ASE Guidelines and Standards

Guidelines for the Standardization of Adult Echocardiographic Reporting: Recommendations from the American Society of Echocardiography

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Abbreviations

2D = Two-dimensional
3D = Three-dimensional
ACHD = Adult congenital heart disease
AI = Artificial intelligence
AK = Akinesis
AoV = Aortic valve
AR = Aortic regurgitation
AS = Aortic stenosis
ASD = Atrial septal defect
ASE = American Society of Echocardiography
BP = Blood pressure
BSA = Body Surface Area
CCT = Cardiac computed tomography
CEUS = Contrast-enhancing ultrasound
CFD = Color flow Doppler
CHD = Congenital heart disease
CMR = Cardiovascular magnetic resonance
CQI = Continuous quality improvement
CWD = Continuous-wave Doppler
DICOM = Digital Imaging and Communications in Medicine
DK = Dyskinesis
EACVI = European Association of Cardiovascular Imaging
ECG = Electrocardiogram
Echo = Echocardiography
ECL = Echocardiography core laboratory
FAC = Fractional area change
GLS = Global longitudinal strain
HK = Hypokinesis
IABP = Intra-aortic balloon pump
IAC = Intersocietal Accreditation Commission
IAS = Interatrial septum
IVC = Inferior vena cava
IVS = Interventricular septum
LA = Left atrium/atrial
LAA = Left atrial appendage
LLM = Large Language Model
LV = Left ventricle/ventricular
LVAD = Left ventricular assist device
LVEF = Left ventricular ejection fraction
LVIDd = LV internal dimension at end-diastole
LVIDs = LV internal dimension at end-systole
LVOT = Left ventricular outflow tract

MCS = Mechanical circulatory support
MR = Mitral regurgitation
MRI = Magnetic resonance imaging
MRN = Medical record number
MS = Mitral stenosis
MV = Mitral valve
NK = Normokinesis
PACS = Picture archiving and communication system
PDA = Patent ductus arteriosus
PFO = Patent foramen ovale
POCUS = Point-of-care ultrasound
PWD = Pulsed-wave Doppler
QA = Quality assurance
QI = Quality improvement
RA = Right atrium/atrial
RAP = Right atrial pressure
RV = Right ventricle/ventricular
SCMR = Society for Cardiovascular Magnetic Resonance
SE = Stress echocardiogram
SPECT = Single photon emission computed tomography
TAPSE = Tricuspid annular plane systolic excursion
TDI = Tissue Doppler Imaging
TEE = Transesophageal echocardiography
TTE = Transthoracic echocardiography
UEA = Ultrasound enhancing agent
UCA = Ultrasound contrast agent
VA-ECMO = Veno-arterial extracorporeal membrane oxygenation
Vmax = Maximum Doppler velocity
VSD = Ventricular septal defect
VTI = Velocity-time integral
WMS = Wall motion score

Abstract

The American Society of Echocardiography (ASE) plays a vital role in establishing practice standards and guidelines within the echocardiography field. Its influence is comprehensive, covering training, image acquisition, nomenclature, measurements, diagnosis, and quality improvement. This report focuses on the final phases of the imaging life cycle, specifically reporting and communicating exam results. It provides updates to previously published guidelines on the required components of a comprehensive echocardiography report. Standardization within echocardiography reports is essential to uphold quality, consistency, and interoperability across various echocardiography (echo) labs, institutions, and healthcare systems, as well as over different time points. Additionally, standardized reporting is crucial for facilitating big data analysis, aligning with the current emphasis on machine learning and artificial intelligence.

This document delineates core measurements and statements applicable to transthoracic, transesophageal, and stress echocardiography. It also elucidates abbreviations, acronyms, terminology, and definitions to enhance communication. The path from preliminary report to final submission is clarified, alongside examples of critical, urgent, and significant findings. Recommendations include comparison of serial echocardiograms and, when clinically relevant, comparisons with other imaging modalities. The document addresses the integration of simple congenital heart disease (CHD) findings appropriate for an adult echo lab. Standardization facilitates clinical and research endeavors by ensuring clear and consistent data reporting, thereby enabling seamless data sharing and reusability.

Introduction

The ASE has published guidelines and standards "for training (and certification); performance; nomenclature and measurement; and quality improvement related to echocardiography" for more than 40 years.[1,2] In 1998, Dr. Richard Kerber, then president of the ASE, convened a task force "to develop recommendations for a standardized report for adult echocardiography" to improve the quality of echocardiography practice. The specific goals of their 2002 report remain valid.[1] Standardized reporting should 1) promote quality by defining the core of measurements and statements that constitute the report, 2) encourage the comparison of serial echocardiograms

performed in patients at the same site or different sites, 3) improve communication by expediting the development of structured report form software, and 4) facilitate multicenter research and analyses of cost-effectiveness.

