthesia are qualified and have credentials to manage and rescue patients at whatever level of sedation or anesthesia is achieved, either intentionally or unintentionally… In addition to the individual performing the procedure, a sufficient number of qualified staff are present to evaluate the patient, to provide the sedation and/or anesthesia, to help with the procedure, and to monitor and recover the patient… For operative or other high-risk procedures, including those that require the administration of moderate or deep sedation or anesthesia: The hospital has equipment available to monitor the patient's physiological status… For operative or other high-risk procedures, including those that require the administration of moderate or deep sedation or anesthesia: The hospital has resuscitation equipment available…During operative or other high risk procedures, including those that require the administration of moderate or deep sedation or anesthesia, the patient's oxygenation, ventilation, and circulation are monitored continuously… The hospital assesses the patient's physiological status immediately after the operative or other high-risk procedure and/or as the patient recovers from moderate or deep sedation or anesthesia.

4. Practice Guidelines for Sedation and Analgesia by Non-Anesthesiologists: An updated report by the American Society of Anesthesiologists Task Force on Sedation and Analgesia by Non-Anesthesiologists. *Anesthesiology* 2002; 96:1004

All patients undergoing sedation/analgesia should be monitored by pulse oximetry with appropriate alarms. In addition, ventilatory function should be continually monitored by observation or auscultation. Monitoring of exhaled carbon dioxide should be considered for all patients receiving deep sedation and

for patients whose ventilation cannot be directly observed during moderate sedation. When possible, blood pressure should be determined before sedation/analgesia is initiated. Once sedation/analgesia is established, blood pressure should be measured at 5-minintervals during the procedure, unless such monitoring interferes with the procedure… Individuals monitoring patients receiving sedation/analgesia should be able to recognize the associated complication. At least one individual capable of establishing a patent airway and positive pressure ventilation, as well as a means for summoning additional assistance, should be present whenever sedation/analgesia is administered. It is recommended that an individual with advanced life support skills be immediately available (within 5 min) for moderate sedation and within the procedure room for deep sedation.

Challenges to Implementation

Not all laboratories have facilities for sedated echocardiography. Laboratories not performing studies under sedation would not use this metric.

There may be difficulty within laboratories in designating specific adverse events as minor, moderate, or severe, though guidelines included in this metric should be helpful.
The definition of prolonged sedation and prolonged recovery will vary between centers using different sedative medications as the time course for sedation and recovery will vary depending on the agent utilized.

Echocardiographic laboratories routinely using sedation services or anesthesia teams to perform sedation may not have direct access to information regarding adverse events and may need to partner with colleagues in other areas such as anesthesia or intensive care to obtain this data. However it is critical that those making decisions to sedate patients for echocardiography, and involved in the performance and interpretation of these echocardiograms be familiar with the adverse events occurring in the course of sedation and modify their practice of referral for and performance of sedation accordingly.

It is anticipated that the number of moderate and major events annually in each lab will be low, which may make it difficult to improve the metric over data review cycles. The process of review of events may be more valuable than the value of the metric itself in guiding the modification of sedation practices to optimize patient care.

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Metric #: 006
Effective: 10.9.2015

Daily documentation of nutrition for infant cardiac admissions	
Measure Description: Proportion of days infants, ≤ 30 days of age with cardiac disease, had both feeding status and caloric intake documented.	
Numerator	Number of days[1] during which the infants had their feeding status[2] and caloric intake[3] documented.
Denominator	Number of days infants, ≤ 30 days of age, with cardiac disease[4] are admitted to a patient care unit during the measurement period.
Denominator Exclusions	Infants with cardiac disease admitted for less than 24 hours.
Denominator Exceptions	None
Definitions / Notes	1. **Days**: 24-Hour Periods 2. **Feeding status** include parenteral and enteral. 3. **Caloric intake** is documented as calories per kilograms per day. 4. **Cardiac disease** is defined as an acquired or congenital heart defect **Note:** *Feeding status/caloric intake should be documented every 24 hours. (Eg. If a patient is admitted for 28 hours, only one instance of feeding status needs to be documented. After 48 hours, there would need to be two notes regarding feeding status, etc.)*
Measurement Period	Quarterly
Sources of Data	Medical record
Attribution	Unit and institution level
Care Setting	Inpatient

Rationale

Nutrition is a critical component of care for infants with congenital heart disease. Although documentation of daily fluid intake is a standardized activity performed by nurses, assessment or measurement of nutritional intake is not consistently performed.

Clinical Recommendation(s)

ACC/AHA Guidelines:

Supporting literature:

1. Varan B, Kursad T, Yilmaz Y. Malnutrition and growth failure in cyanotic and acyanotic congenital heart disease with and without pulmonary hypertension. *Arch Dis Child*. 1999;81:49-52.
2. Cameron JW, Rosenthal A, Olson AD. Malnutrition in hospitalized children with congenital heart disease. *Arch Pediatr Adolesc Med*. 1995;149(10):1098-1102.

Challenges to Implementation
Requires primary data collection

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Chest Pain – Documentation of Family History	
Measure Description: Proportion of patients, 5-18 years old, with a chief complaint of chest pain who have documentation of a family history of early coronary artery disease, cardiomyopathy and sudden cardiac or unexplained death.	
Numerator	Number of patients with documentation of family history[1] of early coronary artery disease[2] (in a first and/or second degree relative[3]), cardiomyopathy, and sudden cardiac or unexplained death during the measurement period or in the past 12 months from the clinic visit[4].
Denominator	Number of patients, ages 5-18 years old, seen for initial consultation in an ambulatory pediatric cardiology clinic visit[1] with a chief complaint of chest pain during the measurement period.
Denominator Exclusions	• Patients who were adopted and have unknown family history
Denominator Exceptions	None
Definitions/Notes	1. **Documentation of family history**: includes documentation of the presence or absence of cardiomyopathy, early coronary artery disease, and sudden cardiac or unexplained death 2. **Early coronary artery disease (CAD)**: includes those with CAD before the age of 55 years for males and before the age of 65 years in females. 3. **First and/or second-degree relative**: a patient's first-degree relative is a parent, sibling, or child. A second-degree relative is an uncle, aunt, nephew, niece, grandparent, grandchild, or half-sibling. 4. **Clinic Visit:** If the patient has had multiple visits during the measurement period, use the most recent visit (i.e. last visit in the measurement period).
Measurement Period	Quarterly
Sources of Data	Retrospective medical record review, electronic medical record
Attribution	This measure should be reported by pediatric cardiologists and practitioners evaluating children in the outpatient setting.
Care Setting	Outpatient
Rationale	
Family history should document the presence or absence of cardiomyopathy, early coronary artery disease in a first-degree relative, and sudden cardiac or unexplained death. Several retrospective studies have shown chest pain can be the presenting symptom in HCM[1-5]. The AHA recommendations for screening child athletes recommends obtaining a family history to include HCM, DCM, SCD<50[6]. Our expert panel supports this recommendation in children presenting with chest pain. Class IIa recommendation	

Level of evidence: C

Clinical Recommendation(s)

ACC/AHA Guidelines

A Scientific Statement From the American Heart Association Expert Panel on Population and Prevention Science; the Councils on Cardiovascular Disease in the Young, Epidemiology and Prevention, Nutrition, Physical Activity and Metabolism, High Blood Pressure Research, Cardiovascular Nursing, and the Kidney in Heart Disease; and the Interdisciplinary Working Group on Quality of Care and Outcomes Research. Circulation. 2006; 114:2710-2738

Other guidelines:

Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents. Pediatrics 2011; 128;S213-S256

Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents and Grading of the Evidence Review for the Role of Family History in Cardiovascular Health ; NIH Publication No. 12-7486 October 2012

- Overwhelmingly consistent evidence from observational studies strongly supports inclusion of a positive family history of early coronary heart disease in identifying children at risk for accelerated atherosclerosis and for the presence of an abnormal risk profile. (Grade B)
- For adults, a positive family history is defined as a parent and/or sibling with a history of treated angina, myocardial infarction, percutaneous coronary catheter interventional procedure, coronary artery bypass grafting, stroke or sudden cardiac death before age 55 years in men or age 65 years in women. Because the parents and siblings of children and adolescents are usually young themselves, it was the Expert Panel's consensus that when evaluating family history in a child, history should also be ascertained for the occurrence of CVD in grandparents, aunts, and uncles, although the evidence supporting this is insufficient to date. (Grade D)
- Overwhelmingly consistent evidence from observational studies shows that identification of a positive family history for CVD and/or CV risk factors should lead to evaluation of all family members, especially parents, for CV risk factors. (Grade B)
- Family history evolves as a child matures, so regular updates are necessary as part of routine pediatric care. (Grade D)
- Education about the importance of accurate and complete family health information should be part of routine care for children and adolescents. As genetic sophistication increases, linking family history to specific genetic abnormalities will provide important new knowledge about the atherosclerotic process. (Grade D).

References:

1. Kane DA, Fulton DR, Saleeb S, Zhou J, Lock JE, Geggel RL. Needles in hay: chest pain as the presenting symptom in children with serious underlying cardiac pathology. Congenit Heart Dis 2010;5:366-73.
2. Yetman AT, McCrindle BW, MacDonald C, Freedom RM, Gow R. Myocardial bridging in children with hypertrophic cardiomyopathy--a risk factor for sudden death. N Engl J Med 1998;339:1201-9.
3. Azzano O, Bozio A, Sassolas F, et al. [Natural history of hypertrophic obstructive cardiomyopathy in young patients: apropos of 40 cases]. Archives des maladies du coeur et des vaisseaux 1995;88:667-72.
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6. Maron BJ, Thompson PD, Ackerman MJ, et al. Recommendations and considerations related to preparticipation screening for cardiovascular abnormalities in competitive athletes: 2007 update: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism: endorsed by the American College of Cardiology Foundation. Circulation 2007;115:1643-455

Challenges to Implementation

Family members may have poor knowledge/recollection as to actual diagnoses of relatives. Many non-myopathic conditions (e.g. CHF) are referred to by laypersons by various terms such as “enlarged heart”.

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Metric #: 008
Effective: 10.9.2015

Electrocardiogram for chest pain	
Measure Description: Proportion of patients, 5-18 years old, with a chief complaint of chest pain who completed an electrocardiogram (ECG).	
Numerator	Number of patients who had an ECG performed within 30 days (before or after) their initial consultation for chest pain.
Denominator	Number of patients, age 5-18 years old, seen for an initial consultation in an ambulatory pediatric cardiology clinic with a chief complaint of chest pain during the measurement period.
Denominator Exclusions	Patient refusal
Denominator Exceptions	None
Definitions/Notes	None
Measurement Period	Quarterly
Sources of Data	Retrospective medical record review, electronic medical record, ECG storage systems
Attribution	This measure should be reported by physicians or physician extenders
Care Setting	Outpatient

Rationale

Cardiac etiology for chest pain is rare in children[1-11]. Of 3700 patients presenting with chest pain to outpatient cardiology clinic with an ECG, there were no cardiac deaths at median 4.4 year follow up[1]. Multiple retrospective studies show small number of abnormal ECGs in patients presenting with chest pain with the following diagnoses: pericarditis, myocarditis, arrhythmias, and cardiomyopathy[2-7]. Meta-analysis of asymptomatic children who underwent ECG screening demonstrated high negative predictive value for hypertrophic cardiomyopathy, long QT syndrome, and Wolff-Parkinson-White syndrome[9].

Class I Recommendation
Level of evidence: C

Clinical Recommendation(s)

ACC/AHA Guidelines
ACC/AHA Guidelines for Ambulatory Electrocardiography. A report of the American College of Cardiology/American Heart Association Task Force on Practice Guidelines (Committee to Revise the Guidelines for Ambulatory Electrocardiography). Developed in collaboration with the North American Society for Pacing and Electrophysiology. JACC 1999; 34(3): 912-48.

Other guidelines:
Management of Pediatric Chest Pain Using a Standardized Assessment and Management Plan. Pediatrics 2011; 128; 239-245
Resource Utilization Reduction for Evaluation of Chest Pain in Pediatrics Using a Novel Standardized

Clinical Assessment and Management Plan (SCAMP). J Am Heart Assoc. 2012; 1:1-7

References:

1. Saleeb SF, Li WY, Warren SZ, Lock JE. Effectiveness of screening for life-threatening chest pain in children. Pediatrics 2011;128:e1062-8.
2. Sert A, Aypar E, Odabas D, Gokcen C. Clinical characteristics and causes of chest pain in 380 children referred to a paediatric cardiology unit. Cardiol Young 2012:1-7.
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8. Friedman KG, Kane DA, Rathod RH, et al. Management of pediatric chest pain using a standardized assessment and management plan. Pediatrics 2011;128:239-45.
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11. Evangelista JA, Parsons M, Renneburg AK. Chest pain in children: diagnosis through history and physical examination. Journal of pediatric health care : official publication of National Association of Pediatric Nurse Associates & Practitioners 2000;1.
12. Saleeb SF, Li WY, Warren SZ, Lock JE. Effectiveness of screening for life-threatening chest pain in children. Pediatrics 2011;128:e1062-8

Challenges to Implementation

- ECG may not be well documented in patient chart.
- Chest pain may not be listed as the chief complaint but may be an associated symptom.
- Noncompliance with getting the ECG done.

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Metric #: 009
Effective: 10.9.2015

Echocardiogram for exertional chest pain	
Measure Description: Proportion of patients, 5-18 years old, with a history of exertional chest pain who had an echocardiogram.	
Numerator	Number of patients who had an echocardiogram (including comment regarding coronary artery anatomy) performed 6 months prior or 30 days after the clinic visit.
Denominator	Number of patients, ages 5-18 years old, seen for initial consultation in an ambulatory pediatric cardiology clinic for chief complaint of exertional chest pain during the measurement period.
Denominator Exclusions	• Previous cardiac MRI/CT within 6 months with documentation of coronary artery anatomy, or chest pain characteristic of musculoskeletal chest pain or exercise induced asthma. • Patient refusal
Denominator Exceptions	None
Definitions/Notes	None
Measurement Period	Quarterly
Sources of Data	Retrospective medical record review, electronic medical record
Attribution	This measure should be reported by physicians or physician extenders.
Care Setting	Outpatient

Rationale

Sudden death may occur with exertion related to coronary artery anomalies.[1]
Coronary artery anomaly is the most common cardiac diagnosis to present with CP.[2]
Exertional CP is useful for identifying coronary anomalies.[2]
Class IIb recommendation.
Level of evidence: B

References:

1. Eckart RE, Scoville SL, Campbell CL, et al. Sudden death in young adults: a 25-year review of autopsies in military recruits. Ann Intern Med 2004;141:829-34.
2. Kane DA, Fulton DR, Saleeb S, Zhou J, Lock JE, Geggel RL. Needles in hay: chest pain as the presenting symptom in children with serious underlying cardiac pathology. Congenit Heart Dis 2010;5:366-73.

Clinical Recommendation(s)

ACC/AHA Guidelines

ACCF/ASE/AHA/ASNC/HFSA/HRS/SCAI/SCCM/SCCT/SCMR 2011 AppropriateUse Criteria for Echocardiography. A Report of the AmericanCollege of Cardiology Foundation Appropriate Use Criteria Task Force, American Society of Echocardiography, American Heart Association, American Society of Nuclear Cardiology, Heart Failure Society of America, Heart Rhythm Society, Society for Cardiovascular Angiography and Interventions, Society of Critical Care Medicine, Society of Cardiovascular Computed Tomography, and Society for Cardiovascular Magnetic Resonance Endorsed by the American College of Chest Physicians. J Am Coll Cardiol. 2011;57(9):1126-66. “Symptoms or conditions potentially related to suspected cardiac etiology including but not limited to chest pain”

Other guidelines:
Management of pediatric chest pain using a standardized assessment and management plan. Pediatrics. 2011;128(2):239-45.

Challenges to Implementation

Exertional CP is an imperfect marker (both sensitivity and specificity)[1,2], and a high proportion (33% in one cohort) may have exertional CP[3].

Exertional CP could also be exercise-induced asthma, and may not require an echocardiogram.

References:

1. Eckart RE, Scoville SL, Campbell CL, et al. Sudden death in young adults: a 25-year review of autopsies in military recruits. Ann Intern Med 2004;141:829-34.
2. Kane DA, Fulton DR, Saleeb S, Zhou J, Lock JE, Geggel RL. Needles in hay: chest pain as the presenting symptom in children with serious underlying cardiac pathology. Congenit Heart Dis 2010;5:366-73.
3. Saleeb SF, Li WY, Warren SZ, Lock JE. Effectiveness of screening for life-threatening chest pain in children. Pediatrics 2011;128:e1062-8.

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Metric #: 010
Effective: 10.24.2016

Recommendation for Antibiotic Prophylaxis in Patients with Heterotaxy and Asplenia	
Measure Description: Proportion of patients, < 5 years old, with heterotaxy and asplenia and a documented recommendation for antibiotic prophylaxis.	
Numerator	Number of patients with at least one documented recommendation for antibiotic prophylaxis within a note in the medical record.
Denominator	Number of patients, < 5 years old, with diagnosis of heterotaxy[1] and asplenia who had an outpatient visit[2] to the pediatric cardiology clinic during the measurement period.
Denominator Exclusions	• Patients with heterotaxy in whom documentation of normal splenic function has occurred (irrespective of method used to determine normalcy of splenic function). • Patients who do not have congenital heart disease, but who have documented asplenia or hyposplenism and are being seen by a pediatric cardiologist for varied reasons (the most common example would be patients with sickle cell disease).
Denominator Exceptions	None
Definitions/Notes	1. **Heterotaxy**: ○ **Patient should have at least <u>one</u> of the following cardiac malformations**: interrupted inferior caval vein, left sided superior caval vein, atrioventricular septal defect, double outlet right ventricle, pulmonary atresia, and anomalous pulmonary venous connection. **<u>AND</u>** ○ **Patient should have at least <u>one</u> of the following isomerisms:** 1) central nervous system anomaly, 2) intestinal malrotation, 3) bronchial isomerism, 4) pulmonary isomerism, 5) thoraco-abdominal laterality discordance. 2. **Clinic Visit:** If the patient has had multiple visits during the measurement period, use the most recent visit (i.e. last visit in the measurement period).
Measurement Period	Quarterly
Sources of Data	Retrospective review of outpatient clinic notes.
Attribution	N/A
Care Setting	Outpatient
Rationale	
While controversy exists as to the age at which antibiotic prophylaxis should continue to be recommended, most experts agree that antibiotic prophylaxis against severe pneumococcal disease is	

appropriate until the age of 5. Documented rates of severe pneumococcal sepsis decrease markedly after the age of 5. However, there is no national published guideline on which to rely for guidance in this issue.

