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)