The 1998 task force developed its recommendations in response to an emergent computing and information age explosion, heralding the end of an era in which echocardiography reports were typed or even hand-written. Their recommendations laid the groundwork for acceptable structured reporting methods that were readily adopted by clinical and academic practitioners, industry, and accreditation agencies. In 2008, ASE President Dr. William Zoghbi commissioned a task force to explore quality aspects of echocardiography laboratory operations using a multi-faceted approach, including facility, equipment, personnel, various aspects of the imaging process, interpretation and reporting, and the presence of a continuous quality improvement process. The resultant publication, the ASE's Recommendations for Quality Echocardiography Laboratory Operations, remains an important reference, establishing a framework for quality standards that are readily achievable by most clinical echocardiography labs performing adult transthoracic (TTE), transesophageal (TEE), and stress echocardiography (SE) examinations.[3] Some 23 years after the ASE's initial 2002 reporting standards recommendations, many laboratories continue to use reporting methods and software solutions developed for the dawn of the information age. We now practice in an advanced information age with pervasive digital image processing, near-universal adoption of electronic health records, automated data exchanges, and the potential for big data analysis using machine learning and large language model (LLM).[4] A high-quality echo report should meet four criteria, as proposed by Chao et al., completeness, conciseness, correctness, and clinical utility.[5]

In recent years, there has been an increasing recognition that clinically relevant reporting should integrate more comprehensive demographic information and normative and abnormal data metrics derived from up-to-date societal guidelines to better define, categorize, and communicate both normal and pathological findings.[6] A more consistent reporting language is increasingly achievable because of the maturation of the field, including an increasingly large portfolio of updated science and consensus-driven echocardiography guidelines. With this history and new developments in mind, the ASE

commissioned a new task force to examine and provide guidance upon standards for adult echocardiography reporting.

Scope

Consistent with the ASE's 2002 reporting standards recommendations, the focus of this document is to update the reporting component of the greater echo lab quality framework established by Picard et al., rather than addressing performance or interpretation of echocardiograms.[3] This document will 1) provide recommendations for which demographic elements, descriptive items, and measurements should be included in a report, 2) provide recommendations on how reports should be presented stylistically to improve communication and translation of findings into patient care, and 3) facilitate research. Although many elements of this guideline may be useful for laboratories performing comprehensive adult congenital and pediatric echocardiography, recommendations are limited to consultative adult echocardiography laboratories performing TTE, TEE, and SE examinations. New to this reporting standards guideline are tables for reporting SE for coronary artery disease, reporting simple CHD findings in adults, and the incorporation of mechanical circulatory support (MCS) devices. A table of basic assumptions and definitions is provided, along with a glossary table for recommended morphologic descriptions. Measurement tables include reporting precision recommendations that should be consistent across clinical and core echo laboratories, registries, and the National Institutes of Health Common Data Elements repository.[6] We include recommendations for incorporating prior or suggested multimodality imaging data. Because the ASE's clinical practice guidelines and standards are continually surveilled for necessary published updates when needed ("living guidelines"), this reporting standards guideline also exists as a living guideline that becomes updated after significant source document updates are published. A recent ASE guideline distinguishes consultative echocardiography from the various forms of cardiac point-of-care ultrasound (POCUS).[7] Although this document may provide guidance for those performing POCUS examinations, recommendations herein are intended for individuals practicing in laboratories performing consultative echocardiography examinations in adults.

Echocardiography's improved spatial and temporal resolution enables detailed cardiovascular morphological assessment and descriptions; the results may be more accurate and informative when certain standards are followed. We provide recommendations for terms, definitions, morphologic descriptions, and abbreviations that may critically influence readers' understanding and allow accurate data incorporation into electronic medical records and registries. Therefore, the recommendations will appear more granular than historical ones. Recommendations are not dictums, but consensus-driven strategies to improve reporting content. While many descriptions and linked numerical data should be concise and easily understood, our recommendations support the need for preserving interpreters' critical ability to synthesize, contextualize, and report findings with a nuanced analysis of the clinical scenario, particularly in summary statements, in ways that may not be reflected in standardized reporting templates. Important tenets for this updated guideline are that new recommendations should be easily implemented given current medical informatics practices in a way that improves reporting accuracy and enhances patient care, while also improving workflow,

Methodology

Writing Committee Composition

The members of the writing committee were selected based on their domain expertise in echocardiography, multimodality imaging, health informatics, artificial intelligence, and leadership experience in echo lab quality improvement, cardiac imaging registry, research core lab, and lab accreditation. Experts with a spectrum of backgrounds, such as geographic regions, sexes, races, ethnicities, and clinical practice settings, were chosen. The writing committee consisted of thirteen members, including five females, two cardiac sonographers, one pediatric representative, two members with Intersocietal Accreditation Commission (IAC) expertise, three with artificial intelligence and data registry experience, one with imaging data expertise at the National Institutes of Health, and four with an international training background.

Relationships with Industry and Other Entities

The ASE has rigorous policies to ensure this document was developed without improper influence. All members of the writing committee were required to complete and submit a disclosure form showing

all personal, professional, or business relationships that may pose actual, perceived, or potential conflicts of interest. The relationships with industry and other entities pertinent to this standard document are disclosed in the Conflict-of-Interest statements. The work of the writing committee is based on volunteerism and is supported exclusively by the ASE without commercial support.

Review of Literature

Relevant existing literature links were shared by email correspondence by all members of the writing committee.

Consensus Development

This writing committee was established in July 2022, using the processes described in the ASE Guideline Development Manual. [8] The chair and co-chair created writing committee subgroups and task assignments based on expertise and interests. ASE staff and writing committee subgroup leaders coordinated virtual meetings to review writing assignments, which were then incorporated into a master document after review and consensus from the entire writing committee.