Clinical Recommendation(s)

Price, VE et al. The Prevention and Management of Children with Asplenia or Hyposplenia. Infect Dis Clin N Am (2007) 21:697.

Challenges to Implementation

The lack of a standard means to document the recommendation for antibiotic prophylaxis in the medical record may make assessment of adherence to the metric cumbersome. Some institutions may differ on what is included under a diagnosis of "heterotaxy".

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Metric #: 011
Effective: 12.3.2015

Influenza Vaccination Compliance of Health Care Personnel	
Measure Description: Proportion of health care personnel (HCP) in a pediatric cardiology practice who receive timely influenza vaccination.	
Numerator	Number of HCP[1] who received an influenza vaccination during the current flu season[2]
Denominator	Number of health care personnel working in patient care areas at least one working day during the measurement period
Denominator Exclusions	• Personnel with medical reasons to forego vaccination • Visiting team members not employed by primary employer (technical supportive staff such as pacemaker/ICD technicians).
Denominator Exceptions	None
Definitions/Notes	1. **Health care personnel**: Medical, front office/check-in, other administrative staff (i.e. practice managers, schedulers), all clinical personnel: ECG technicians, medical assistants (CNA), LPN, RN, MD, NP, PA, as well as imaging personnel including sonographers, and other healthcare personnel. [http://www.hhs.gov/ash/initiatives/hai/hcpflu.html] 2. **Current Flu Season**: period of time between when the vaccine becomes available (approximately October each year) until March of the following year.
Measurement Period	Quarterly (Quarter 1: Jan 1 to Mar 31st, Quarter 4: Oct 1st to Dec 31st)
Sources of Data	Documentation/confirmation of vaccine administration by Clinical Director/Manager of practice.
Attribution	Shared accountability: Practice administrative & clinical leadership; all staff; all health care providers
Care Setting	Outpatient

Rationale

Overall, 67% of HCP report having received the Influenza vaccine for 2011-12 season. This is improving, but remains poor. Pediatric cardiologists and their staff care for a potentially vulnerable patient population prone to increased morbidity/mortality from influenza.

Clinical Recommendation(s)

ACC/AHA Guidelines:

None

Other guidelines: "Emphasis that all HCP, not just those with direct patient care duties, should receive an annual influenza vaccination." "Comprehensive programs to increase vaccine coverage among HCP are needed; influenza vaccination rates among HCP within facilities should be measured and reported regularly." MMWR November 25, 2012, Vol 60, No. 7. Immunization of Health-Care Personnel: Recommendations of the Advisory Committee on Immunization Practices.

Challenges to Implementation
Varied forms of leadership among practices, may lead to diffusion of responsibility or confusion of who is to provide oversight and accountability. There may also be varied methods of accounting vaccinations among staff.

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Metric #: 012
Effective: 10.9.2015

Adherence to Recommended Regimens of Secondary Prevention of Rheumatic Fever in Patients with a Previous History of Rheumatic Fever

Measure Description: Proportion of patients with documented recommendation for antibiotics for secondary prevention of rheumatic fever.

Numerator	Number of patients with a documented recommendation, or a specific prescription, for the prevention of secondary rheumatic fever.
Denominator	Number of patients, ≤ 21 years old, with a known prior diagnosis of rheumatic fever and an outpatient clinic visit during the measurement period.
Denominator Exclusions	None
Denominator Exceptions	None
Definitions/Notes	None
Measurement Period	Quarterly
Sources of Data	Retrospective medical record review of outpatient clinic note
Attribution	N/A
Care Setting	Outpatient

Rationale

Although rheumatic fever is uncommon in the US in the current era, there are periodic increases in the case rate from time to time and clinicians must therefore remain aware of this important sequela of a common bacterial infection. Patients who have an episode of rheumatic fever are at very high risk of recurrent rheumatic fever with subsequent episodes of streptococcal pharyngitis, with the potential significant deleterious effects on cardiac valvular function. It is therefore important for clinicians to document a) that indicated patients are receiving the correct prophylactic regimen and b) that, if indicated, a recommendation for ongoing adherence to a prophylactic regimen is documented.

Clinical Recommendation(s)

ACC/AHA Guidelines

Table 3. Duration of Secondary Rheumatic Fever Prophylaxis

Category	Duration After Last Attack	Rating
Rheumatic fever with carditis and residual heart disease (persistent valvular disease*)	10 years or until 40 years of age (whichever is longer), sometimes lifelong prophylaxis (see text)	IC
Rheumatic fever with carditis but no residual heart disease (no valvular disease*)	10 years or until 21 years of age (whichever is longer)	IC
Rheumatic fever without carditis	5 years or until 21 years of age (whichever is longer)	IC

Rating indicates classification of recommendation and LOE (eg, IC indicates class I, LOE C).

Circulation. 2009;119:1541-1551

Challenges to Implementation
The relative rarity of rheumatic fever in the US, along with the fact that many patients may have had their rheumatic fever many years previously, may make it difficult for clinicians to properly ascertain a prior history of rheumatic fever. Also, the lack of a standard means to document need for SBE prophylaxis in the medical record may make assessment of adherence to the metric cumbersome.

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Metric #: 013
Effective: 2.8.2016

Aspirin therapy in Acute and Subacute Phases	
Measure Description: Proportion of Kawasaki Disease (KD) patients with a recommendation for aspirin during the first 6 weeks after onset of disease.	
Numerator	Number of patients who were prescribed (upon discharge) daily low dose aspirin (<10 mg/kg/day) for 6 weeks or more.
Denominator	Number of patients, ≤ 18 years old, who had an inpatient discharge within the measurement period for acute KD.
Denominator Exclusions	• Patients with G6PD deficiency (who should receive an alternative therapy) • Patients on other anti-platelet therapy • Other contraindications to aspirin therapy (allergy, recent chickenpox vaccination)
Denominator Exclusions	None
Definitions/Notes	None
Measurement Period	Quarterly
Sources of Data	Pediatric cardiologists' outpatient medical records
Attribution	This measure should be reported by all pediatric cardiologists
Care Setting	Inpatient

Rationale

All patients discharged with the diagnosis of Kawasaki disease should be placed on antiplatelet therapy irrespective of receiving intravenous immunoglobulin (IVIG). Risk of aneurysm development persists during this period, and thrombosis risk exists in patients with aneurysms. Furthermore, accelerated thrombocytosis provides a hypercoagulable state after the first week.

Clinical Recommendation(s)

ACC/AHA Guidelines Evidence level C recommendations

"When high-dose aspirin is discontinued, clinicians begin low-dose aspirin (3 to 5 mg/kg per day) and maintain it until the patient shows no evidence of coronary changes by 6 to 8 weeks after the onset of illness." Guidelines also recommend continued antiplatelet therapy for patients with coronary involvement.

Newburger JW, Takahashi M, Gerber MA, Gewitz MH, Tani LY, Burns JC, Shulman ST, Bolger AF, Ferrieri P, Baltimore RS, Wilson WR, Baddour LM, Levison ME, Pallasch TJ, Falace DA, Taubert KA. Diagnosis, treatment, and long-term management of Kawasaki disease: a statement for health professionals from the Committee on Rheumatic Fever, Endocarditis and Kawasaki Disease, Council on Cardiovascular Disease in the Young, American Heart Association. Circulation. 2004 Oct 26;110(17):2747-71.

Other references:

Durongpisitkul K, Gururaj VJ, Park JM, Martin CF. The prevention of coronary artery aneurysm in Kawasaki disease: A meta-analysis on the efficacy of aspirin and immunoglobulin treatment. Pediatrics. 1995; 96: 1057–1061.

Challenges to Implementation
The accuracy of the reporting method will depend on each physician's verification process.

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Metric #: 014
Effective: 10.9.2015

Appropriate Follow-up, Cardiac Evaluation	
Measure Description: Proportion of Kawasaki Disease (KD) patients who received an echocardiographic evaluation within 3 weeks of a hospital discharge.	
Numerator	Number of patients who had at least one echocardiogram within 3 weeks after being discharged from the hospital.
Denominator	Number of KD patients, ≤ 18 years old, who had an outpatient cardiology clinic visit during the measurement period and who had their initial inpatient hospital discharge[1] for KD within the past 12 months of the outpatient visit. **Note:** *Only KD patients who have been followed by the same clinic since their initial inpatient hospital discharge meet the denominator criteria.*
Denominator Exclusions	• Patients at higher risk including those with persistent or recrudescent fever or who remained hospitalized longer than five days or were readmitted • Patients with aneurysms any time in their medical history • Patient/guardian refusal
Denominator Exceptions	None
Definitions/Notes	**1. Initial inpatient hospital discharge** refers to the time the patient was discharged with a primary diagnosis of Kawasaki disease.
Measurement Period	Quarterly
Sources of Data	pediatric cardiologists' outpatient medical record or echocardiographic report
Attribution	This measure should be reported by pediatric cardiologists caring for patients with Kawasaki Disease.
Care Setting	Outpatient

Rationale

Patients with KD can develop coronary dilation and aneurysm formation during the first 2 months of illness. Lack of standard evaluation at these specific time points will result in underdiagnoses of coronary artery abnormalities

Clinical Recommendation(s)

ACC/AHA Guidelines

"For uncomplicated cases, echocardiographic evaluation should be performed at the time of diagnosis, at 2 weeks, and at 6 to 8 weeks after onset of the disease."

1. Newburger JW, Takahashi M, Gerber MA, Gewitz MH, Tani LY, Burns JC, Shulman ST, Bolger AF, Ferrieri P, Baltimore RS, Wilson WR, Baddour LM, Levison ME, Pallasch TJ, Falace DA, Taubert KA. Diagnosis, treatment, and long-term management of Kawasaki disease: a statement for health professionals from the Committee on Rheumatic Fever, Endocarditis and Kawasaki Disease, Council on Cardiovascular Disease in the Young, American Heart Association. Circulation. 2004 Oct 26;110(17):2747-71.

Other guidelines:

1. Lowry AW, Knudson JD, Myones BL, Moodie DS, Han YS. Variability in delivery of care and echocardiogram surveillance of Kawasaki disease. Congenital Heart Disease. 2012 Jul-Aug;7(4):336-43.
2. Scott JS, Ettedgui JA, Neches WH. Cost-effective use of echocardiography in children with Kawasaki disease. Pediatrics. 1999 Nov;104(5):e57

Challenges to Implementation

Patients are not seen in a timely fashion.

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Metric #: 015
Effective: 10.9.2015

Appropriate Consideration and Evaluation of Fever	
Measure Description: Proportion of Kawasaki Disease (KD) patients who were evaluated for fever after discharge.	
Numerator	Number of patients who have documentation of the presence or absence of fever during the outpatient visit.
Denominator	Number of KD patients, ≤ 18 years old, who had their first outpatient pediatric cardiology clinic visit during the measurement period and after their initial inpatient hospital discharge[1].
Denominator Exclusions	Patients whose first outpatient visit is more than two months after discharge from hospital.
Denominator Exceptions	None
Definitions/Notes	**1. Initial inpatient hospital discharge** refers to the time the patient was discharged with a primary diagnosis of Kawasaki disease.
Measurement Period	Quarterly
Sources of Data	Pediatric cardiologists' outpatient medical record
Attribution	Pediatric Cardiologists seeing patients for first outpatient visit after diagnosis and treatment of KD
Care Setting	Outpatient

Rationale

Patients with KD who have persistent or recurrent fever after IVIG are at increased risk for developing coronary changes/aneurysms, and should be identified for re-evaluation and re-treatment.

Clinical Recommendation(s)

ACC/AHA guidelines

"Failure to respond usually is defined as persistent of recrudescent fever ≥ 36 hours after completion of the initial IVIG infusion. Most experts recommend retreatment with IVIG, 2 g/kg"

Newburger JW, Takahashi M, Gerber MA, Gewitz MH, Tani LY, Burns JC, Shulman ST, Bolger AF, Ferrieri P, Baltimore RS, Wilson WR, Baddour LM, Levison ME, Pallasch TJ, Falace DA, Taubert KA. Diagnosis, treatment, and long-term management of Kawasaki disease: a statement for health professionals from the Committee on Rheumatic Fever, Endocarditis and Kawasaki Disease, Council on Cardiovascular Disease in the Young, American Heart Association. *Circulation*. 2004 Oct 26;110(17):2747-71.

Other guidelines:

Japanese Circulation Society Guidelines

"It is important to treat patients not responding to initial IVIG therapy, who will count for about 15% of children with Kawasaki disease"

JCS Joint Working Group. Guidelines for diagnosis and management of cardiovascular sequelae in Kawasaki disease (JCS 2008). *Circ J.* 2010 Sep;74(9):1989-2020.

Challenges to Implementation
This metric assesses the cardiologists' concern for this important issue of recurrent fever, not whether the inpatient team appropriately counseled the parents, or whether the parents followed instructions. Therefore, there should be no significant challenges.

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Metric #: 016
Effective: 5.11.2016

Appropriate Care (No Therapy or Restrictions)	
Measure Description: Proportion of Kawasaki Disease (KD) patients with documentation to not restrict physical activities.	
Numerator	Number of patients with documentation to not restrict physical activities during the measurement period or 3 years prior to the outpatient clinic visit[1].
Denominator	Number of KD patients, 6-18 years, who had an outpatient pediatric clinic visit[1] during the measurement period.
Denominator Exclusions	• Patients who are unable to do any physical activity or sports for other reasons • Patients with a history of aneurysm (any time in medical history) • Patients with a KD diagnosis < 6 weeks from outpatient visit date
Denominator Exceptions	None
Definitions/Notes	1. **Clinic Visit:** If the patient has had multiple visits during the measurement period, use the most recent visit (i.e. last visit in the measurement period).
Measurement Period	Quarterly
Sources of Data	Pediatric cardiologists' outpatient medical record
Attribution	This measure should be reported by the pediatric cardiologist evaluating the patient during or after the post-6 week follow-up appointment.
Care Setting	Outpatient

Rationale

KD patients should have no restrictions on physical activities after 6 weeks post KD diagnosis based on the risk stratification categories listed below.

Clinical Recommendation(s)

AAP/AHA guidelines

Risk Level I—Patients with no coronary artery changes on echocardiography at any stage of the illness

- No antiplatelet therapy is needed beyond the initial 6 to 8 weeks after the onset of illness.
- No restriction of physical activity is necessary after 6 to 8 weeks.
- Because the degree of future risk for ischemic heart disease in this category of patients is still undetermined, periodic assessment and counseling about known cardiovascular risk factors every 5 years is suggested.
- Coronary angiography is not recommended.

Risk Level II—Patients with transient coronary artery ectasia or dilatation (disappearing within the initial 6 to 8 weeks after the onset of illness)

- No antiplatelet therapy is needed beyond the initial 6 to 8 weeks after the onset of illness.
- No restriction of physical activity is necessary after 6 to 8 weeks.
- Risk assessment and counseling is recommended at 3- to 5-year intervals.
- Coronary angiography is not recommended.

Newburger JW, Takahashi M, Gerber MA, Gewitz MH, Tani LY, Burns JC, Shulman ST, Bolger AF, Ferrieri P, Baltimore RS, Wilson WR, Baddour LM, Levison ME, Pallasch TJ, Falace DA, Taubert KA. Diagnosis, treatment, and long-term management of Kawasaki disease: a statement for health professionals from the Committee on Rheumatic Fever, Endocarditis and Kawasaki Disease, Council on Cardiovascular Disease in the Young, American Heart Association. Circulation. 2004 Oct 26;110(17):2747-71

Challenges to Implementation

Patients lost to follow-up.

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Metric #017 Kawasaki Disease: Stress Evaluation with Aneurysm was retired from ACPC Quality Network Data Collection as of 2018 Q2

Metric #: 018
Effective: 10.9.2015

Appropriate Follow-up for Patients with Giant Coronary Aneurysms	
Measure Description: Proportion of Kawasaki Disease (KD) patients with a history of giant coronary artery aneurysms who have documentation of being educated regarding symptoms of angina and myocardial infarction.	
Numerator	Number of patients with documentation of being educated regarding symptoms of angina and MI within the last 3 years from the clinic visit[1].
Denominator	Number of KD patients, ≤ 18 years old, with current giant coronary artery aneurysms[2] and who had outpatient clinic visit[1] during the measurement period.
Denominator Exclusions	None
Denominator Exceptions	None
Definitions/Notes	1. **Clinic Visit:** If the patient has had multiple visits during the measurement period, use the most recent visit (i.e. last visit in the measurement period). 2. **Giant Coronary Artery Aneurysms** (CAA): Z scores are >10 or maximum dimension is > 8 mm.
Measurement Period	Quarterly
Sources of Data	Pediatric cardiologists' outpatient medical record
Attribution	This measure should be reported by pediatric cardiologists caring for patients with Kawasaki Disease.
Care Setting	Outpatient

Rationale

Patients with a history of giant coronary aneurysms have a substantial risk of myocardial ischemia/infraction. Rapid recognition of symptoms may result in improved outcomes of patients presenting with myocardial infarction related to their previous Kawasaki disease.