Relation to Other Standards

The writing committee reviewed published data standards, IAC standards, ASE guidelines, and guidelines from other societies, such as the European Association of Cardiovascular Imaging (EACVI), were also important for consensus building.[9]

Peer Review, Public Comment, and Board Approval

The document was posted on the XXXX website for a 21-day public comment period. The document was revised based on feedback from all reviewers including the ASE Guidelines and Standard Committee Chairs and members and with consideration of public comments. PENDING

<u>Stylistic Principles to Improve Communication</u>

An echocardiography report should use simple sentences that clearly describe the pathology, convey a message that can be translated into clinical care, and avoid excessively wordy or "teaching" statements, which can lead to confusion. Some echocardiography laboratories may favor concise

bullets, while others may prefer full sentences. However, agreement and consistency on writing styles among readers in each laboratory is recommended. For example, it may be sufficient to report "normal structure and function" when what constitutes normalcy for the structure referred to is likely to be universally understood (e.g., a trileaflet aortic valve). However, more descriptive statements may be required in less common situations or to emphasize normalcy. Vocabulary and terminology that adhere to existing guidelines should be favored, and consistent laboratory-specific terminology should be utilized when a universal nomenclature is not available. Unclear technical terms, names (e.g., McConnell's sign), and jargon (e.g., smoke [for spontaneous echo contrast]) that are either not accepted medical terms or that non-cardiologists or non-physicians are unlikely to understand, should be avoided.

Avoiding prepositional phrases is an easy way to shorten communication. When describing cardiac anatomy, structure (or morphology) and function should be reported consistently and in that order. Abnormal numerical values should be accompanied by a description of the associated pathology and not simply reported as values. For example, "left atrial volume index is 35 ml/m^2" should not stand alone but be accompanied by "left atrium is mildly dilated." Cardiac structure and function assessments should be reported as normal or abnormal and only graded (e.g., mild, moderate, severe) when current guidelines include grading recommendations. A consistent grading system should be developed within a laboratory in exceptional cases when grading outside of standard guideline recommendations is important (e.g., grading the severity of mitral annular calcification when contemplating mitral valve interventions or the degree to which valves are thickened). The descriptions of normal variants should be reported as such (e.g., Eustachian valve, Chiari network, Lambl's excrescence, mild dilatation of the left atrium during pregnancy). In general, communications using concise, broadly understood terminology are encouraged, and the use of arcane language is discouraged. See Table 1 for echocardiography reporting stylistic dos and don'ts. Certain colloquial descriptions found in medical literature may be helpful, but they should not be used in isolation. For example, "Diastolic doming of the anterior mitral valve leaflet tip (hockey-stick appearance) which is consistent with chronic rheumatic mitral valve changes."

Abbreviations are helpful communication shortcuts that can lessen time and effort expenditure by reducing words. However, the proliferation of abbreviations in medical literature and clinical reporting has become a significant communication impediment. Improper, inconsistent, and excessive use of abbreviations can lead to medically dangerous interpretation errors by human readers, or by natural language-processing algorithms. [9-11] Abbreviations and acronyms should be defined when needed; their use should be limited to standard ones likely to be understood by a non-cardiologist and must be used in a consistent manner.

In a recent examination of abbreviation usage by 114 guidelines documents published by seven cardiovascular and cardiovascular imaging societies over the past six years, there were >5,000 entries for 1,782 unique abbreviations.[12,13] The discrepancy rate was up to 14.5% in certain cases, with certain common abbreviations having up to 5 different meanings (e.g., BAV, PVR). This same document identified numerous commonly used abbreviations that we can recommend for standardized echo reporting, particularly when the meaning is also defined within the document. See Table 2 for recommended abbreviations. Laboratories may develop internal abbreviation lists if the definitions are uniformly applied across interpreting physicians and their health systems.

Acronyms are abbreviations formed from the initial letters of other words that are then said as a single word. Acronyms are frequently not understood by many readers. For example, “MAC” for mitral annular calcification or “SAM” for systolic anterior motion may be well-understood by echocardiographers reading this document, but they are unlikely to be understood by non-cardiologists reading an echocardiography report. In general, acronyms should be avoided.

Elements of Comprehensive Echocardiographic Reports

Standard reporting assumptions and definitions are listed in Tables 3-7. The discussion below and Table 8 provide detailed recommendations for the interpretation section of a comprehensive TTE and TEE (and stress echo in many cases) report based on required cardiac structure categories, reporting parameters specific to each structure (morphology, function, physiology), and the recommended

findings to be included in the report. The following criteria and assumptions were used in developing these recommendations:

- "Yes" is used to indicate elements that should be reported consistently, as long as technically feasible.
- "No" is used to indicate elements that are usually not applicable to a specific modality and not expected in the report.
- "Yes, if present" is used to indicate elements that should be reported if present, abnormal, or if considered a pertinent negative based on the reason for the study.
- "Optional" is used to indicate elements that may be reported depending on the clinical context, study indication, and patient-specific factors, at the discretion of the reading physician.
- Each structure is adequately visualized for interpretation.
- Various descriptions, including for masses, should reference Table 7.
- Reports should include appropriate information about additional diagnostic maneuvers (e.g., Valsalva maneuver, leg raising). Table 9 describes the recommendations for reporting maneuvers used during the echocardiogram.