Suda K, Iemura M, Nishiono H, Teramachi Y, Koteda Y, Kishimoto S, et al. Long-Term Prognosis of Patients with Kawasaki Disease Complicated by Giant Coronary Aneurysms : A Single-Institution Experience. Circulation. 2011;123:1836-1842.

Clinical Recommendation(s)

ACC/AHA guidelines

Guidelines currently under revision.

Other guidelines:

"Patients should also be educated regarding the signs and symptoms of myocardial ischemia and actions to take if they are observed."

The Japanese Circulation Society. Guidelines for the Diagnosis and Management of Cardiovascular Sequelae in Kawasaki Disease (JCS 2008).

Challenges to Implementation
Lack of adequate medical record documentation or appropriate follow-up.

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Complete Echocardiogram Evaluation	
Measure Description: Proportion of echocardiograms for Kawasaki Disease (KD) patients that include documentation of coronary artery measurements.	
Numerator	Number of echocardiograms with documentation of coronary artery measurements[1].
Denominator	Number of echocardiograms during the measurement period for KD patients, ≤ 18 years old.
Denominator Exclusions	Patients with Kawasaki disease whose coronary arteries cannot be imaged well enough for measurement (eg. due to body habitus or poor echo windows outside the control of the echocardiographer.)
Denominator Exceptions	None
Definitions/Notes	1. Measurements should include, at a minimum, the left anterior descending coronary artery (LAD) and right coronary artery (RCA). *(See clinical recommendation section below)*
Measurement Period	Quarterly
Sources of Data	Pediatric cardiologists' outpatient medical record and echocardiography reports
Attribution	This measure should be reported by the pediatric cardiologist interpreting the echocardiogram at the time of initial diagnosis.
Care Setting	Outpatient

Rationale

Initial study at time of diagnosis should be complete and contain accurate and reproducible measurements as described below. In order to maintain consistency in terms of diagnosis and risk stratification, coronary artery measurements should be made from standard views and measurements should be normalized for patients' body surface area (using z-score calculations).

Clinical Recommendation(s)

ACC/AHA guidelines

In addition to standard imaging from parasternal, apical, subcostal and suprasternal notch windows, 2DE of patients with suspected Kawasaki disease should focus on imaging the left main coronary artery (LMCA), left anterior descending coronary artery (LAD), left circumflex coronary artery (LCX), right coronary artery (RCA) and posterior descending coronary arteries. If possible, multiple imaging planes should be used to visualize each of the coronary artery segments (as described below). In addition to detailed imaging of the coronary arteries, assessment of LV dimensions and LV function should be a part of all echocardiograms (standard M-mode tracings) and mention should be made of any regional wall motion abnormalities. The aortic root should be imaged, measured and compared with z-score references for BSA as mild aortic root dilation may be common in patients with Kawasaki disease. Standard views and interrogation for any valvular regurgitation and any evidence of pericardial effusion should be performed.

Echocardiographic Views of Coronary Arteries in Patients With Kawasaki Disease
Left main coronary artery: parasternal short axis at level of aortic valve; parasternal long axis of left ventricle; subcostal left ventricular long axis
Left anterior descending coronary artery: parasternal short axis at level of aortic valve; parasternal superior tangential long axis of left ventricle; parasternal short axis of left ventricle
Left circumflex: parasternal short axis at level of aortic valve; apical 4-chamber
Right coronary artery, proximal segment: parasternal short axis at level of aortic valve; parasternal long axis (inferior tangential) of left ventricle; subcostal coronal projection of right ventricular outflow tract; subcostal short axis at level of atrioventricular groove
Right coronary artery, middle segment: parasternal long axis of left ventricle (inferior tangential); apical 4-chamber; subcostal left ventricular long axis; subcostal short axis at level of atrioventricular groove
Right coronary artery, distal segment: Apical 4-chamber; subcostal atrial long axis
Posterior descending coronary artery: Apical 4-chamber (inferior); subcostal atrial long axis (inferior); parasternal long axis (inferior tangential) imaging posterior interventricular groove

Quantification of the coronary artery dimensions:
Measurements of the internal diameters of the coronary arteries should be made from inner edge to inner edge and should exclude points of branching which may have normal focal dilation. For the LMCA, proximal LAD, and proximal RCA, these measurements should be reported with z-scores (as defined below). The remaining segments may be measured and can be described as aneurysmal dilation if they measured "1.5 times that of the surrounding segment." Aneurysms should be further classified as small (< 5 mm internal diameter), medium (5-8 mm internal diameter), or giant (> 8 mm internal diameter). In addition, mention should be made of the lack of normal tapering and/or perivascular echogenicity or brightness.

Z-score measurements are based on nonlinear regression equations derived from a normal, nonfebrile population between the ages of 0-18 years (Boston Children's Hospital from 1987-2000).

$LMCA = 0.31747 \cdot (BSA^{0.36008}) - 0.02887, SD=0.03040 + (0.01514 \cdot BSA)$

$pLAD = 0.26108 \cdot (BSA^{0.37893}) - 0.02852, SD=0.01465 + (0.01996 \cdot BSA)$

$pRCA = 0.26117 \cdot (BSA^{0.39992}) - 0.02756, SD=0.02407 + (0.01597 \cdot BSA)$

Newburger JW, Takahashi M, Gerber MA, Gewitz MH, Tani LY, Burns JC, Shulman ST, Bolger AF, Ferrieri P, Baltimore RS, Wilson WR, Baddour LM, Levison ME, Pallasch TJ, Falace DA, Taubert KA. Diagnosis, treatment, and long-term management of Kawasaki disease: a statement for health professionals from the Committee on Rheumatic Fever, Endocarditis and Kawasaki Disease, Council on Cardiovascular Disease in the Young, American Heart Association. Circulation. 2004 Oct 26;110(17):2747-71.

Other guidelines:
Wyman W. Lai, MD, MPH, FASE, Tal Geva, MD, FASE, Girish S. Shirali, MD, Peter C. Frommelt, MD, Richard A. Humes, MD, FASE, Michael M. Brook, MD, Ricardo H. Pignatelli, MD, and Jack Rychik, MD. Guidelines and Standards for Performance of a Pediatric Echocardiogram: A Report from the Task Force of the Pediatric Council of the American Society of Echocardiography. J American Society of Echocardiography 2006; 19:1413-1430.

Challenges to Implementation

No electronic medical records or electronic echocardiographic reports.

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Metric #: 020
Effective: 06.01.2016

Genetic Testing in Tetralogy of Fallot Patients	
Measure Description: Proportion of Tetralogy of Fallot (ToF) patients who received a test for 22q11.2 deletion.	
Numerator	Number of ToF patients who received or had an order for 22q11.2 deletion testing any time in their medical history.
Denominator	Number of patients, ≤ 18 years old, with ToF who had a visit during the measurement period.
Denominator Exclusions	• Patient or parent refusal • Patients with repaired TOF with A-V canal, Pulmonary Atresia/MAPCAS or TOF with absent valve. • Other known genetic diagnoses (e.g. Trisomy 21, 13, 18 and Alagille syndrome)
Denominator Exceptions	None
Definitions/Notes	None
Measurement Period	Quarterly
Sources of Data	Medical Record
Attribution	This measure should be reported by qualified providers with experience and expertise in this modality
Care Setting	Outpatient

Rationale

These measures are meant to be applied to all patients with a 'typical' tetralogy of Fallot repair and may not be suitable for those smaller groups with more complex subtypes. Repaired TOF patients with A-V canal, Pulmonary Atresia/MAPCAS or TOF with absent valve will be excluded. Those with major underlying genetic disorders (e.g. Trisomy 21, 13, 18) will also be excluded from this set of measures.

Patients with TOF can have significant associated genetic syndromes or chromosomal anomalies in up to 25% of cases, including trisomies 21, 18 and 13, Alagille syndrome and others. Up to 15% of cases of ToF have 22q ll.2 deletion (including 6% in those with normal aortic arch and branching). This testing is important as it can have implications on the management of the patient as well as on the counseling of the family.

Clinical Recommendation(s)

ACC/AHA Guidelines

1. Wamcs CA, Williams RG, Bashore TM, Child JS, Connolly HM, Dearani JA, del Nido P, Fasulcs JW, Graham TP, J r., l lijazi ZM, Hunt SA, King ME, Landzberg MJ, Miner PD, Radford MJ, Walsh EP, Webb GO, Smith SC, Jr., Jacobs AK, Adams CD, Anderson JL, Antman EM, Buller CE, Creager MA, Ettinger SM, Halperin JL, Krumholz liM, Kushner FG, Lytle BW, Nishimura RA, Page RL, Riegel B, Tarkington LG, Yancy CW. Ace/aha 2008 guidelines for the management of adults with congenital heart disease: A report of the American College of Cardiology/American Heart Association task force on practice guidelines (writing committee to develop guidelines on the management of adults with congenital heart disease). Developed in collaboration with the American Society of Echocardiography, Heart Rhythm Society, International Society for Adult Congenital Heart

Disease, Society for Cardiovascular Angiography and Interventions, and Society of Thoracic Surgeons. Journal of the American College of Cardiology. 2008;52:c1 43-263

Other guidelines:

1. Pierpont MEet al. Genetics of congenital Heart defects: current knowledge: a scientific statement from the American Heart Association, council on Cardiovascular Disease in the Young. Circulation 2007; 11 5:3015-38.
2. Silversidcs CK, Kiess M, Beauchesne L, Bradley T, Connell y M, Niwa K, Mulder B, Therrien J. Canadian Cardiovascular Society 2009 Consensus Conference on the management of adults with congenital heart disease: outflow tract obstruction, coarctation of the aorta, tetralogy of Fallot, Ebstein anomaly and Marfan'ssyndrome. Qill.1 2010 Mar;26(3):e80-97.
3. Mom ma K, Takao A, Matsuoka R, et al. Tetralogy of Fallot associated with chromosome 22q11 .2 deletion in adolescents and young adults. Genet Mcd. 2001; 3:56-60.
4. Fahed ACet al. Genetics of congenital heart disease: the glass half empty. Circ Res 201 3; 11 2:707-20.
5. Amati F, MariA, Digilio MC, Mingarelli R, Marino 13, Giannotti A, Novelli G, Dallapiccola B. 22q l l deletions in isolated and syndromic patients with tetralogy of Fallot. /hun Genet. 1995; 95:479-482.
6. Goldmuntz E, Clark BJ, Mitchel LE et al. Frequency of22g II deletions in patients with conotruncal defects. J ACC 1998; 32:492-498

Challenges to Implementation

Data collection, submission and database management costs

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Metric #: 021
Effective: 06.01.2016

Echocardiogram performed as an outpatient during the first year of life for ASO patients

Measure Description: Proportion of Arterial Switch Operation (ASO) patients, 3-12 months, with at least one echocardiogram that reports on left ventricular function, aortic root dimensions, the degree of aortic regurgitation, the patency of the systemic and pulmonary outflow tracts, the branch pulmonary arteries, and the coronary arteries.

Numerator	Number of patients who had at least one echocardiogram between 3-12 months that reports on left ventricular function, aortic root dimensions, the degree of aortic regurgitation, the patency of the systemic and pulmonary outflow tracts, the branch pulmonary arteries, and the coronary arteries. ***Note:*** *Echocardiogram must report on ALL the above elements to meet the numerator criteria.*
Denominator	Number of ASO patients, 12-36 months old, who had at least one outpatient cardiology clinic visit during the measurement period.
Denominator Exclusions	Patients/parents who refuse the test.
Denominator Exceptions	None
Definitions/Notes	None
Measurement Period	Quarterly
Sources of Data	Medical Record, or echocardiographic archiving system.
Attribution	This measure should be reported by the departmental quality manager.
Care Setting	Outpatient

Rationale

Patients after ASO are at risk of myocardial dysfunction, aneurysm of the ascending aorta, aortic regurgitation, systemic and pulmonary outflow obstruction and branch pulmonary arterial stenosis.

1. Schwartz ML, Gauvreau K, del Nido P, Mayer JE, Colan SD. Long-term predictors of aortic root dilation and aortic regurgitation after arterial switch operation. Circulation. 2004;110(11 Suppl 1):II128-32.
2. Massin MM, Nitsch GB, Däbritz S, Seghaye MC, Messmer BJ, von Bernuth G. Growth of pulmonary artery after arterial switch operation for simple transposition of the great arteries. Eur J Pediatr. 1998 Feb;157(2):95-100.
3. Losay J, Touchot A, Capderou A, Piot JD, Belli E, Planché C, Serraf A. Aortic valve regurgitation after arterial switch operation for transposition of the great arteries: incidence, risk factors, and outcome. J Am Coll Cardiol. 2006;47(10):2057-62.
4. Hutter PA, Thomeer BJ, Jansen P, Hitchcock JF, Faber JA, Meijboom EJ, Bennink GB. Fate of the aortic root after arterial switch operation. Eur J Cardiothorac Surg. 2001;20(1):82-8.
5. Khairy P, Clair M, Fernandes SM, Blume ED, Powell AJ, Newburger JW, Landzberg MJ, Mayer JE Jr. Cardiovascular outcomes after the arterial switch operation for D-transposition of the great arteries. Circulation.2013;127(3):331-9.

Clinical Recommendation(s)
ACC/AHA Guidelines N/A Other guidelines: N/A
Challenges to Implementation
It may not be possible to obtain all of the information in all patients, for these, comments should be made that attempts had been undertaken to obtain all of the information.

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Metric #: 022
Effective: 06.01.2016

Periodic neurodevelopmental assessment for ASO patients

Measure Description: Proportion of Arterial Switch Operation (ASO) patients, 2-5 years old, who were recommended to have a neurodevelopmental evaluation.

Numerator	Number of patients with at least one documented recommendation for a neurodevelopmental evaluation in their medical chart between the ages of 2-5 years old.
Denominator	Number of ASO patients, ages 5-9 years, who have had at least one outpatient cardiology clinic visit during the measurement period
Denominator Exclusions	None
Denominator Exceptions	None
Definitions/Notes	N/A
Measurement Period	Quarterly
Sources of Data	Medical Record
Attribution	This measure should be reported by the departmental quality manager.
Care Setting	Outpatient

Rationale

Patients after ASO are at high risk of neurodevelopmental disorder.

1. Hövels-Gürich HH, Seghaye MC, Schnitker R, Wiesner M, Huber W, Minkenberg R, Kotlarek F, Messmer BJ, Von Bernuth G. Long-term neurodevelopmental outcomes in school-aged children after neonatal arterial switch operation. J Thorac Cardiovasc Surg. 2002 Sep;124(3):448-58.
2. Marino BS, Lipkin PH, Newburger JW, Peacock G, Gerdes M, Gaynor JW, Mussatto KA, Uzark K, Goldberg CS, Johnson WH Jr, Li J, Smith SE, Bellinger DC, Mahle WT; American Heart Association Congenital Heart Defects Committee, Council on Cardiovascular Disease in the Young, Council on Cardiovascular Nursing, and Stroke Council. Neurodevelopmental outcomes in children with congenital heart disease: evaluation and management: a scientific statement from the American Heart Association. Circulation. 2012 Aug 28;126(9):1143-72.

Clinical Recommendation(s)

ACC/AHA Guidelines

Children with CHD are at increased risk of developmental disorder or disabilities or developmental delay.

Periodic developmental surveillance, screening, evaluation, and reevaluation throughout childhood may enhance identification of significant deficits, allowing for appropriate therapies and education to enhance later academic, behavioral, psychosocial, and adaptive functioning. (Marino BS et al.)

Other guidelines: N/A

Challenges to Implementation
None

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Metric #: 023
Effective: 06.01.2016

Assessment of ASO patient lipid profile

Measure Description: Proportion of Arterial Switch Operation (ASO) patients, with documentation of a fasting lipid profile by age 11

Numerator	Number of patients with at least one documented fasting lipid profile between the ages of 2 and 11 years.
Denominator	Number of ASO patients, ages 11-15 years, who had an outpatient cardiology clinic visit during the measurement period.
Denominator Exclusions	Patients who refused the lipid profile.
Denominator Exceptions	None
Definitions/Notes	None
Measurement Period	Quarterly
Sources of Data	Medical Record
Attribution	This measure should be reported by the departmental quality manager.
Care Setting	Outpatient

Rationale

Patients after ASO are at high risk of acquired cardiovascular disease.

1. Expert Panel on Integrated Guidelines for Cardiovascular Health and Risk Reduction in Children and Adolescents; National Heart, Lung, and Blood Institute. Expert panel on integrated guidelines for cardiovascular health and risk reduction in children and adolescents: summary report. Pediatrics. 2011 Dec;128 Suppl 5:S213-56.
2. Pasquali SK, Marino BS, Powell DJ, McBride MG, Paridon SM, Meyers KE, Mohler ER, Walker SA, Kren S, Cohen MS. Following the arterial switch operation, obese children have risk factors for early cardiovascular disease. Congenit Heart Dis. 2010 Jan-Feb;5(1):16-24.

Clinical Recommendation(s)

ACC/AHA Guidelines

Other guidelines: Expert Panel on Integrated Guidelines for Cardiovascular Health… Pediatrics Dec 2011

9 to 11 years	**Universal Screening** Non-FLP: **Calculate non-HDL Cholesterol:** **Non-HDL cholesterol = TC – HDL cholesterol** If non-HDL ≥ 145 mg/dL ± HDL < 40 mg/dL[b]: Obtain FLP twice, average results OR FLP: If LDL cholesterol ≥ 130 mg/dL ± non-HDL cholesterol ≥ 145 mg/dL ± HDL cholesterol < 40 mg/dL ± triglycerides ≥ 100 mg/dL If < 10 y, ≥ 130 mg/dL if ≥ 10 y: Repeat FLP, average results	Grade B Strongly recommend

Challenges to Implementation
None

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Transition planning for ASO patients

Measure Description: Proportion of Arterial Switch Operation (ASO) patients, ≥ 18 years old, with documentation of transition planning within 2 years.

Numerator	Number of patients with at least one documented transition plan[1] in their medical record in the past 2 years from the clinic visit.
Denominator	Number of ASO patients, age ≥ 18 years, who had an outpatient pediatric cardiology clinic visit during the measurement period and were also seen at the clinic in the past 2 years from the visit.
Denominator Exclusions	None
Denominator Exceptions	None
Definitions/Notes	**1. Transition Plan**: should include documentation regarding their medical cardiac destination (i.e. indication of where the patient will receive their follow-up cardiac care) and ongoing insurance coverage (i.e. indication that the patient's payment options were explored)
Measurement Period	Quarterly
Sources of Data	Medical Record
Attribution	This measure should be reported by the departmental quality manager.
Care Setting	Outpatient

Rationale

Adults with CHD are often lost to follow-up and present with significant complications.

1. Reid GJ, Irvine MJ, McCrindle BW, Sananes R, Ritvo PG, Siu SC, Webb GD. Prevalence and correlates of successful transfer from pediatric to adult health care among a cohort of young adults with complex congenital heart defects. Pediatrics. 2004 Mar;113(3 Pt 1):e197-205.
2. Gurvitz M, Valente AM, Broberg C, Cook S, Stout K, Kay J, Ting J, Kuehl K, Earing M, Webb G, Houser L, Opotowsky A, Harmon A, Graham D, Khairy P, Gianola A, Verstappen A, Landzberg M; Alliance for Adult Research in Congenital Cardiology (AARCC). Prevalence and Predictors of Gaps in Care Among Adult Congenital Heart Disease Patients (The Health, Education and Access Research Trial: HEART-ACHD). J Am Coll Cardiol. 2013 (in press)
3. Sable C, Foster E, Uzark K, Bjornsen K, Canobbio MM, Connolly HM, Graham TP, Gurvitz MZ, Kovacs A, Meadows AK, Reid GJ, Reiss JG, Rosenbaum KN, Sagerman PJ, Saidi A, Schonberg R, Shah S, Tong E, Williams RG; American Heart Association Congenital Heart Defects Committee of the Council on Cardiovascular Disease in the Young Council on Cardiovascular Nursing, Council on Clinical Cardiology, and Council on Peripheral Vascular Disease. Best practices in managing transition to adulthood for adolescents with congenital heart disease: the transition process and medical and psychosocial issues: a scientific statement from the American Heart Association. Circulation. 2011 Apr 5;123(13):1454-85.

Clinical Recommendation(s)

ACC/AHA Guidelines

The pediatric cardiology provider should initiate and work together with the adolescent on a transition plan using a transition resource binder and/or health "passport" ***(Class I; Level of Evidence C). Sable et***

al. 2011.
Other guidelines: N/A
Challenges to Implementation
None
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<table>
<tr><th colspan="2">Echocardiography Diagnostic Accuracy</th></tr>
<tr><td colspan="2">Measure Description: The proportion of potentially preventable and clinically important inaccurate diagnoses among congenital heart surgical patients.</td></tr>
<tr><td>Numerator</td><td>Number of congenital heart surgeries with one or more clinically important inaccurate preoperative echocardiographic diagnoses[2] (moderate clinical impact or greater[3]) that are possibly preventable[4] or preventable[4] determined within 15 days after surgical procedure.</td></tr>
<tr><td>Denominator</td><td>Number of congenital heart surgical patient who underwent preoperative echocardiography during the measurement period</td></tr>
<tr><td>Denominator Exclusions</td><td>• Non-primary cardiac operation preoperative echocardiograms (e.g. sternal closure or wire removal or cannulation/decannulation for extracorporeal support), preoperative studies performed from “outside” echocardiography laboratories.</td></tr>
<tr><td>Denominator Exceptions</td><td>None</td></tr>
<tr><td>Definitions/Notes</td><td>1. Preoperative echocardiogram: The echocardiogram or echocardiography report that is primarily used for surgical planning or echocardiogram report that includes the complete anatomic elements used for surgical planning.
2. Inaccurate Diagnoses: are defined as diagnoses that are unintentionally delayed, wrong or missed as judged from eventual appreciation of the existing data or of more definitive information.
3. Clinical Impact
<table>
<tr><th>Clinical Impact</th><th>Clinical Correlate</th><th>Example</th></tr>
<tr><td>Minor</td><td>No change in patient management or clinical course; no adverse outcome</td><td>Undiagnosed left superior vena cava to intact coronary sinus discovered intra-operatively in patient undergoing surgery for patent ductus arteriosus ligation</td></tr>
<tr><td>Moderate</td><td>Alteration in patient management or clinical course without adverse patient event</td><td>Undiagnosed patent ductus arteriosus but closed at surgery in patient undergoing ventricular septal defect closure</td></tr>
<tr><td>Severe</td><td>Adverse event contributing to patient injury; or error contributing to the performance of an unnecessary/additional invasive procedure; or error that contributed to patient demise</td><td>Inaccurate diagnosis of atrial septal defect contributing to performance of unnecessary cardiac surgery; Missed diagnosis of anomalous origin of left coronary artery contributing to a myocardial infarction and death</td></tr>
</table>
4. Preventability</td></tr>
</table>

Preventability	Definition	Example
Preventable	Error is preventable if accurate diagnosis is expected by the available images, imaging modality and/or imaging conditions (i.e. the diagnosis is readily apparent on study images but is not reported)	An echocardiogram image clearly demonstrates a patent ductus arteriosus by 2D and color Doppler but the study is interpreted as no patent ductus arteriosus
Possibly preventable	Possibly preventable if an accurate diagnosis may be expected by echocardiography and/or imaging conditions but may have required a reasonably different technique such as complete anatomic sweep or use of color Doppler	Failing to diagnose an aortopulmonary window due to incomplete 2D and lack of color Doppler interrogation of the aorta and pulmonary artery
Not preventable	Accurate diagnosis is not possible if the images, imaging modality, or imaging conditions do not permit diagnosis	"Failure" to image a ligamentum arteriosum contributing to a vascular ring or "failure" to diagnose coronary artery anomaly by transthoracic echocardiogram during active CPR

Measurement Period	Quarterly
Sources of Data	Preoperative echocardiographic findings/report will be compared to findings from other tests (e.g., cardiac catheterization, cardiac magnetic resonance imaging, cardiac computed tomography), operative observations, subsequent echocardiographic examinations, autopsy and outpatient clinic records up to 14 days* following the date of the cardiac surgery. Data regarding presence of diagnostic error, severity and contributors as learned from quality improvement meetings can be another source. **time frame can be limited to duration of admission* The recommended optimal approach is that if an inaccurate diagnosis is determined to be present, the categorization of clinical impact (severity) and preventability will take place during each echocardiography laboratories' quality meeting
Attribution	The echocardiography laboratory would collect, review, categorize and report their own data internally.
Care Setting	Outpatient or inpatient

Rationale
Quality in diagnostic imaging is critically related to diagnostic accuracy.

Inaccurate imaging findings may adversely impact patient safety and/or alter patient management.

Quality review is required of echocardiography laboratories for accreditation.

Patient risk factors for diagnostic error include weight < 5 Kg, moderate or complex anatomy, uncommon heart disease. Situational risk factors include echocardiograms performed and interpreted overnight and during weekends and unsedated children <36 months. Common anatomic features involved with diagnostic error include coronary arteries, aortic arch/branching and pulmonary veins.

Clinical Recommendation(s)

ACC/AHA guidelines

Spertus JA, et al; ACCF/AHA Task Force on Performance Measures. ACCF/AHA new insights into the methodology of performance measurement: a report of the American College of Cardiology Foundation/American Heart Association Task Force on performance measures. J Am Coll Cardiol. 2010 Nov 16;56(21):1767-82

Other guidelines:

Benavidez OJ, Gauvreau K, Jenkins KJ, Geva T. Diagnostic errors in pediatric echocardiography: development of taxonomy and identification of risk factors. Circulation. 2008 Jun 10;117(23):2995-3001

Stern KW, Gauvreau K, Geva T, Benavidez OJ. The impact of procedural sedation on diagnostic errors in pediatric echocardiography. J Am Soc Echocardiogr. 2014 Sep; 27(9):949-55.

Benavidez OJ, Gauvreau K, Geva T. Diagnostic errors in congenital echocardiography: importance of study conditions. J Am Soc Echocardiogr. 2014 Jun; 27(6):616-23.

Challenges to Implementation

1. Data collection and re-review of images requires time
2. Adjudication of discrepancy of imaging findings and other data will need to be fairly determined during QI meetings
3. This metric is not useful for centers that do not perform cardiac surgery

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This metric development was an effort of the ACPC Section's Quality Metrics Work Group led by Leo Lopez, M.D., F.A.C.C. The College is grateful for the contributions of the following authors:
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Appendix: Case Review Process (Figure 1)

- This quality improvement activity will involve preoperative echocardiograms from patients presenting for congenital heart surgery.
- Data Collection Strategies
    - Full Review: 100% of cardiac surgical cases
    - Sample Review: 20 consecutive surgical cases with preoperative echocardiograms performed at the participating laboratory reviewed quarterly (100 cases annually)
- Surgical cases under review would be entered into a Non-Invasive Quality Improvement Database (NIQID) or spreadsheet (Figure 2)
- Secondary case review of the preoperative echocardiographic images for patients presenting for congenital heart surgery.
    - Staff cardiologists/cardiology fellows/trained sonographers from the echocardiography group will perform this review.
    - The preoperative echocardiographic findings will be compared to findings from other tests (e.g., cardiac catheterization, cardiac magnetic resonance imaging, and cardiac computed tomography), intraoperative observations, subsequent echocardiographic examinations, and autopsy and outpatient clinic records up to 15 days following the date of the cardiac surgery.
        - In many centers the preoperative echocardiograms undergo a secondary review prior to a child having cardiac surgery
- A case suspected of having an inaccurate diagnosis (candidate cases) would be identified and noted in the a Non-Invasive Quality Improvement Database or spreadsheet
- Among the candidate cases, the relevant clinical and image data related to the inaccurate diagnosis will be presented at a monthly Non-Invasive Quality Improvement Seminar
- A consensus based review of the case and the ensuing discussion will be used to finalize categorization of the inaccurate diagnosis type, severity, preventability and contributor. (Benavidez, et al. *Circulation* 2008)
- Surgical cases under review with a minimum dataset would be entered into a Non-Invasive Quality Improvement Database or spreadsheet
    - Minimal data set includes age, initial diagnosis, presence of diagnostic error, anatomic segment of diagnostic error, final diagnosis, clinical impact, preventability and primary contributor
    - The finalized categorization will be entered into NIQID
- Reporting Strategies
    - Diagnostic Error Rate: Total number of preoperative cases with clinically important, potentially preventable diagnostic errors over the total number of preoperative echocardiograms
    - Diagnostic Accuracy Rate: Total number of preoperative cases with accurate diagnoses over the total number of preoperative echocardiograms

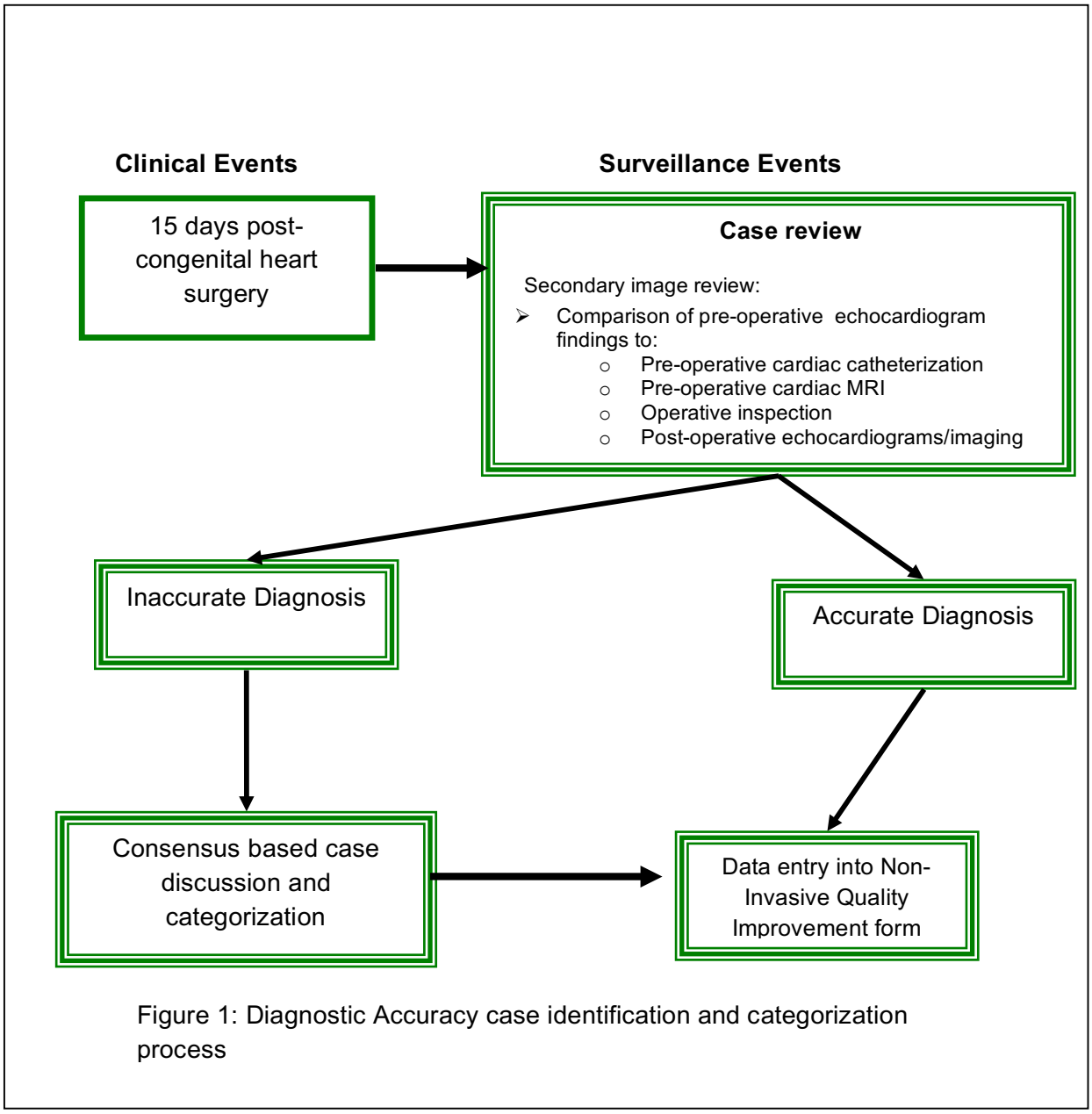

Figure 1: Diagnostic Accuracy case identification and categorization process

Figure 2. Example spreadsheet – minimal dataset

Patient	Age	Initial diagnosis	Accurate Diagnosis?	Final diagnosis	Method of discovery	Clinical impact	Preventability	Contributor
JJ1/1/2001	14 year	Normal	No	Coarctation	Review of echocardiogram	Moderate	Preventable	Mis-identification of study images
AB 2/2/2013	1 year	ASD secundum	No	ASD secundum and muscular VSD	Subsequent echocardiogram	Minor	Possibly preventable	Incomplete examination of the ventricular septum
DC 3/1/2010	4 years	ASD primum and cleft mitral valve	Yes	ASD primum and cleft mitral valve		--	--	--

Initial Transthoracic Echocardiogram Image Quality	
Measure Description: This metric will assess the average image quality score, as measured by the *Image Quality Assessment Tool* (Appendix 1), for initial transthoracic echocardiograms designated as complete studies (either inpatient or outpatient) for patients with structurally normal hearts.	
Numerator	The sum of the *Image Quality Assessment Tool* (Appendix 1) scores for all transthoracic echocardiograms included in the denominator.
Denominator	The number of initial transthoracic echocardiograms with a structurally normal heart designated as complete studies[1] during the measurement period
Denominator Exclusions	None
Denominator Exceptions	None
Definitions/Notes	1. **Complete Studies-** These are defined as those studies that are not labeled as limited or focused based on the echo lab protocol. The Image Quality Metric is intended to examine image quality when echo performance is not inhibited by reasons other than performance by the sonographer or fellow. Studies that are identified as incomplete due to either patient instability or patient agitation will not be included.
Measurement Period	Quarterly.
Sources of Data	Prospective flowsheet, retrospective review of stored echocardiographic images
Attribution	This metric will be reported by each echocardiography laboratory performing transthoracic echocardiography. Attending echo faculty will review sonographer studies unless most of the studies are performed by physicians. The recommended optimal approach is for data to be assessed quarterly and reviewed with the laboratory staff involved in the performance and interpretation of echocardiograms. As the sonographers do the vast majority of imaging, a review of their scans is a direct reflection of the lab quality as a whole, which is the goal of this assessment.
Care Setting	Inpatient or outpatient

Rationale

This metric assesses the image quality of an echocardiographic study, which is often a subjective assessment and impacted by vendor preference of the person performing the assessment. However, certain elements of image quality are standard, such as image orientation, two-dimensional image appearance, and presentation of color and spectral Doppler analysis. Diagnostic accuracy is tied to image quality, and thus a measure of image quality is crucial to the assessment of quality in echo. In imaging, the image is everything.