TTE Report

Demographic information, essential history, indication for the exam and priority of the study, should be included at the top of a TTE report (Table 3). Vital signs such as blood pressure should be obtained at the bedside concurrent with the start of exam (not copied from records). Heart rate and rhythm, particularly significant bradycardia, tachycardia, and irregular rhythm, as well as paroxysmal occurrence of abnormal heart rate and rhythm disturbances during the exam, should be documented. When measurements of height and weight are not practical, information obtained from patients verbally or carried over from the medical record should be labelled as such. In addition to established measurement parameters (Table 4), a TTE report should include report headings for each of the following cardiac structures: left ventricle (LV), interventricular septum (IVS), right ventricle (RV), left atrium (LA, including pulmonary veins), interatrial septum (IAS), right atrium (RA), aortic valve, mitral valve, pulmonic valve, tricuspid valve (TV), aorta, pulmonary artery, inferior vena cava (IVC), superior

vena cava (SVC), pericardium, and when relevant implanted devices (e.g., MCS).[3,9,14,15] Appropriate interpretation details should be organized under the appropriate cardiac structure or device heading.

Reporting Cardiac Chambers

The echocardiography report should include an assessment of the LV size and indexed to the body surface area (BSA), wall thickness, and systolic and diastolic function. If any abnormalities are noted, they should be described in detail.[3,9,14,16-18] The use of ultrasound-enhancing agents (UEAs) should be stated in the report. The report should also describe RV morphology, structure, and systolic function.[17]

When strain evaluation is performed, results should be reported as either positive or negative, depending on the type of strain assessed. For example, LV and RV global longitudinal strain (GLS) are conventionally expressed as negative values.[19] Strain values should be consistently classified as normal, abnormal, or borderline according to established laboratory standards. Significant changes from prior studies (e.g., relative GLS change exceeding 15%) should be documented, clearly indicating whether the absolute strain value has increased or decreased to prevent confusion.[16]

The size and morphology of the LA should be described and indexed to the BSA, and any masses should be described. The pulmonary vein spectral Doppler blood flow patterns should be mentioned when significant mitral regurgitation (MR) is present or if there is suspicion for elevated LA or LV pressure. The RA size should be reported , and any masses should be described.[17]

The morphology and structure of the IVS and the presence of ventricular septal defects (VSDs) should be reported when indicated.[3,9] The morphology and structure of the IAS should also be reported.[3,9] Finally, if agitated saline contrast studies are performed, the absence or presence of shunting should be stated along with the maneuver used, if any. Commenting on the degree of shunting is recommended (e.g., “large amount of saline contrast seen in the left heart”).

Reporting Cardiac Valves

Each cardiac valve should be reported as structurally normal or abnormal. For the normal aortic valve,

in addition to stating that it is structurally normal, reporting the normal presence of three leaflets and normal leaflet (cusp) mobility is recommended. Many normal tricuspid valves are not trileaflet, and reporting the number of TV leaflets, if properly visualized, is also recommended. Reporting pulmonary valve leaflet number may be deferred. Valve abnormalities should be described in detail, including an abnormal number of leaflets (congenital abnormalities), thickening, abnormal leaflet mobility, or other relevant findings such as calcifications or suspected types of degenerative changes (e.g., calcific, myxomatous, rheumatic). For all abnormal valves, the presence or absence of stenosis or regurgitation should be reported along with one of three severity qualifiers recommended by ASE guidelines: mild, moderate, or severe.[3,9,20-24] These grades are supported by well-established published parameters. The writing committee acknowledges that terms such as "trace," "insignificant," "trivial," "physiologic," or "minimal" have been historically used to describe the presence of “less than mild” regurgitation. However, these jets often exhibit incomplete spectral Doppler displays. We advise against using the above terms to indicate “less than mild” unless there is a need to indicate clinically insignificant regurgitation in a structurally normal valve with a low likelihood of progression. "Trace" regurgitation of a structurally normal native aortic or mitral valve may be considered normal, whereas mild or greater aortic or mitral valve regurgitation should be classified as abnormal. However, for structurally normal native tricuspid or pulmonary valves, mild regurgitation may be regarded as a normal functional finding (physiologic). A statement such as “mild tricuspid regurgitation is present, which may be within normal limits”, can be used in the report.

For prosthetic or repaired valves, the report should mention the type, size, motion, and function of the valve, any mass lesion, as well as stenosis or regurgitation grading.[25]

Reporting Arteries and Veins

The report should include information on the size and any abnormalities of the aorta and PA. The size and respiratory changes of the IVC are recommended but optional. The estimated right atrial pressure should always be reported, even if the observation is “unable to assess” due to imaging limitations. A description of the pulmonary vein flow should be included when appropriate. Abnormal hepatic vein Doppler waveform observations should be reported when warranted (e.g., pericardial pathology,

volume status, TV pathology). Any vascular abnormalities (such as thrombus, tumors, catheters) should be reported and described.[3,9,14]

Reporting the Pericardium

The report including the presence or absence of pericardial effusion and, if present, should describe the size qualitatively, location, and the presence or absence of hemodynamic compromise, including cardiac tamponade or constrictive physiology. Reporting the presence of pericardial adipose tissue depends on the clinical indication of the study and is under the discretion of the reader. Suspected pericardial pathologies such as masses or thickening should be reported.[3,9]

Reporting Extra-cardiac Findings

The report should include extra-cardiac findings such as pleural effusions (left, right, or bilateral) and ascites. Other suspected incidental abnormalities in the chest, abdomen, and neck within the field of view of the echocardiogram should be described. Additional dedicated imaging with other modalities may be recommended.

Reporting the Use of Ultrasound-Enhancing Agents

A UEA should be used when there is poor visualization of the endocardium and two or more contiguous segments cannot be adequately visualized for the assessment of LV function and regional wall motion.[16] If a UEA is used, the type of UEA (agent) and the administered dose should be stated in the report.[3,9,26] Within echocardiography guidelines, UEA has been established as the preferred terminology for microbubbles employed to improve endocardial border delineation. This clarification assists patients and referring physicians in distinguishing it from agitated saline contrast, iodinated contrast, and gadolinium chelates.[26-28] However, within the radiology community, the term ultrasound contrast agent (UCA) is considered synonymous with UEA, with contrast-enhanced ultrasound referring to the technique of using UEAs/UCAs with ultrasound imaging.

Reporting the Use of Agitated Intravenous Saline Contrast

An intravenous saline study, performed during normal breathing and with maneuvers (e.g., Valsalva, abdominal compression), can detect intracardiac and intrapulmonary shunting .[27,28] The report should specify if shunting occurs early during normal breathing (patent foramen ovale (PFO) or atrial septal defect (ASD) or after maneuvers (Table 9). PFO shunting may occur only after Valsalva release or when RA pressure exceeds LA pressure, even if transiently. Delayed bubbles in the left atrium after several cardiac cycles suggest intrapulmonary shunting. In addition to qualitatively reporting the amount of shunting, the report should mention the likely shunt location (atrial septal vs intrapulmonary) and nuances such as the intravenous saline study's reliability related to image quality and patient cooperation.

Reporting Additional Maneuvers

Physiologic maneuvers, generally used to provoke right-to-left shunt, evaluate left ventricular outflow tract (LVOT) outflow, or LV diastolic filling, should be reported in the appropriate section of the report that has been specifically designated with the reporting tool. A recent review outlining techniques for the most common provocative maneuvers and their reporting is described in Table 9.[14,16,18,23,27,29]

TEE Report

In addition to the basic parameters, a TEE report should include information regarding the medications used during the procedure (referencing sedation provided by the anesthesiology service if applicable), comments about the ease or difficulty in TEE transducer insertion, and the presence or absence of complications. The report should provide information regarding the morphology/structure and function of the cardiac structures imaged, and describe any abnormalities identified. When compared with TTE, the quantitative evaluation of cardiac morphology/structure and function by TEE can be limited by factors related to the imaging technique itself (e.g., LA volume), or the paucity of normative data, and qualitative evaluation may be sufficient in many cases. However, an effort should be made to provide quantitative data when possible and when clinically necessary.[15] Additionally, the scope of structures examined in detail via TEE, and consequently included in the report, may vary based on the specific study indication. Table 8 provides a summary of the recommended components for a comprehensive TEE report.

Reporting Cardiac Chambers

The TEE report should include information about the size and systolic function of both ventricles. A qualitative assessment is required, with quantitative parameters provided optionally. Additionally, any regional/segmental wall motion abnormalities, structural anomalies, or masses or devices should be reported and described when present. References to wall thickness, hypertrophy, and quantitative assessments of systolic or diastolic function are optional albeit less commonly reported, given that normative data in current guidelines primarily relies on TTE.[14] Advanced methods such as three-dimensional (3D) imaging can enable quantitative evaluation despite lack of well-established normative range.[16] Conversely, TEE offers superior visualization of the right and left atria, the IAS, and venous connections compared to TTE. Consequently, the report should address the presence or absence of interatrial shunt, the detection technique employed, and a description of any structural abnormalities or abnormal venous connections or flow pattern.[27,28,30] Reports should include evaluation and commentary on the left atrial appendage (LAA), optionally noting its shape and providing measurements appropriate for specific devices when indicated.[31] LAA comments should note the presence or absence of a thrombus and spontaneous echo contrast, and optionally attempting to grade it.[15,28] Additionally, LAA emptying velocity should be reported when indicated.

Reporting Cardiac Valves

The TEE report for cardiac valves should mirror the content of the TTE report, including the description of valvular structure and function, with quantitative information when acquired. Enhanced visualization capabilities of TEE often facilitate precise identification and localization of pathology within specific leaflets or scallops, necessitating a more detailed description. Additional morphologic and quantitative parameters specific to screening and planning for structural valve interventions should be reported when applicable. [31] TEE excels in detecting valvular vegetations; when noted, their detailed characteristics and their location with respect to leaflet(s) or other anatomic structures should be described. Similarly, prosthetic valve assessment is recommended to adhere to TTE standards, leveraging TEE's superior imaging for detailed descriptions of pathology and its location. Any identified abnormalities such as abscesses, fistulas, fractures, perforations, pannus, thrombi, or vegetations

should be documented and described by leaflet or structure location, size, shape, mobility, and textural features if applicable.[14,15,23,25]

Reporting Arteries and Veins

TEE has a superior ability to evaluate the thoracic aorta; therefore, aortic size and any associated pathology should be reported.[15,32] Though not always imaged by TEE, the IVC and hepatic veins can be imaged when indicated, and if properly visualized, their size and flow pattern should also be reported.[15] Pulmonary vein anatomy descriptions may be important in congenital anomalies, following lung transplant, or in the setting of other pathology (e.g., neoplasm, thrombus) or device placements. Therefore, analysis systems should provide specific fields for comments, which may be used on a case-by-case basis.