The initial study at an institution is selected as the target study population, since repeat studies may be limited; therefore investigation of these studies may not adequately reflect best performance of echocardiography within any given lab.

Clinical Recommendation(s)
Zoghbi et al. Recommendations for evaluation of the severity of native valvular regurgitation with two-dimensional and Doppler Echocardiography. *J Am Soc Echocardiogr* 2003;16:777-802. Lai WW et al. Guidelines and Standards for Performance of a Pediatric Echocardiogram: A Report from the Task Force of the Pediatric Council of the American Society of Echocardiography. J Am Soc Echocardiogr 2006;19:1413-30.
Challenges to Implementation
This metric has attempted to change a subjective assessment into an objective one. We have attempted to provide guidance with the use of qualifiers accompanying the yes/no answers. However, the validity and application of this tool remains worthy of further investigation, validation, and likely refinement. Another potential shortcoming inherent in the design of this metric is the exclusion of repeat studies for examination of image quality. Doing so restricts image quality assessment to a selected type of study, and may obfuscate any issues that may prevail in the larger population of studies performed in a lab. Thus, this assessment may be considered a "best case" assessment. A lab may consider opening the metric to a larger population for one quarter, to reveal if there are significant, clinically important discrepancies in image quality between first and follow up studies. For categories 2-4, we do not define what proportion of images need to meet the standard for it to be considered met. For instance, if half the Color Flow Imaging have a frame rate of 15 Hz, should that be graded as not meeting standards, or do we need a higher proportion, such as 90% are > 20 but 10% are not? We did not set such a goal because the tool would become unmanageable, as raters would then need to grade each and every image clipped to determine the proportion. Each lab should determine its goal and maintain that consistently, so that longitudinal quality trends can be tracked within a lab.
Authors
This metric development was an effort of the ACPC Section's Quality Metrics Work Group led by Leo Lopez, M.D., F.A.C.C. The College is grateful for the contributions of the following authors: **Terri Tacy, M.D.** Stanford Children's Health **Oscar Benavidez, M.D.** Massachusetts General Hospital **Lisa Hom, RN** Children's National Medical Center **Mark Fogel, M.D., F.A.C.C** Children's Hospital of Philadelphia **Ann Kavanaugh-McHugh, M.D., F.A.C.C.** Vanderbilt Children's Hospital **Vivek Allada, M.D., F.A.C.C.** Children's Hospital of Pittsburgh **Stacey Drant, M.D.** Children's Hospital of Pittsburgh

Appendix 1.

Image Quality Assessment Tool

Category 1: Image Orientation

For this category only, please assess whether any image collected meets the standards described below (in italics). The rationale is that it may take several attempts to find the ideal image orientation in a patient. Thus if that is achieved within the study, then the goal of appropriate image orientation has been accomplished.

	YES	NO	
1.	☐	☐	Parasternal long axis image *The septum is nearly horizontal, and deviates less than 30° from the horizontal plane. The aortic valve and mitral valve are each displayed, as is the proximal aorta. At least half of the length of the ventricular septum seen.*
2.	☐	☐	Parasternal short axis image *When viewed at the base of the heart, the tricuspid, pulmonary, and aortic valves are visible.*
3.	☐	☐	Apical 4 chamber *The LV apex is centered over the transducer. The septum is nearly vertical, and deviates less than 30° from the vertical plane. Both TV and MV are visible.*
4.	☐	☐	Subcostal sagittal view *The subcostal views includes a view of the SVC and of the IVC, (when applicable) as well as a view through the right ventricular outflow tract in line with the flow.*
5.	☐	☐	Suprasternal notch view *The long axis of the arch is seen from the ascending to the proximal descending aorta*

For the remaining three categories, indicate if the study adheres to the ideal image quality standards, which are summarized below each category for clarity and consistency.

Category 2: Two-Dimensional (2D) Imaging

Brightness level appropriate

Agree	Somewhat Agree	Disagree
☐	☐	☐

(Impacted primarily by gain, time gain compensation (TGC), dynamic range)

Ideal image quality standard: Appropriate brightness involves retention of pixel independence on 2D imaging, resulting in preserved spatial resolution. The pericardium is visible, but its brightness does not bleed into the endocardium. The ventricular cavity is easily defined, and the border of the ventricular cavity with the

endocardium is clearly visible from base to apex. *The endovascular spaces (coronary arteries, pulmonary veins, aortic arch) are easily defined, and the endovascular border with the vascular wall is clearly visible*.

Needs improvement: When brightness is not appropriate, 2D clips show an image that (1) is so dark that certain elements of the anatomy are not visible, or (2) is so bright that pixels lack spatial clarity and spread to adjacent areas, or (3) involves background noise that impedes image detail such as endocardial surface delineation.

Balanced penetration: resolution

Agree	Somewhat Agree	Disagree
☐	☐	☐

(Impacted primarily by imaging frequency [probe selection])

Ideal image quality standard: Balanced penetration: resolution preserves good differentiation between the blood pool and endocardium, and the region of interest is visible without loss of information at greater depth. Transducer and imaging modality selection results in maximal image resolution possible for given depth of imaging.

Needs improvement: When penetration and resolution are not balanced, 2D images show (1) insufficient penetration, with loss of image at greater depths (within area of interest), or (2) image resolution is very poor for a given depth of imaging or for the size of the structure of interest, or (3) inappropriate use of harmonic imaging, resulting in over-penetration of image, with loss of image detail.

Region of interest presented well

Agree	Somewhat Agree	Disagree
☐	☐	☐

(Impacted by depth and zoom settings)

Ideal image quality standard: When the region of interest is presented well, the image occupies about 75% of sector space, and the zoom settings are used appropriately for coronaries, aortic valve, etc.

Needs improvement: When the region of interest is not presented well, the anatomic focus of the images is either over-zoomed with missing data or the depth is set so that the region of interest is inappropriately small.

Category 3: Color Flow Imaging

Frame rate appropriate

Agree	Somewhat Agree	Disagree
☐	☐	☐

(Impacted by imaging frequency [probe selection], color flow imaging (CFI), box size, depth of imaging)

Ideal image quality standard: An appropriate frame rate for CFI clips is 20 Hz or greater. Note: this value of 20 Hz refers to the frame rate of the image when CFI is applied.

Needs improvement: An inappropriate frame rate for CFI clips is less than 20 Hz.

Gain level appropriate

Agree	Somewhat Agree	Disagree
☐	☐	☐

(Impacted by imaging frequency [probe selection], gain settings)

Ideal image quality standard: When the gain level is appropriate, CFI clips display ideal color density and fill-in over structure being interrogated.

Needs improvement: When the gain level is not appropriate, CFI clips display (1) no color visible at all, or (2) color covers entire sector, or (3) visualization of anatomy is obscured by color, or (4) there is excessive color noise (speckle, or (5) the CFI is not diagnostic.

Nyquist limit settings appropriate

Agree	Somewhat Agree	Disagree
☐	☐	☐

(Impacted by imaging frequency [probe selection], Nyquist limit settings)

Ideal image quality standard: Nyquist limits in CFI appropriate for structure being interrogated are set so that frame rate and aliasing are balanced. Note: a specific value for Nyquist limit is not specified, as this limit will vary depending on the region of interrogation.

Needs improvement: When Nyquist limits are not set appropriately for structure being interrogated, CFI clips show significant aliasing in the entire sector, or is not diagnostic.

Category 4: Spectral Doppler Display (SDD)

Choice of pulsed wave (PW) or continuous wave (CW) Doppler appropriate

Agree	Somewhat Agree	Disagree
☐	☐	☐

Ideal image quality standard: The choice of spectral Doppler modality is appropriate when PW is used when pattern discernment is the goal of Doppler interrogation, whereas CW is used predominantly to determine peak gradient, especially when the Nyquist limit is exceeded on PW Doppler.

Needs improvement: The choice of spectral Doppler modality is inappropriate when the above standard is breached, or when high pulsed repetition frequency (HPRF) results in uninterpretable Doppler display.

Gain setting appropriate

Agree	Somewhat Agree	Disagree
☐	☐	☐

Ideal image quality standard: The Doppler gain setting is appropriate when SDD clips demonstrate full and clearly visible Doppler signals, spectral envelopes are full, and Doppler patterns are discernible.

Needs improvement: The Doppler gain setting is inappropriate when SDD clips show one of the following: (1) significant background noise, impairing ability to discern spectral envelope, (2) overgain resulting in display of overlying flow signals that impair ability to assess Doppler pattern (PW), or (3) inadequate gain likely leading to dropout of signal in the spectral envelope.

Scale adjusted to provides maximal signal size

Agree	Somewhat Agree	Disagree
☐	☐	☐

Ideal image quality standard: The Doppler scale setting is appropriately set when the SDD clip demonstrates full and clearly visible Doppler signals, spectral envelopes are full, and Doppler patterns are discernible.

Needs improvement: The Doppler scale setting is inappropriately set when SDD clips utilize either a speed scale that results in (1) less than three interpretable beats to measure, or (2) a velocity scale that is not conducive to ideal measuring because of the scale being too small with cut-off Doppler peaks or too small with minimized Doppler patterns.

Image Quality Assessment WORKSHEET

Each worksheet is for ONE echo evaluation

Patient Name: _____ Date of Birth: _____

Sonographer: _____Date of Study: _____

Interpreter: _____ Location of Study: _____

Echo Machine: _____

Reviewer: _____Date of Review: _____

Time Spent for Review: _____

Category 1: Image Orientation

For this category only, if any image collected achieves the goals described below, the study can be rated "yes". The rationale is that it may take several attempts to find the ideal image orientation in a patient. Thus if that is achieved within the study, then the goal of appropriate image orientation has been accomplished. Score as 1 for "Yes" response, 0 for "No".

	YES	NO	
1.	☐	☐	Parasternal long axis image *The septum is nearly horizontal, and deviates less than 30° from the horizontal plane. The aortic valve and mitral valve are each displayed, as is the proximal aorta. The ventricular septum should be seen almost to the apex.*
2.	☐	☐	Parasternal short axis image *When viewed at the base of the heart, the tricuspid, pulmonary, and aortic valves are visible.*
3.	☐	☐	Apical 4 chamber *The LV apex is centered over the transducer. The septum is nearly vertical, and deviates less than 30° from the vertical plane. Both TV and MV are visible.*
4.	☐	☐	Subcostal sagittal view *The subcostal views include both a bicaval view (when applicable) and a view through the right ventricular outflow tract in line with the flow, with the pulmonary valve visible (when applicable).*
5.	☐	☐	Suprasternal notch view *The long axis of the arch is seen from the ascending to the proximal descending aorta*

For the remaining three categories, indicate if the study adheres to the ideal image quality standards. Score as 2 for "Agree" response, 1 for "somewhat Agree" 0 for "Disagree".

Category 2: Two-Dimensional (2D) Imaging

Agree	Somewhat Agree	Disagree	
☐	☐	☐	Brightness level appropriate
☐	☐	☐	Balanced penetration: resolution
☐	☐	☐	Region of interest presented well

Category 3: Color Flow Imaging

Agree	Somewhat Agree	Disagree	
☐	☐	☐	Frame rate appropriate
☐	☐	☐	Gain level appropriate
☐	☐	☐	Nyquist limit settings appropriate

Category 4: Spectral Doppler Display (SDD)

Agree	Somewhat Agree	Disagree	
☐	☐	☐	Choice of pulsed wave (PW) or continuous wave (CW) Doppler appropriate
☐	☐	☐	Gain level appropriate
☐	☐	☐	Scale adjusted to provides maximal signal size

TOTAL SCORE: (Maximum = 23)

Comprehensive Echocardiographic Examination	
Measure Description: This metric will assess the average completeness score, as measured by the *Comprehensiveness Exam Assessment* worksheet (Appendix 1), of initial transthoracic echocardiograms designated as complete studies (either inpatient or outpatient) for patients with hearts interpreted as structurally normal	
Numerator	The sum of the *Comprehensiveness Exam Assessment* worksheet (Appendix 1) scores for all transthoracic echocardiograms included in the denominator.
Denominator	The number of initial transthoracic echocardiograms designated as complete studies[1] during the measurement period for patients with structurally normal hearts.
Denominator Exclusions	None
Denominator Exceptions	None
Definitions/Notes	1. **Complete Studies-** Studies that are identified as being focused, limited, or incomplete due to either patient instability or patient agitation will not be included.
Measurement Period	Quarterly
Sources of Data	Prospective flowsheet, retrospective review of stored echocardiographic images
Attribution	This metric will be reported by each echocardiography laboratory performing transthoracic echocardiography. The recommended optimal approach is for data to be assessed quarterly by the laboratory director or their designate and reviewed with the laboratory staff involved in the performance and interpretation of echocardiograms.
Care Setting	Inpatient or outpatient
Rationale	
Adequate image acquisition in echocardiography relies on a variety of components. The integration of two-dimensional imaging, color Doppler, and spectral Doppler is required for a comprehensive echocardiographic examination. A complete transthoracic echocardiogram is one that images all cardiac chambers, valves, and great vessels from a series of multiple orthogonal views and performs Doppler assessment of antegrade and retrograde flow across all cardiac valves, as well as the atrial and ventricular septa. Important echocardiographic components, or elements, that are not identified on echocardiograms in a specific echocardiography laboratory may result from limitations in image quality for a particular patient, incomplete delineation of the echo protocol to ensure assessment of these elements, or incomplete training of those tasked with obtaining the images. Assessment of the number of required elements identified as outlined in this quality improvement activity provides a method to evaluate compliance with imaging standards and may suggest to the echo lab particular processes that need revision.	
Clinical Recommendation(s)	

1) Picard et al. American Society of Echocardiography Recommendations for Quality Echocardiography Laboratory Operations. J Am Soc Echocardiogr 2011;24:1-10
"The standard integration of two-dimensional, color, and spectral Doppler modalities is required to provide a comprehensive evaluation by TTE and TEE imaging. Assessment of the number of complete studies with all components (two-dimensional, color, and Doppler) reported provides a method to estimate compliance with current imaging standards. This should be measured for each sonographer annually.
A complete TTE or TEE study is one that images all cardiac chambers, valves, and great vessels from a series of multiple views and performs Doppler assessment of antegrade and retrograde flow across all cardiac valves, as well as the atrial and ventricular septa."

2) Lai WW et al. Guidelines and Standards for Performance of a Pediatric Echocardiogram: A Report from the Task Force of the Pediatric Council of the American Society of Echocardiography. J Am Soc Echocardiogr 2006;19:1413-30.

3) The IAC Standards and Guidelines for Pediatric Echocardiography Accreditation. Updated 8/2012.
"1.6.1.1B Complete Examination: Includes standard views from multiple planes including views of all cardiac structures and selected extracardiac structures."

4) Lopez L et al. Recommendations for Quantification Methods During the Performance of a Pediatric Echocardiogram: A Report From the Pediatric Measurements Writing Group of the American Society of Echocardiography Pediatric and Congenital Heart Disease Council. J Am Soc Echocardiogr 2010;23:465-495

Challenges to Implementation

Time required identifying, selecting and reviewing echocardiograms.

Authors

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Appendix 1.

Comprehensive Exam Assessment WORKSHEET

Each worksheet is for ONE echo evaluation

Patient Name: _____ **Date of Birth:** _____

Sonographer: _____ **Date of Study:** _____

Interpreter: _____ **Location of Study:** _____

Echo Machine: _____

Reviewer: _____ **Date of Review:** _____

Time Spent for Review: _____

Indicate if each item listed is evaluated. Score as 1 for "Yes" response, 0 for "No".