Reporting the Pericardium

TEE findings should be reported as described for TTE.

Stress Echo Report

Stress echo encompasses specific protocols for the assessment of coronary artery disease (ischemic heart disease) and other specific protocols designed for a variety of structural heart diseases.[33,34] Rather than focusing on protocols, we will discuss reporting for different cardiac structures (and the needed reporting tools and associated elements) separately, since one or more components may be needed, depending upon the clinical situation, including study indication and unexpected observations during the exam. Tables 10 and 11 provide elements for stress echo reporting.

The report for the stress echocardiogram should include the date, type of stress test performed (i.e., exercise [treadmill, supine bike], pharmacologic), and indication for the test.[3,9,33-35] The test indication should describe the clinical question being addressed. In addition, the imaging protocol should be stated, as well as the exercise time, pharmacologic peak dose, maximum heart rate, systolic blood pressure (BP) response to stress, and if the appropriate level of stress was achieved. Moreover, the adequacy of the workload based on sex and age should be included in the report.[34] If cardiac

symptoms, electrocardiogram (ECG) changes, or arrhythmias are present and/or if the test needs to be terminated early, the report should note these events. At each protocol stage (exercise [baseline, post-exercise] and pharmacologic [baseline and low, intermediate, and peak dose]), relevant changes in structure, function, and physiology should be reported.[9,33-35] A conclusion statement for the stress echo for coronary artery disease evaluation should include the presence or absence of myocardial ischemia, ECG evidence of ischemia or dysrhythmia, patient's symptoms during stress, and pertinent baseline echocardiographic findings.

Stress Echo Reporting the Left Ventricle

The LV chamber and myocardium should be reported as recommended for TTE. Statements regarding systolic BP, global systolic function, and regional wall motion should be provided. [9,34] The LV segments and regional motion should be described using the terms in Table 5. A regional score (wall motion score [16-64] and/or estimated wall motion score index [1.0-4.0]) may be derived. A bull's eye diagram display is optional.

These report elements should be reported at baseline and at each stage of the stress echocardiogram protocol.[33,34] In additional stages, comparison statements should also be included in the report. At each stage, the LV chamber size and regional score should be compared and reported as unchanged, increased, or reduced.[9,33,34] In addition, the LV global systolic function should be reported with a specific comment on whether the LV ejection fraction (LVEF) increased, decreased, was biphasic, or remained unchanged. In patients with hypertrophic cardiomyopathy, Doppler assessment of LV intraventricular and outflow velocities should be reported with descriptions of location and severity of obstruction at baseline, and during stress and recovery, if present.

Stress Echo Reporting the Right Ventricle

The RV chamber and myocardium should be reported as recommended for TTE. When clinical indications for stress echo are focused on the right ventricle such as evaluation of pulmonary hypertension, and mitral stenosis, quantitative RV measures, if available [e.g., tricuspid annular plane systolic excursion (TAPSE)], should be reported at baseline, during and after exercise. Reporting fields should allow for RV measurements to be incorporated into each phase of stress. At a minimum, a

qualitative assessment of the RV chamber size and function should be reported at each stage. Whenever RV abnormalities exist (at baseline and/or with stress), a statement comparing RV size and function at rest and during stress should be included.[9,33,34]

Stress Echo Reporting the Interventricular Septum

Interventricular septal motion should also be described in the stress echocardiogram report if abnormal.[9,33,34] Interventricular septal motion should be described as normal (rightward), leftward, paradoxical, or otherwise abnormal (conduction abnormality) or flattened if appropriate. Septal motion and position should be reported for each stage of the protocol as part of the regional wall motion analysis and bull's eye display, but also independent of wall scoring as many septal motion abnormalities may occur from causes other than ischemia (e.g., RV pressure overload, RV volume overload, conduction abnormalities, ventricular interdependence, constriction) and may become exaggerated during stress testing.

Stress Echo Reporting the Mitral Valve

Various mitral valve parameters may be measured during stress if the exam is intended to assess MR, mitral stenosis (MS), or mitral valve flow parameters related to diastolic stress exams. In general, exercise stress protocols are recommended when mitral valve assessment is needed. Pharmacologic stress may be used for MS evaluation. It is recommended that the stress protocol employed is clearly indicated by linking each stage's parameters to the appropriate baseline, individual stress stages, and recovery stage (when utilized) headers.

Mitral valve structure and function at baseline should be reported. Depending upon the mitral valve abnormality being assessed, reporting tools should allow for complete mitral valve assessment and related parameters (e.g., systolic PA pressure estimate) at baseline and at each stage of stress. While a new valve morphology description may not be necessary at each stage, any change in MR severity (or lack thereof) should be reported at each stage. If MR is present, the report should state if MR severity is unchanged, increased, or reduced during stress.[33,34] Assessment of MR severity at each stage of stress may be required as an add-on to a coronary ischemia stress protocol. In a protocol

designed to evaluate non-ischemic MR, the severity of MR may be assessed at each stage. In MS protocols, the functional data during each stage will determine if stenosis is progressive or severe which the report should reflect. If mitral valve parameters are gathered in the context of a diastolic heart failure assessment (often not related to the degree of MR or MS), this should be evident in the diastolic stress test summary statement.

Stress Echo Reporting the Aortic Valve

Stress echocardiography is sometimes used to evaluate the severity of aortic stenosis. The reporting tool must allow for a comprehensive aortic valve assessment, including aortic valve morphology at baseline and all required aortic stenosis Doppler parameters at all stress stages. The report summary should synthesize baseline and stress data to address aortic stenosis severity in a clear manner.

Stress Echo Reporting the Tricuspid Valve

If indicated, the TV can also be evaluated with stress echocardiography. Careful measurement and reporting of the maximal tricuspid regurgitation (TR) velocity (and estimated systolic PA pressure) is most important for evaluating dyspnea, breathlessness, and fatigue, and for assessing diastolic function or valve disease. The severity of TR, the peak TR velocity, and the corresponding systolic PA pressure should be assessed at each protocol stage and described as unchanged or increased and reported as mild, moderate, or severe.

Stress Echo Reporting the Use of Ultrasound Enhancing Agents

A UEA should be used in stress echocardiography when there is insufficient visualization of the endocardium to adequately assess wall motion. If a UEA is used, the report should state the type and dose of the UEA agent.[3,9,26,34]

<u>Mechanical Circulatory Support</u>

Patients with durable and temporary surgical and percutaneous MCS devices may undergo a baseline examination protocol, which requires a single set of standard heart failure protocol measurements for analysis and reporting. Additionally, measurements may be needed during a single examination

(analogous to a stress exam) after a change in device speed setting or position, or a drug or fluid challenge. Reporting metrics unique to MCS speed change protocols include aortic valve opening duration (if present), inflow cannula and outflow graft flow velocities, atrial and ventricular septal positions, and aortic regurgitation duration. For aortic micro-axial flow pumps, the inflow zone-to-aortic annulus position (linear measurement) should be reported at baseline examination and after repositioning. Temporary support devices may be implanted in the circulation surgically or percutaneously and reporting fields for cannulation sites should be available, noting that two or more devices may be operating concurrently in the same patient. Interpretation of MCS echocardiography exams requires description of device type(s), inflow and outflow locations, speed(s), and setting(s). Device types, appropriate annotation and reporting abbreviations, device-specific central and peripheral implant locations, and MCS imaging protocols are found in reviews by Stainback et al. and Estep et al.[36,37]

Report Communication: From Preliminary Report to Final Report

The patient demographic information within a report is often auto populated. Its completeness and accuracy must be confirmed. Echo measurements and findings can be initially completed by a sonographer as part of a draft report. A preliminary report (verbal or written) can only be prepared by a physician. Only a physician qualified for independent interpretation of echocardiography studies can issue a final report and make it available to the ordering provider.[38,39] Any significant changes between the preliminary and final reports must be noted and echocardiography labs should establish a process for communicating significant changes between the preliminary and final reports and consider developing a mechanism for tracking the frequency of these changes.

Stat or urgent studies should be prioritized. It is recommended that the cardiac sonographer alert the reporting physician of any findings requiring immediate attention, but it is the reporting physician's responsibility to expeditiously communicate critical or urgent findings to the ordering provider. The sonographer should not render a diagnostic opinion or generate a preliminary report.[38]

In addition to routine communication of the echocardiography findings in the patient's medical record, urgent or critical findings that may require immediate changes in the plan or intervention should be directly communicated to the ordering provider or the care team based on the acuity and significance of the finding.[3,39] This communication should be documented in the echocardiography report or elsewhere, based on the individual laboratory policy for critical results communication.[39] The laboratory should have a procedure for tracking compliance with this reporting policy. A list of critical findings that may warrant direct communication both from the sonographer to the interpreting physician and from interpreting physician to the care team is proposed in Table 12. However, each laboratory should develop a critical findings list, and a communication system that adapts to the institution's needs. The reporting physician should consider the indication, patient history, and acuity of a finding and exert clinical judgment when determining the urgency and method for communicating these findings. Similarly, findings that represent a significant abnormality or change from prior testing may require clinical action in the short term, and those may warrant direct personal notification to the ordering clinician are outlined in Table 12.

If an echocardiogram study or report is readily available in the same electronic medical record or a picture archiving and communication system (PACS), it is recommended that a statement be included to address any significant changes from the prior study. Differences in echocardiographic findings between a previous report and a current report may occur for several reasons including technical, physiologic, and pathologic causes. For example, the prior study may have been performed during atrial fibrillation and the current exam is being performed during normal sinus rhythm.

Although it is left to the discretion of the interpreting physician to recommend additional imaging and/or clinical consultation considering the individualized clinical context, we believe recommending clinical consultation in the summary statement of an echo report in certain situations, such as a new diagnosis of severe aortic stenosis, will redefine the role of echocardiography in patient care from passive, descriptive reporting to active participation in patient management.

As an example, the following language is recommended: *"This patient has significant aortic stenosis that, according to the current American College of Cardiology/American Heart Association/ASE valvular heart disease guidelines, may warrant treatment. As clinically appropriate, further evaluation and/or referral should be considered."* Table 13 highlights examples of echocardiographic findings that may be regarded as significant changes and might warrant additional imaging or consultation, and comparison statements that could be reported.