SITUS, VEINS, ATRIA

YES	NO	
☐	☐	Liver and stomach shown (transverse plane)
☐	☐	Cardiac position
☐	☐	IVC and aorta demonstrated in relation to spine (transverse plane)
☐	☐	IVC, and SVC evaluated, imaging and color (in at least one view)(+/- azygous connection to SVC)
☐	☐	IVC connection to atrium documented in at least one view
☐	☐	Two left and two right pulmonary veins evaluated by color Doppler
☐	☐	Coronary sinus visualized
☐	☐	Atrial septum evaluated by imaging and color Doppler (in at least one view)

VENTRICLES

YES	NO	
☐	☐	Ventricular septum is evaluated by color Doppler (in at least two views)
☐	☐	Imaging for qualitative RV function assessment (in at least two views)
☐	☐	Imaging of LV function (in at least two views)
☐	☐	Evaluation adequate for measurement of LV end diastolic internal dimension or volume

☐	☐	Evaluation adequate for measurement of LV end systolic internal dimension or volume
☐	☐	Evaluation adequate for measurement of LV end diastolic septal and ventricular end diastolic wall thickness or LV mass
☐	☐	LV Outflow evaluated by color Doppler/spectral Doppler (in at least one view)
☐	☐	RV Outflow evaluated by color/spectral Doppler (in at least one view)

AV VALVES, SEMILUNAR VALVES

YES	NO	
☐	☐	TV imaging (adequate for measurement)/color/spectral Doppler (in at least one view)
☐	☐	TR jet evaluation by Doppler (in two views, if available)
☐	☐	MV imaging (adequate for measurement) /color/spectral Doppler (in at least one view)
☐	☐	MV in short axis (with and without color Doppler)
☐	☐	PV evaluated by imaging (adequate for measurement)/color Doppler/spectral Doppler (in at least two views)
☐	☐	AoV evaluated by imaging/color Doppler/spectral Doppler (in at least one view)
☐	☐	Coronary arteries evaluated by imaging/color Doppler in parasternal short-axis

VESSELS

YES	NO	
☐	☐	Evaluation adequate for measurement of AoV/Ao root/Ao sinotubular junction diameters in parasternal long-axis
☐	☐	Branch PA's evaluated by imaging/color Doppler/spectral Doppler (in at least one view)
☐	☐	Patent ductus arteriosus excluded in at least one view
☐	☐	Ascending Ao evaluated by imaging/color Doppler/spectral Doppler in at least one view
☐	☐	Ao Arch sidedness and branching evaluated by imaging/color Doppler
☐	☐	Ao Arch evaluated by imaging/color Doppler/spectral Doppler in suprasternal long-axis
☐	☐	Abdominal aorta evaluated by color Doppler/PW spectral Doppler in subxiphoid short axis/sagittal plane

TOTAL SCORE (Maximum = 30):

Application of the Pediatric Appropriate Use Criteria (AUC) To Initial Outpatient Echocardiogram Orders	
Measure Description: This metric will assess the proportion of initial outpatient transthoracic echocardiograms (TTEs) performed for indications rated Rarely Appropriate. Indications related to one of the following 4 categories based on the tables in the AUC document[1] will be chosen for quarterly assessment. Detailed indications for each category are provided at the end of this form and in the data entry form. 1. Palpitations and arrhythmias 2. Syncope 3. Chest pain 4. Murmur	
Numerator	Number of TTEs included in the denominator that were ordered for AUC indications rated Rarely Appropriate.
Denominator	Twenty initial outpatient TTEs ordered by any provider in patients ≤ 18 years of age for AUC indications related to any of the 4 categories listed above (palpitations and arrhythmias, syncope, chest pain or murmur). **Excluded Populations:** • Studies for which details of clinical indication are not available. • Patients with history of a previous evaluation with an echocardiogram. • Patients referred from inpatient services. • If a specific patient scenario is not available in the current AUC document
Period of Assessment	20 TTE studies every quarter.
Sources of Data	Retrospective review of medical records for 20 TTE orders for any of the 4 categories (palpitations and arrhythmias, syncope, chest pain or murmur). *Data collection sheet is attached.* This sheet has some optional components, but the rest are mandatory. Centers may choose to modify this sheet for collection of additional data.
Rationale	
Since 2005 the American College of Cardiology Foundation, in conjunction with other societies, has released Appropriate Use Criteria (AUC) for various diagnostic tests and procedures for adult patients. The first pediatric AUC were published in Nov 2014.[1] The primary intent of AUC is to evaluate patterns of care by physicians and improve resource utilization. The AUC have been designed to guide provider's decision-making at the time of ordering a test. Unlike guidelines that are very broad in their scope, the	

AUC provide indications with more specific clinical scenarios. AUC have served as an important quality improvement tool in adult cardiology and are being increasingly recognized as an important link in the chain of quality improvement processes by hospitals and accreditation bodies.[2] The first multicenter pediatric AUC implementation study reported that the overall rate for studies ordered for indications rated Rarely Appropriate was 12%, but there was a wide variation between physicians and centers.[3] Majority of the Rarely Appropriate indications were related to one of the four categories chosen for this metric. The current metric only includes patients who have undergone an echocardiogram, since it is an echocardiographic lab-based metric. It therefore does not address the issue of "underutilization" where an echocardiogram was not performed when it was indicated. However, this is not an area of significant concern based on recent data.[4] Application of this AUC quality metric in usual clinical care will help in benchmarking the appropriateness of care by various providers ordering echocardiograms. It will also provide the framework for labs to design educational activities to improve the appropriateness of echocardiograms ordered for initial outpatient evaluation of pediatric patients.

Clinical Recommendation(s)

1. Campbell RM, et al. ACC/AAP/AHA/ASE/HRS/SCAI/SCCT/SCMR/SOPE 2014 Appropriate Use Criteria for Initial Transthoracic Echocardiography in Outpatient Pediatric Cardiology. J Am Coll Cardiol 2014 Nov; 64(19):2039-2060.
2. The IAC Standards and Guidelines for Pediatric Echocardiography Accreditation. QI measure guidelines implemented on 2/3/2016:Section 2.1C The facility should evaluate the appropriateness of the initial outpatient transthoracic echocardiogram performed and categorize as: appropriate, may be appropriate; or rarely appropriate. There should be a mechanism for education of referring physicians to improve the appropriateness of testing.
3. Sachdeva R, et al. Pediatric Appropriate Use Criteria Implementation Project: A Multicenter Outpatient Echocardiography Quality Initiative. J Am Coll Cardiology 2015:66:1132-40.
4. Stern KWD, et al. Factors Influencing Pediatric Outpatient Transthoracic Echocardiography Utilization Before Appropriate Use Criteria Release: A Multicenter Study. J Am Soc Echocardiogr. 2017 Dec;30(12):1225-1233.

Attribution

This metric will be reported by each echocardiography lab performing pediatric TTE. Data will be assessed every quarter by the laboratory director or their designee and reviewed with the physicians ordering TTEs. The labs will be responsible for developing and instituting their own processes for improving appropriateness of TTE orders. Some such examples are, improving the order intake process, integration of AUC with the electronic order system and other educational interventions suggested at the end of this form. Some on-line educational resources and a sample Power-Point presentation have been included with this form. In addition, a sample letter for providing feedback to the providers is also attached here.

Method of Reporting

The overall lab AUC quality metric for each cycle will be reported as the percentage of studies performed for the indications rated Rarely Appropriate. The data collection sheet will auto-populate the lab aggregate data.

Challenges to Implementation

1. The AUC document does not include all possible case scenarios that could present to outpatient settings. In such instances the AUC indications would not be applicable, and the scenario should be considered "unclassifiable" and excluded from the metric.
2. Identification of patients for the 4 specific categories chosen for the metric may be challenging if the labs or clinics do not have any existing databases. The lab directors will have to determine how they will collect the data required for this metric based on their existing workflow.
3. Variations among labs in terms of their policies for accepting orders from outside physicians (open vs. closed labs) may influence the proportion of studies ordered by cardiologists versus non-cardiologists.
4. Different systems to receive echo orders (electronic/paper/others) and variations in who actually enters the echo orders (provider/sonographer/other clinic staff) may impact determination of the exact AUC indication if the clinical notes are not reviewed. Availability of detailed clinical information may vary depending on access to clinic notes. This will significantly impact assignment of AUC indication.

Instructions to complete the data collection form (Excel spreadsheet):

SECTION 1: Center characteristics

1. Fill out the center characteristics and information that will help collate data across centers.

SECTION 2: Patient and Study information

1. This section is *OPTIONAL* but may be helpful for internal tracking by the centers and for giving feedback to providers ordering echo.
2. Each line represents ONE patient/echo. At least twenty patients should be evaluated each quarter.
3. Study location is center specific if there are multiple clinic locations. Centers will use free text in this column based on their outpatient clinic model.
4. Ordering provider type has a drop down menu to choose from.

SECTION 3: Echo indication and AUC rating

1. This section is *MANDATORY.*

For *EACH ROW*: Fill in the echo order details for the patient.

1. INDICATION CLASS:
    a. Click on a cell under the column for "Indication Class,"
    b. Click the arrow to the RIGHT of the cell and a drop-down menu will appear
    c. Choose the appropriate indication: murmur, chest pain, syncope or palpitations and arrhythmias. (This will populate the cell for this patient).
2. INDICATION DESCRIPTION
    a. Select the specific AUC indication from the drop-down menu.
    b. Suggestion: As you review each patient, you may find it useful to refer to the AUC tables provided below to assign the category.
    c. The cells under the columns for "Indication Number" and "AUC rating" will get auto-populated after you choose the indication description.

SECTION 4: Summary of data

a. This section auto-populates based on information you have entered in SECTION 3.
b. This will automatically summarize the % of RARELY appropriate, MAYBE appropriate and APPROPRIATE from the list of patients you enter above

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)**

Appropriate Use Key: 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)**

Appropriate Use Key: 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)**

Appropriate Use Key: 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)**

Appropriate Use Key: A = Appropriate; M = May Be Appropriate; R = Rarely Appropriate
ECG = Electrocardiogram

Metric #: 029
Effective: 01.01.2021

Quality Metric TEE 1: Accuracy of Pediatric Pre-Cardiac Surgery Transesophageal Echocardiogram	
Measure Description: Diagnostic discrepancies of pre-cardiac surgery transesophageal echocardiogram (TEE) assessment in congenital heart disease patients.	
Numerator	Total number of pre-cardiac surgery TEEs with 1 or more major discrepancies* (see definitions) identified within 24 hours of surgery.
Numerator Exclusions	Structures that are attempted and cannot be reasonably or always imaged by the TEE examination (aortic arches, distal branch pulmonary arteries, vertical veins, anterior structures, inferior vena cava, inferior atrial septum, coronary arteries, BT shunts, Glenn shunts, or Fontan shunts).
Denominator	Total pre-cardiac surgery TEE reports.
Period of Assessment	Quarterly
Sources of Data	Post-cardiac surgery TEE, retrospective medical record review, and operative reports.

Definitions

*Diagnostic major discrepancy is defined as a discrepancy between the findings on the pre-operative TEE and surgical findings that changes the surgical plan (focused or comprehensive TEE). Discrepancies include the following:

1. Failure of reporting anatomic structures visualized on pre-cardiac surgery TEE
2. Failure of interrogating anatomic or hemodynamic elements
3. Failure of correct interpretation
    a. False positive (structure that was seen or reported when it is not present)
    b. False negative (structure that was not seen or reported when it is present)
    c. Incorrect diagnosis

Rationale
Inaccurate or incomplete imaging findings may adversely impact patient safety and/or alter patient management. Identification of discrepancies will guide tests of change to improve TEE accuracy. Quality review is required of echocardiography laboratories for accreditation. Evaluate and track granular details based on institutional preference (example worksheet attached).
Clinical Recommendation(s)
ACC/AHA guidelines Spertus JA, et al; ACCF/AHA Task Force on Performance Measures. ACCF/AHA new insights into the methodology of performance measurement: a report of the American College of Cardiology Foundation/American Heart Association Task Force on performance measures. J Am Coll Cardiol. 2010 Nov 16;56(21):1767-82 ASE/Other guidelines: Ayres NA, Miller-Hance W, Fyfe DA, Stevenson JG, Sahn DJ, Young LT, Minich LL, Kimball TR, Geva T, Smith FC, Rychik J. Indications and guidelines for performance of transesophageal echocardiography in the patient with pediatric acquired or congenital heart disease: report from the task force of the Pediatric Council of the American Society of Echocardiography. J Am Soc Echocardiogr. 2005 Jan;18(1):91-8. Benavidez OJ, Gauvreau K, Jenkins KJ, Geva T. Diagnostic errors in pediatric echocardiography: development of taxonomy and identification of risk factors. Circulation. 2008 Jun 10;117(23):2995-3001. Benavidez OJ, Gauvreau K, Geva T. Diagnostic errors in congenital echocardiography: importance of study conditions. J Am Soc Echocardiogr. 2014 Jun; 27(6):616-23.
Attribution
This measure should be reported by pediatric cardiologists at tertiary care children's hospital.

Method of Reporting
Pre-cardiac surgery TEE reports from tertiary care children's hospitals compared to the operative findings. **Implementation strategies:** • **Full Review** – 100% of pediatric cardiac surgical cases that require TEE **or** • **Sample Review** – 80 cases per year (20 consecutive surgical cases per quarter) or minimum criteria of 20 cases per year (minimum criteria of 5 cases per quarter)
Challenges to Implementation
No quality electronic medical records Not all cardiac centers have cardiac surgery Commitment and time of personnel
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Worksheet for institution to track granular details of major discrepancies.

Patient	Physician	Date of TEE study	Wt (kg)	Age	Type of TEE probe: 1. Micro 2. Pediatric 3. Adult	Type of TEEs: 1. Focused 2. Comprehensive*	What is the discrepancy?	Discrepancies: 1. Failure of reporting 2. Failure of interrogation	How was discrepancy found? 1. Surgical inspection 2. Retrospective image review

								3. Failure of correct interpretation a. False positive b. False negative c. Incorrect diagnosis	
EB	3	2/22/2018	20kg	6 yrs	2	1	VSD was missed on the TEE	2	1

***Comprehensive TEE is a full TEE evaluation of all cardiac structures within the limitation of TEE**

Metric #: 030
Effective: 01.01.2021

Quality Metric TEE 2: Transesophageal Echocardiogram Adverse Events	
Measure Description: Identifying transesophageal echocardiogram (TEE) with adverse events.	
Numerator	Number of TEEs with adverse events identified during a TEE assessment. Please see appendix for granular details to be tracked internally.
Denominator	All TEE assessment in the hospital.
Period of Assessment	Quarterly
Sources of Data	The operator within several day after TEE probe is removed or any adverse events recognized.

Definitions

Definition of major and minor adverse events:

Major adverse events:

1. Endotracheal dislodgement
2. Esophageal tear
3. Oral mucosa / GI injury that requires treatment
4. Deterioration of vital signs monitoring that requires treatment

Minor adverse events:

1. Teeth dislodgement
2. Oral mucosal /GI injury
3. Transient deterioration of vital signs monitoring (loss of arterial BP, dampening of arterial BP, desaturations)

Rationale

To decrease complications rates associated with TEE use in the hospital setting and to improve safety use of TEE in pediatric and congenital heart disease patients.

Quality review is required of echocardiography laboratories for accreditation.

Clinical Recommendation(s)

ACC/AHA guidelines

Spertus JA, et al; ACCF/AHA Task Force on Performance Measures. ACCF/AHA new insights into the methodology of performance measurement: a report of the American College of Cardiology Foundation/American Heart Association Task Force on performance measures. J Am Coll Cardiol. 2010 Nov 16;56(21):1767-82

ASE/Other guidelines:

Ayres NA, Miller-Hance W, Fyfe DA, Stevenson JG, Sahn DJ, Young LT, Minich LL, Kimball TR, Geva T, Smith FC, Rychik J. Indications and guidelines for performance of transesophageal echocardiography in the patient with pediatric acquired or congenital heart disease: report from the task force of the Pediatric Council of the American Society of Echocardiography. J Am Soc Echocardiogr. 2005 Jan;18(1):91-8.

Kallmeyer IJ, Collard CD, Fox JA, Body SC, Shernan SK. The safety of intraoperative transesophageal echocardiography: a case series of 7200 cardiac surgical patients. Anesth Analg. 2001 May;92(5):1126-30.

Attribution

This measure should be reported by any personnel who performed TEE.

Method of Reporting

Adverse events can be found in a log in the echocardiography laboratory and can help capture late adverse events that occur days after the TEE is performed.

Adverse events can be reported by any caregiver.

Appendix below to help facilitate reporting by personnel who perform TEE.

Implementation strategies:

- **Full Review** – 100% of pediatric cardiac surgical cases
- **Sample Review** – 100 cases per year (20 consecutive surgical cases per quarter)

Challenges to Implementation

Recognition of adverse events several days later after placement of TEE probe.

No documentation of adverse events after TEE use and no documentation in electronic platform after TEE are performed.

Rare events but this metric is meant to serve the echocardiography laboratory to document any adverse events that maybe related to the TEE procedure or the inappropriate use of TEE probes.

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Appendix

Name:					
DOB:					
Age:					
Weight:					
Date of Study:					
Performing TEE personnel					
TEE Adverse Events?	**Yes** □		**No** □		
Location:	**OR** □	**Cath lab** □	**ICU** □	**ER** □	**Other** □
Placement:	**Anesthesiologist** □		**Cardiologist** □		
Was history obtained to evaluate esophageal problems?	**Yes** □		**No** □		
Appropriate TEE probe size?	**Yes** □		**No** □		

Endotracheal dislodgement	**Yes □ = 2 points**	**No □**
Esophageal tear	**Yes □ = 2 points**	**No □**
Oral mucosa / GI injury that requires treatment	**Yes □ = 2 points**	**No □**
Deterioration of vital signs monitoring that requires treatment	**Yes □ = 2 points**	**No □**
Teeth dislodgement	**Yes □ = 1 point**	**No □**
Oral mucosal / GI injury	**Yes □ = 1 point**	**No □**
Transient deterioration of vital signs monitoring (loss of arterial BP, dampening of arterial BP, desaturations)	**Yes □ = 1 point**	**No □**
Total points out of 11 points		

Diagnostic Accuracy of Fetal Echocardiography	
This measure provides a mechanism for fetal echocardiography laboratories to record and analyze diagnostic discrepancies between fetal and postnatal findings.	
Numerator	Number of fetal patients with a moderate or severe discrepancy between prenatal and postnatal diagnosis.
Denominator	All fetal patients born during quarter with prenatal diagnosis of significant structural congenital heart disease (CHD), defined as known or highly suspected structural heart disease in the fetus that is expected to require surgical or catheter intervention within the first year of life. **Excluded Populations:** • Postnatal diagnoses not available (e.g. termination of pregnancy, fetal demise, transfer of care, lost to follow-up) • Uncertainty as to whether prenatal finding represents significant structural heart disease as defined above (e.g. possible aortic coarctation), and cases where there is expected evolution of pathology over time (e.g. pulmonary valve stenosis). Cases should only be included in the denominator if the family was counseled to *expect* an intervention, not if an intervention *may* be necessary.
Period of Assessment	Quarterly
Sources of Data	Comparison of prenatal imaging findings and reports with postnatal investigations and reports from echocardiography, cardiac magnetic resonance imaging, computed tomography, catheter angiography, surgical and/or pathologic inspection. In cases of discrepancies between fetal echocardiograms or changes in fetal diagnosis/assessment over gestation, the *most recent* fetal echocardiogram and assessment prior to gestation will be used as the prenatal diagnosis.
Rationale	
A significant, and increasing, proportion of CHD is diagnosed prenatally.[1] Prenatal diagnosis allows for advance counseling of the family and helps guide prenatal and postnatal diagnostic and therapeutic options.[2] Appropriate counseling and prenatal planning depends on accurate anatomic diagnosis. This metric provides a framework for fetal echocardiography laboratories to	

identify, categorize and analyze diagnostic discrepancies that impact care.

Clinical Recommendation(s)

Other guidelines:

Intersocietal Accreditation Committee (IAC):

The IAC Standards and Guidelines for Pediatric Echocardiography Accreditation, published 8/2015

"2.1.4.1C Correlation must be performed with any appropriate imaging modality, surgical findings or clinical outcomes for a minimum of four cases annually with at least two cases per relevant testing area (TTE, TEE, fetal) to be reviewed in QI meetings."

"*Correlation of Fetal Echocardiograms (if performed): For those patients who have undergone fetal echocardiograms and other diagnostic procedures (such as postnatal echocardiography, postnatal cardiac catheterization or angiography), or post mortem examination, the results of fetal echocardiograms and other procedures must be routinely compared with regard to the accuracy of the fetal echocardiography examination. Comparison studies for each physician responsible for the performance/interpretation of fetal echocardiograms in the facility must be accumulated by the facility and distributed to the physician. Statistics must be generated to ascertain the overall accuracy of the fetal echocardiograms being performed in the facility. A process for addressing discrepancies between echocardiogram examination results and results of other procedures must be in place.*"

Attribution

Potential cases of discrepancy may be identified and reported by anyone involved in the care of fetuses or infants with prenatal diagnosis of CHD to the medical director of the fetal echocardiography laboratory, or their designee. Centers should also systematically review all cases of prenatal diagnosis of CHD and compare pre and postnatal findings (see Method of Reporting, below)

All relevant imaging and clinical data for diagnostic discrepancies will be organized and presented at least quarterly at laboratory quality improvement meetings or another appropriate venue. The discussants may include, but should not be limited to: those performing and interpreting fetal echocardiograms (sonographers, fellows, attending physicians); practitioners involved in the care of families and fetuses with prenatal diagnoses of CHD (e.g. nurses, social workers, cardiologists, obstetricians); practitioners involved in providing care to infants with prenatal diagnosis of CHD (e.g. surgeons, interventionalists, intensivists). Consensus on categorization of discrepancy severity, preventability and contributing factors will be reached via group discussion. If

consensus cannot be reached, the medical director, or designee of their choice, may determine final categorizations.

Potential changes to practice should be considered in order to reduce the likelihood of repeating similar discrepancies in the future. Education of sonographers and clinicians may also be targeted based on the types of diagnostic discrepancies that are discovered.

Method of Reporting

Two mechanisms of reporting are recommended, passive and active.

Passive reporting: Potential diagnostic discrepancies may be identified and reported by anyone involved in the care of fetuses or infants with prenatal diagnosis of CHD to the medical director of the fetal echocardiography laboratory, or their designee. All such providers should be encouraged to report any potential discrepancies.

Active reporting: All cases with a prenatal diagnosis of CHD that were born should have their postnatal findings reviewed and compared with prenatal diagnosis by a designee of the medical director of the fetal echocardiography laboratory. Many centers maintain a list of fetal patients with significant structural CHD. This list may be reviewed to determine the denominator.

Challenges to Implementation

Quarterly review of all fetal diagnoses and postnatal records will be labor intensive, and will require medical knowledge sufficient to identify cases of diagnostic discrepancy.

Without a systematic mechanism to identify candidate cases of diagnostic discrepancy, they may go unreported.

Cases of moderate and severe severity may not be sufficiently prevalent enough for centers to target statistically significant reduction. However, it is anticipated that the process of discussing these cases will be useful to fetal echocardiography centers. Although not an official part of this metric, centers may wish to review and discuss discrepancies of minor severity.

Definition and categorizations of discrepancies are subjective, and identical discrepancies may be categorized differently by different individuals or centers. Regular discussion and categorization of discrepancies amongst stakeholders at a center may help reduce this variation.

Definitions of significant CHD may differ between, and within centers. This is particularly true for cases where it is not certain if intervention is needed (e.g. aortic coarctation). For this reason, this metric aims to include only prenatal diagnosis where intervention within the first year is either a certainty or highly suspected.

The authors acknowledge that not all aspects of fetal diagnosis are addressed by this metric. For example, cases of missed diagnoses are not captured. In particular, a patient may be seen in a center, and a diagnosis of no heart disease made, but return postnatally with missed CHD (e.g.

aortic coarctation). Additionally, cases of discrepancies between different fetal echocardiograms on the same patient are not included. Such cases are important for centers to record and review, and future fetal diagnostic metrics may be developed to address this particular situation.

References

1. Quartermain MD, Pasquali SK, Hill KD, Goldberg DJ, Huhta JC, Jacobs JP, Jacobs ML, Kim S and Ungerleider RM. Variation in Prenatal Diagnosis of Congenital Heart Disease in Infants. *Pediatrics*. 2015;136:e378-85.
2. Donofrio MT, Moon-Grady AJ, Hornberger LK, Copel JA, Sklansky MS, Abuhamad A, Cuneo BF, Huhta JC, Jonas RA, Krishnan A, Lacey S, Lee W, Michelfelder EC, Sr., Rempel GR, Silverman NH, Spray TL, Strasburger JF, Tworetzky W, Rychik J, American Heart Association Adults With Congenital Heart Disease Joint Committee of the Council on Cardiovascular Disease in the Y, Council on Clinical Cardiology CoCS, Anesthesia, Council on C and Stroke N. Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association. *Circulation*. 2014;129:2183-242.

APPENDIX

Categorization of diagnostic discrepancies:

- *False positive*: Misdiagnosis of lesion that is not present (e.g. diagnosis of ventricular septal defect made on fetal echocardiogram when none is present)
- *False negative*: Failure to identify lesion that is present (e.g. missed total anomalous pulmonary venous return in heterotaxy)
- *Discrepant diagnosis*: Lesion is identified on fetal, but differs from postnatal diagnosis (e.g. ventricular septal defect described as muscular, but is in fact membranous – *or* – fetal diagnosis of tricuspid atresia with postnatal diagnosis of double-inlet left ventricle)

Anatomic segment:

Centers will categorize the discrepancies according to the anatomic segment involved. A discrepancy may encompass more than one segment.

Abdominal situs
Atrial situs
Systemic venous return
Pulmonary venous return
Atrial morphology/anatomy
Atrial septum
Atrioventricular valves

Ventricular morphology/looping
Ventricular Size
Ventricular Septum
Great Artery Relationships
Semilunar valves/outflows
Pulmonary arteries
Aortic arch
Ductal arch

Severity:

- *Minor*: Discrepancy between prenatal and postnatal diagnosis with no significant change in clinical management or prognosis.
    - *e*.g. Missed left superior vena cava to intact coronary sinus in patient with tetralogy of Fallot

- *Moderate*: Discrepancy leads to meaningful alteration in clinical/surgical management, but does not involve *major* change in long-term prognosis (e.g. single vs. biventricular repair).
    - *e*.g. Missed ventricular septal defect in a patient with transposition of the great arteries that requires closure
    - *e*.g. Diagnosis of complete atrioventricular canal defect in fetus with known trisomy 21, but missed additional diagnosis of tetralogy of Fallot with mild right ventricular outflow obstruction.

- *Severe*: Discrepancy turns out to be a pathology for which the prenatal counseling with regards to management/prognosis would have differed sufficiently, or prompted further testing which would have revealed additional pathology (e.g. genetic conditions), such that family may have considered different care decisions (e.g. termination).
    - *e*.g. Prenatal diagnosis of a ventricular septal defect, but missed tetralogy of Fallot and right aortic arch, and child eventually diagnosed with 22q11 deletion.
    - *e*.g. Prenatal diagnosis of a balanced atrioventricular canal defect, but in fact unbalanced and requires single ventricle palliation.

-OR-

Patient injury or adverse patient event directly related to discrepant diagnosis.

- *e.g.* Atrial septum in hypoplastic left heart described as unrestrictive when is in fact highly restrictive, and patient delivers at center without capacity to perform emergent atrial septostomy and suffers adverse outcome.

Preventability

- *Preventable***:** Accurate diagnosis is expected based on review of available images (e.g. large ventricular septal defect clearly visible by 2D and color Doppler, but report states no ventricular septal defect is present).
- *Possibly Preventable*: Accurate diagnosis is not readily apparent on review of images, but could have been made under different circumstances or imaging conditions (e.g. poor quality images or incomplete examination leading to missed diagnosis of large ventricular septal defect).

*Note – discrepancies that are considered 'not preventable,' which are diagnosis that are not expected to be made on fetal echocardiography (e.g. coronary anomalies) will not be reported, as there is no mechanism to reduce these type of discrepancies.

Contributors

Centers will select contributors to discrepancies. More than one contributor per discrepancy may be present.

- *Procedural or conditional factors*: Incomplete examination, poor imaging environment, early gestation, late gestation
- *Cognitive*: Misidentification/interpretation of findings, overappreciation of finding, underappreciation of finding, distraction by other diagnosis, incorrect calculation
- *Technical*: Poor acoustic windows due to fetal lie, maternal factors (body habitus, fibroids, abdominal scarring), artifact, equipment malfunction
- *Patient or disease related*: Misleading anatomy or physiology, multiple gestations

Fetal Echocardiography
Diagnostic Discrepancy Worksheet

Mother's name _____ Mother's MRN_____ Date of examination_____ Child's name_____ Child's MRN_____	Sonographer_____ Interpreting physician_____ Indication for examination_____ Gestational age at examination_____

Diagnostic discrepancy	**Description of discrepancy with clinical impact**
□ False positive □ False negative □ Discrepant diagnosis	_____ _____ _____
Anatomic segment(s) Involved	**Severity**
□ Abdominal situs	□ Minor

<table>
<tr>
<td rowspan="2">□ Atrial situs
□ Systemic venous return
□ Pulmonary venous return
□ Atrial morphology/anatomy
□ Atrial septum
□ Atrioventricular valves
□ Ventricular morphology/looping
□ Ventricular Size
□ Ventricular Septum
□ Great Artery Relationships
□ Semilunar valves/outflows
□ Pulmonary arteries
□ Aortic arch
□ Ductal arch</td>
<td>□ Moderate
□ Severe</td>
</tr>
<tr>
<td>Preventability</td>
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<tr>
<td></td>
<td>□ Preventable
□ Possibly preventable</td>
</tr>
<tr>
<td></td>
<td>Contributors (may select more than one)
• Procedural or conditional factors
□ Incomplete examination
□ Poor imaging environment
□ Early gestation
□ Late gestation
• Cognitive
□ Misidentification/interpretation of findings
□ Overappreciation of finding
□ Underappreciation of finding
□ Distraction by other diagnosis
□ Incorrect calculation
• Technical
□ Poor acoustic windows due to fetal lie
□ Maternal factors (body habitus, fibroids, abdominal scarring)
□ Artifact
□ Equipment malfunction
• Patient or disease related
□ Misleading anatomy or physiology
□ Multiple gestations</td>
</tr>
</table>

Prenatal Detection of Severe Structural Congenital Heart Defects	
This metric will serve as a means for centers to track and report rates of prenatal detection of severe structural congenital heart defects, defined as lesions requiring surgical or catheter intervention within first 28 days of life.	
Numerator	Number of patients who had a prenatal diagnosis of structural congenital heart defect (CHD) in which intervention was expected or possible
Denominator	All patients undergoing initial surgical or catheter intervention for a structural congenital heart defect at ≤ 28 days of life
Period of Assessment	Quarterly
Sources of Data	Means of data collection will be center specific but may include: Medical record/Chart review STS or other surgical registries or databases IMPACT or other catheterization registries or databases

Rationale

Congenital heart defects account for the largest percentage of birth defects that contribute to neonatal mortality. The most severe lesions are considered critical congenital heart defects (CCHD). The specific definition of CCHD varies in the literature, but in general includes lesions that are dependent on early and prompt recognition to avoid patient harm.[1] Prenatal detection of CCHD has been demonstrated to reduce neonatal morbidity and mortality, particularly in infants who are at high risk of rapid decompensation from lesions such as transposition of the great arteries or hypoplastic left heart syndrome.[2-4] Prenatal detection leads to improved outcomes by allowing centers to anticipate the birth of a child with CCHD and plan accordingly. Also, prenatal detection affords the family the opportunity to make pregnancy related decisions such as termination.

Prenatal detection rates in the United States vary by lesion, but were 42% overall on a recent study, and slightly higher (50%) in neonates with CCHD.[5] Thus there is considerable room for improvement of prenatal detection rates.

The population targeted in this metric is neonates ≤ 28 days of age undergoing surgical or catheter intervention for structural heart disease. This age range was chosen as it will include the most severe cases that are often considered CCHD. Improving detection rates in this population will likely have the most clinical impact of reducing perinatal morbidity and mortality. Note we do not propose this as a definition of CCHD, but rather use the term “severe structural CHD.”

Through use of this metric, centers will not only be able to track rates of prenatal detection of severe structural CHD, but also identify targets for improvement, such as certain lesion types and barriers to effective prenatal screening. It is anticipated that interventions meant to improve prenatal detection will cross disciplines to include all those involved in the care of pregnant women and their fetuses.

Clinical Recommendation(s)

ACC/AHA Guidelines:

Donofrio MT, Moon-Grady AJ, Hornberger LK, et al., Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association. Circulation. 2014;129:2183-2242.

Other guidelines:

Rychik J, Ayres N, Cuneo B, et al. American Society of Echocardiography guidelines and standards for performance of the fetal echocardiogram. J Am Soc Echocardiogr. 2004;17:803-810.

AIUM Practice Parameter for the performance of Obstetric Ultrasound Examinations - 2013 (http://www.aium.org/resources/guidelines/obstetric.pdf)

International Society of Ultrasound in Obstetrics and Gynecology, Carvalho JS, Allan LD, et al. ISUOG Practice Guidelines (updated): sonographic screening examination of the fetal heart. Ultrasound Obstet Gynecol. 2013;41:348-359.

Attribution

This measure should be reported by centers who wish to track the success of interventions aimed at improving prenatal detection. These interventions would likely involve engaging front line providers who screen for CHD in the community, including referring cardiologists, obstetricians, radiologists and maternal-fetal-medicine physicians.

Method of Reporting

Centers will perform a quarterly review of their institution's surgical and catheter interventions for structural CHD in neonates ≤ 28 days of age. After exclusions as listed appendix, they will be left with the denominator. They will then review records to determine how many of those neonates had a prenatal diagnosis. This will be the numerator.

Challenges to Implementation

Labor intensive to review surgical and catheterization cases. Difficulty linking child records to maternal records. Lack of documentation and details of prenatal diagnosis.

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3. Tworetzky W, et al. Improved surgical outcome after fetal diagnosis of hypoplastic left heart syndrome. Circulation. 2001;103:1269-73
4. Morris SA, et al. Prenatal diagnosis, birth location, surgical center, and neonatal mortality in infants with hypoplastic left heart syndrome. Circulation. 2014;129:285-92
5. Quartermain MD, et al. Variation in Prenatal Diagnosis of Congenital Heart Disease in Infants. Pediatrics. 2015;136:e378-85

APPENDIX

Exclusions: (not to be included in denominator)

Non –structural lesion (e.g. cardiomyopathy for ECMO, VAD or heart transplant)

Specific structural lesions that are not amenable to prenatal detection: Anomalous coronary artery origin (e.g. ALCAPA), PDA.

Definitions/Clarifications:

A prenatal diagnosis is made if a prenatal examination by any provider (cardiologist, maternal-fetal-medicine, radiologist) detects structural heart disease that will either definitely or possibly require surgical intervention at any time in a child's life

The prenatal diagnosis need not be accurate. For example, a prenatal diagnosis of double outlet right ventricle that turns out to be truncus arteriosus will still be included in the numerator.

Limitations:

It is recognized that this metric will not detect missed prenatal diagnoses for lesions that are operated on after 28 days of life (e.g. atrioventricular canal defects, tetralogy of Fallot, ventricular septal defects). The age limit of 28 days was chosen because these are the patients in whom a prenatal diagnosis is critical in order to prevent morbidity/mortality (e.g. hypoplastic left heart syndrome, transposition). Also, practically, it would be harder to determine whether a prenatal diagnosis was made for patients presenting for surgical repair later in childhood. This information is usually more readily available in neonates.

The age limit of intervention at ≤ 28 days' gestation will exclude infants born prematurely who may wait longer than that time for intervention, as well as infants who suffer neonatal morbidity who wait longer than that time to recover before intervention. Infants who die prior to intervention or who are not candidates due to neonatal morbidities will also not be included.

Worksheet:

Centers will only report numerator/denominator, but a worksheet with additional clinical information can be filled out for missed cases of CHD that can help centers identify areas for improvement. (e.g. anatomy of lesion, whether prenatal screening was performed and by whom, maternal or other issues that may complicate screening: access to care, poor acoustic windows).

Comprehensive Fetal Echocardiographic Examination	
This metric will assess the average completeness score, as measured by the *Comprehensiveness Fetal Echo Assessment* worksheet (see attached) of initial fetal echocardiograms for fetuses with hearts interpreted as structurally normal.	
Numerator	The sum of the *Comprehensiveness Fetal Echo Assessment* worksheet scores for all fetal echocardiograms included in the denominator.
Denominator	The number of complete fetal echocardiograms assessed during the measurement time period. **Excluded Populations:** • Studies that are identified as being incomplete or limited • Studies in fetuses with structurally abnormal cardiac anatomy, rhythm or function • Studies in fetuses that have had a prior echocardiogram at the institution, as this metric is intended to apply to all initial fetal echocardiograms performed at the institution • Studies in fetuses with poor acoustic windows due to maternal body habitus, fetal position/movement, advanced gestational age or otherwise technically limited
Period of Assessment	Minimum: Quarterly review
Sources of Data	Prospective flowsheet, retrospective review of stored fetal echocardiographic images. For each quarterly assessment a minimum of 10 fetal echocardiograms will be reviewed.

Rationale

A complete fetal echocardiogram should include adequate acquisition of key elements required to exclude the presence of structural, functional and/or rhythm-related heart disease.[1,2] Integration of various imaging modalities, including two-dimensional imaging, color and pulsed Doppler is vital to a comprehensive evaluation of the fetal heart. Two-dimensional imaging of all the cardiac structures, color Doppler assessment of the atrial and ventricular septae, valves, veins and arteries, and pulsed Doppler interrogation of the valves, and ductus venosus are essential components of the exam. Assessment of the heart rhythm and function should also be included.[3-5] Failure to include these important features in an initial fetal cardiac exam may result in adverse fetal outcomes due to misdiagnoses and inappropriate management. This quality assessment activity provides a simple baseline strategy for evaluating compliance with standard fetal cardiac imaging techniques and may be helpful in identifying areas for sonographer, physician and/or laboratory improvement in fetal scanning.

Authors

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References

1) Donofrio MT, Moon-Grady AJ, Hornberger LK, Copel JA, Sklansky MS, Abuhamad A, et al. Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association. *Circulation*. 2014; 129(21):2183-242.

2) Fetal Echocardiography Task Force: American Institute of Ultrasound in Medicine Clinical Standards Committee; American College of Obstetricians and Gynecologists: Society of Maternal-Fetal Medicine. AIUM practice guidelines for performance of fetal echocardiography. *J Ultrasound Med*. 2013; 32:1067-1082.

3) Lee W, Allen L, Carvalho JS, Chaoui R, Cope J, Devore G, Hecher K, Munoz H, Nelson T, Paladini D, Yagel S; ISUOG Fetal Echocardiography Task Force. ISUOG consensus statement: what constitutes a fetal echocardiogram? *Ultrasound Obstet Gynecol*. 2008; 32:239-242.

4) Rychik J, Ayres N, Cuneo B, Gotteiner N, Hornberger L, Spevak PJ, Van Der Veld M. American Society of Echocardiography guidelines and standards for performance of the fetal echocardiogram. *J Am Soc Echocardiogr*. 2004; 17:803-810.

5) Allan L, Dangel J, Fesslova V, Marek J, Mellander M, Oberhansli I, Oberhoffer R., Sharland G, Simpson J, Sonesson SE; Fetal Cardiology Working Group: Association for European Paediatric Cardiology. Recommendations for the practice of fetal cardiology in Europe. *Cardiol Young*. 2004; 14:109-114.

Attribution

This metric will be reported by each echocardiography laboratory performing maternal transabdominal fetal echocardiography. Data will be assessed quarterly by the laboratory director or their designate and reviewed with the laboratory staff involved in the performance and interpretation of fetal echocardiograms.

Method of Reporting

This measure will be reviewed at laboratory quality assurance meetings quarterly. The overall Comprehensive Fetal Echo Exam Metric includes a total of 34 elements for each exam reported

for the Lab during the Quarter of interest. Each element is graded as "Yes" only if all components are visualized.
Challenges to Implementation
Time required identifying, selecting and reviewing fetal echocardiograms.

Comprehensive Fetal Exam Assessment WORKSHEET

Each worksheet is for ONE fetal echo evaluation

Patient Name: _____ **Date of Birth:** _____

EDD: _____ **Gestational Age:** _____

Sonographer: _____ **Date of Study:** _____

Interpreter: _____ **Location of Study:** _____

Echo Machine: _____ **Date of Review:** _____

Reviewer: _____ **Time Spent for Review:** _____

Indicate if each item listed is evaluated. Score as 1 for "Yes" response, 0 for "No".

2-DIMENSIONAL IMAGING (18), COLOR FLOW IMAGING (8), PULSED DOPPLER INTERROGATION (5)

YES	NO	
☐	☐	Pericardial effusion (2-D) *Image able to assess for pericardial effusion.*
☐	☐	Cardiac position/axis/size (2-D) *Chest shown in cross sectional view adequate for qualitative assessment of position, axis and size.*
☐	☐	Situs determination (2-D) *Sweep from heart to stomach shown, identifying clearly R/L fetal orientation.*
☐	☐	Ductus venosus (Color Flow)
☐	☐	Ductus venosus (Pulsed Doppler)
☐	☐	Systemic venous connections (SVC and IVC) (2-D) *Bicaval view shown or SVC and IVC shown separately. Hepatic veins or tapering veins do not count.*
☐	☐	Superior and inferior vena cava (Color Flow)
☐	☐	Pulmonary venous connections (2-D) *Two pulmonary veins seen by 2D imaging OR color Doppler, one from each side.*
☐	☐	Two pulmonary veins (one from each side) (Color Flow)
☐	☐	Two pulmonary veins (one from each side) (Pulsed Doppler)
☐	☐	Atrial morphology and size (2-D)
☐	☐	Atrial septum (Color Flow)
☐	☐	Atrial septal morphology (2-D) *Septal anatomy visible.*
☐	☐	Tricuspid and mitral valve visualization adequate for morphology assessment and measurement (2-D) *Valve leaflets seen with clear imaging in 4C view at largest diameter.*
☐	☐	Tricuspid and mitral valve inflows (Color Flow)
☐	☐	Tricuspid and mitral valve inflows (Pulsed Doppler)

☐	☐	Atrioventricular connection (2-D) *4C view to determine AV concordance.*
☐	☐	Ventricular morphology (LV, RV) (2-D) *LV, RV, IVS well seen in one of the following views confirming ventricular morphology: 4C and SAX.*
☐	☐	Ventricular size and function – qualitative assessment (2-D) *4C view adequate for measuring RV and LV length.*
☐	☐	Ventricular septal morphology (2-D) *IVS evaluated in at least 2 views to confirm septum is intact.*
☐	☐	Ventricular septum (in at least two views) (Color Flow)
☐	☐	Ventricular-arterial connections (pulmonary and aortic) (2-D) *2D sweep showing crossover, both PA and Ao anatomic features demonstrated.*
☐	☐	Pulmonary and aortic valve morphology and size (2-D) *Pulmonary and aortic valves seen well enough to measure.*
☐	☐	Pulmonary and aortic outflow (Color Flow)
☐	☐	Pulmonary and aortic outflows (Pulsed Doppler)
☐	☐	Great artery anatomy and size (2-D) *The main pulmonary artery and ascending aorta are seen so that relative sizes can be compared to each other.*
☐	☐	3 vessel view (2-D) *SVC/Ao/PA seen together in transverse plane, noting leftward position of the transverse aortic arch and ductal arch to the trachea; may or may not include branch pulmonary arteries in this view.*
☐	☐	Aortic and ductal arch morphology (2-D) *Both arches seen in two planes, axial 3-vessel-trachea view and sagittal view.*
☐	☐	Ductal and aortic arches (in both sagittal and axial views) (Color Flow)
☐	☐	Ductal and aortic arches (Pulsed Doppler)
☐	☐	Proximal right and left branch pulmonary arteries (2-D and color) *Each branch PA seen.*

RHYTHM ASSESSMENT (2)

YES	NO	
☐	☐	Heart rate *Rate measured and displayed by Doppler or M-mode*
☐	☐	Rhythm assessment (i.e. inflow/outflow Doppler, M-mode or TDI)

CINE CLIPS INCLUDED (1)

YES	NO
☐	☐

TOTAL SCORE (34):

Initial Fetal Echocardiogram Image Quality Metric	
This metric will assess the average image quality score, as measured by the *Fetal Echo Image Quality Assessment Tool* (Appendix 1), for initial fetal echocardiograms designated as complete studies for fetuses with structurally normal hearts.	
Numerator	The sum of the *Fetal Echo Image Quality Assessment* worksheet scores for all fetal echocardiograms assessed for the measurement time period.
Denominator	The number of complete transabdominal fetal echocardiograms >18 week gestational age assessed during the measurement time period. **Excluded Populations:** • Studies in fetuses with structurally abnormal cardiac anatomy, rhythm or function • First trimester fetal echocardiograms • Multiple gestation • Studies in fetuses that have had a prior echocardiogram at the institution, as this metric is intended to apply to all initial fetal echocardiograms performed at the institution • Studies in fetuses with poor acoustic windows due to maternal body habitus, fetal position/movement, advanced gestational age or otherwise technically limited
Period of Assessment	Minimum: Quarterly review
Sources of Data	Prospective flowsheet/ retrospective review of stored fetal echocardiographic images. For each quarterly assessment, a minimum of 10 fetal echocardiograms/center/program will be reviewed. If the center performs <20 fetal echocardiograms /quarter, all studies performed for that quarter will be reviewed.

Rationale

A complete fetal echocardiogram should include technically adequate acquisition of key elements required to exclude the presence of structural and /or functional heart disease. Optimal image quality is essential for accurate diagnosis, however there is variability in imaging technique and acquisition. Assessment of image quality is subjective; however, certain elements of image quality are standard, such as image orientation, two-dimensional image appearance, and optimization of color and spectral Doppler analysis. This quality metric provides a quantitative assessment of fetal echocardiographic image quality, which then can be used by individual echocardiography laboratories to assess their performance and track progress.

The initial study at an institution is selected as the target study population, since repeat studies may be limited; therefore investigation of these studies may not adequately reflect best performance of echocardiography within any given lab.

2) Fetal Echocardiography Task Force: American Institute of Ultrasound in Medicine Clinical Standards Committee; American College of Obstetricians and Gynecologists: Society of Maternal-Fetal Medicine. AIUM practice guidelines for performance of fetal echocardiography. *J Ultrasound Med*. 2013; 32:1067-1082.

3) ISUOG Practice Guidelines (updated): sonographic screening examination of the fetal heart. Ultrasound Obstet Gynecol 2013; 41: 348–359

4) AIUM Practice Parameter for the Performance of Obstetric Ultrasound Examination 2013 , www.aium.org

5) Lee W, Allen L, Carvalho JS, Chaoui R, Cope J, Devore G, Hecher K, Munoz H, Nelson T, Paladini D, Yagel S; ISUOG Fetal Echocardiography Task Force. ISUOG consensus statement: what constitutes a fetal echocardiogram? *Ultrasound Obstet Gynecol*. 2008; 32:239-242.

6) Rychik J, Ayres N, Cuneo B, Gotteiner N, Hornberger L, Spevak PJ, Van Der Veld M. American Society of Echocardiography guidelines and standards for performance of the fetal echocardiogram. *J Am Soc Echocardiogr*. 2004; 17:803-810.

7) Allan L, Dangel J, Fesslova V, Marek J, Mellander M, Oberhansli I, Oberhoffer R., Sharland G, Simpson J, Sonesson SE; Fetal Cardiology Working Group: Association for European Paediatric Cardiology. Recommendations for the practice of fetal cardiology in Europe. *Cardiol Young*. 2004; 14:109-114.

6) The IAC Standards and Guidelines for Pediatric Echocardiography Accreditation- Section 3B: Fetal Echocardiography Testing https://www.intersocietal.org/echo/standards/IACPediatricEchocardiographyStandards2017

8) Recommendations for ultrasound output settings
https://www.aium.org/officialStatements/65
https://www.aium.org/officialStatements/9
https://www.aium.org/officialStatements/63

Attribution

This metric will be reported by each echocardiography laboratory performing maternal transabdominal fetal echocardiography. Data will be assessed quarterly by the laboratory director or their designate and reviewed with the laboratory staff involved in the performance and interpretation of fetal echocardiograms.

Method of Reporting

This measure will be reviewed at laboratory quality assurance meetings quarterly. The Fetal Echo Image Quality Metric includes a total of 15 elements for each exam assessed for the quarter. Each element is graded as “Yes” only if the study meets criteria as specified in the *Fetal Echo Image Quality Assessment Tool*.

Challenges to Implementation

1) Time required identifying, selecting and reviewing fetal echocardiograms.
2) There is inherent subjectivity in the assessment of image quality that this objective metric may not fully overcome.

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References

1) Donofrio MT, Moon-Grady AJ, Hornberger LK, Copel JA, Sklansky MS, Abuhamad A, et al. Diagnosis and treatment of fetal cardiac disease: a scientific statement from the American Heart Association. *Circulation*. 2014; 129(21):2183-242.

Appendix 1

Fetal Echo Image Quality Assessment Tool

Each worksheet is for ONE fetal echo evaluation

Patient Name:_____ **Date of Birth:** _____

EDD: _____ **Gestational Age:** _____

Sonographer: _____ **Date of Study:** _____

Interpreter:_____ **Location of Study:** _____

Echo Machine: _____ **Date of Review:** _____

Reviewer: _____ **Time Spent for Review:** _____

Indicate if each item listed is evaluated. Score as 1 for "Yes" response, 0 for "No".

Category 1

2-DIMENSIONAL IMAGING (Total possible points=6)

Question is answered "Yes" if images meet the stated criteria for quality under each category. It is recognized that fetal position and movement can affect the quality of the study. If optimal images are obtained for each view during the course of the study, question is answered "Yes".

YES NO

☐ ☐ **Ultrasound output settings appropriate and consistent with ALARA (As Low as Reasonably Achievable)** *The ultrasound output settings are displayed on the screen. Mechanical Index (MI) should be as low as possible to allow for optimal image quality, ideally < 0.7. Thermal Index bone (TIB) should be at 0.7-1.0 for scanning time of 60 min and <0.7 for longer scanning time.*

☐ ☐ **Brightness and contrast level appropriate**
Primarily affected by the gain, compression, time gain compensation and dynamic range settings, optimal settings result in a 2 D image with good spatial resolution in which individual structures such as the pericardium, myocardium, ventricular cavity, valvar structures and endovascular borders of vascular structures are clearly delineated.

☐ ☐ **Balanced Penetration: Resolution**
Primarily affected by transducer choice and imaging settings such as harmonics, optimal imaging results in preserved differentiation between the individual structures such as blood pool and endocardium, and the region of interest is visible without loss of information at greater depth. Transducer and imaging modality selection results in maximal image resolution possible for given depth of imaging

YES NO

☐ ☐ **Zoom / Region of interest**
Zoom and depth of imaging adjusted such that the region of interest is optimally visualized. The fetal heart should fill at least one third of the imaging sector display. The focal zone should be appropriately positioned to region of interest.

☐ ☐ **Cine loops**
The fetal heart is examined as a moving structure and images should be saved as video clips in the form of cine loops and sweeps. Live scanning should be performed at the highest frame rate possible while DICOM images are typically compressed and stored at 30fps

☐ ☐ S**weeps**
Sweep(s) of the fetal abdomen and chest are performed with appropriate transducer alignment for demonstration of visceral situs and segmental anatomy of the heart and great arteries.

Category 2

RHYTHM ASSESSMENT (Total possible points=1)
Question is answered "Yes" if the M-mode/Doppler images meet the stated criteria for quality

YES NO

☐ ☐ **Rhythm assessment**
Ideal image should be obtained by aligning the M-mode across the atrium and ventricle so as to obtain clearly identifiable waves from atrial and ventricular contractions. If rhythm assessment is performed by Doppler, the sample is appropriately placed and Doppler tracings are optimized as described below

Category 3

COLOR FLOW IMAGING (Total possible points = 4)
Question is answered "Yes" if any images meeting the stated criteria for quality are present for each standard view or scan plane.

YES	NO	
☐	☐	**Frame rate appropriate** *Transducer selection and CFI settings such as box size and imaging depth is adjusted to obtain highest frame rates possible (minimum frame rate of 20fps is desirable). Color box should be limited to region of interest being interrogated.*
☐	☐	**Nyquist limit settings appropriate** *Nyquist limits are set appropriate to the structure being investigated so as to allow for diagnostic imaging (inflows /outflows > 50cm/s, venous flows <35cm/s).*
☐	☐	**Color settings appropriate** *Ideal color settings (color gain, color frequency, wall filter etc.) result in appropriate color fill of the structure being interrogated without loss of information from under gained images or excessive color bleeding or speckle artefact from over gained images.*
☐	☐	**Color persistence** *Color persistence is set to low /none such that color fill of structures is appropriate for the cardiac cycle. Of note, color persistence may be used to interrogate low velocity blood flow such as systemic and pulmonary venous flow.*

Category 4

SPECTRAL DOPPLER (Total possible points = 3)

Question is answered "Yes" if images meet the stated criteria for quality. If optimal images are obtained for each structure being interrogated during the course of the study, question is answered "Yes".

YES	NO	
☐	☐	**Alignment and placement of Doppler sample** *Spectral Doppler of cardiac structures obtained with proper alignment (as parallel to direction of blood flow as possible but angle <20 degrees at all times) and appropriate sample volume size and position so as to obtain clearly discernable spectral Doppler envelopes. Alignment angle does not apply to structures where the Doppler pattern rather than the peak velocity is being assessed (ex. ductus venosus, umbilical vein Doppler)*
☐	☐	**Appropriate Doppler scale and baseline** *Spectral Doppler scale and baseline, wall filter appropriately adjusted for the structure being interrogated such that the Doppler envelopes are complete with maximal signal size and minimal artefact*
☐	☐	**Appropriate sweep speed** *Standard sweep speed adjusted appropriately for visualization of Doppler contours and measurement of time interval, if performed. (Sweep speed of 100mm/s is suggested or adjustment of sweep speed so as to include 4-6 cardiac cycles in the acquisition)*

TOTAL SCORE (14):