Comparison with Prior Reports, Cardiovascular Magnetic Resonance and Cardiac Computed Tomography

It is increasingly likely that a prior noninvasive cardiac study has been performed and either the study or the report is available for comparison to the echocardiogram. This section provides guidance on how to address those comparisons in a consistent and clinically relevant manner. See also the "Report Communication: From Preliminary Report to Final Report" section regarding when to recommend that consultation be considered.

It is important to recognize that each of the commonly performed cardiovascular diagnostic tests has its own indications, strengths, and limitations. Similarly, each modality has its own normal range values that must be taken into consideration when providing comparison comments. It is not uncommon that the noted change in LVEF between different modalities represents a difference in technology and method of quantitation rather than a clinically relevant difference in left ventricular systolic function.

When reports for other imaging modalities are readily available in the same electronic medical record, it is recommended that a statement be included that addresses the correlation of findings on the echocardiogram to these reports. Some examples of comparison statements are provided below and are categorized by correlation type by modality and either report review or image review. When a change in echocardiographic finding advances from normal to abnormal or from less than severe to a severe reported value, this should be considered a "significant" interval change. Otherwise, the reported change should be considered of "uncertain clinical significance."

Comparisons with prior echo studies (focusing on changes in chamber dimensions, ventricular function, valve physiology, and clinical indication for the exam) can be stated below.

Comparison with report:

- "In comparison to the previous report from xx (month/day/year; include time if same day), there has been no significant interval change."
- "In comparison with the previous reported study from xx (month/day/year; include time if same day), there has been a significant interval change in xx (e.g., the reported aortic valve stenosis is worse)."
- "In comparison with the previous reported study from xx (month/day/year; include time if same day), the interval changes in xx (e.g., the maximal aortic valve gradient has increased) are of uncertain clinical significance."

Comparison with image:

- "In direct side-by-side comparison of images to the previous study from xx (month/day/year; include time if same day), there has been no significant interval change."
- "In direct side-by-side comparison of images with the previous study from xx (month/day/year; include time if same day), there has been a significant interval change in xx (e.g., the aortic stenosis severity has increased from moderate to severe)."
- "In direct side-by-side comparison of images with the previous study from xx (month/day/year; include time if same day), the interval changes in xx (e.g., the aortic valve gradient has increased) are of uncertain clinical significance."

Comparison with prior studies from a different diagnostic modality (this should only be included when the reader is an expert in multimodality imaging):

Comparison with report:

- "In comparison to a reported xx (include modality, e.g., cardiovascular magnetic resonance [CMR]) study from xx (month/day/year; include time if same day), there has been no significant interval change."
- "In comparison with a reported xx (include modality, e.g., CMR) study from xx (month/day/year; include time if same day), there has been a significant interval change in xx (focus on chamber dimension, ventricular function, valve physiology and clinical indication for the exam)."
- "In comparison with a reported xx (include modality, e.g., CMR) study from xx (month/day/year; include time if same day), the interval changes in xx (focus on chamber dimension, ventricular function, valve physiology, and clinical indication for the exam) are of uncertain clinical significance."

Comparison with image (only if the reader has sufficient multimodality imaging expertise):

- "In direct comparison to a xx (modality) study from xx (month/day/year), there has been no significant interval change."
- "In direct comparison with a xx (modality) study from xx (month/day/year), there has been a significant interval change in xx (focus on chamber dimension, ventricular function, valve physiology, and clinical indication for the exam)."
- "In direct comparison with a xx (modality) study from xx (month/day/year), the interval changes in xx (focus on chamber dimension, ventricular function, valve physiology and clinical indication for the exam) are of uncertain clinical significance."

Important considerations for comparison statements:

- Significant changes should be further classified as new, resolved, worse, or improved findings.
- If no previous imaging study or report is available for comparison, this should be included in the comparison statement (e.g., "There is no previous study available for direct comparison").
- These comparison statements should include recent studies (within 1 year) of the same type of imaging modality (e.g., TTE, TEE, exercise, or pharmacologic stress).
- These comparison statements may include studies performed more remotely (>1 year) with the same type of imaging modality.

- These comparison statements may include recent studies using a different type of imaging modality such as cardiac computed tomography or CMR when the interpreting physician is able to provide comparisons that address the known technical differences related to the comparison study modality.
- All comparisons to previous report comments should include the date of the study being compared and a statement of whether the findings are new, unchanged, resolved, improved, or worsened.
- All comparisons to previous report comments should include a summary statement on the clinical significance of the comparison findings: "clinically significant," "clinically insignificant," or "uncertain significance."

A noninvasive cardiovascular study is often available for comparison with the echocardiogram. Expertise in multimodality imaging is also becoming more frequent and allows for accurate comparisons between the echocardiogram and the other available diagnostic studies. It is not adequate to simply compare reported findings between studies since each modality has its own reported normal ranges. For example, reporting a difference in LVEF between a nuclear single-photon emission computed tomography myocardial perfusion imaging report and an echocardiogram may imply a clinical difference when there is none. Comparisons between imaging modalities should only be reported by experts in multiple imaging modalities and with ability to review the images from each modality. Optimal comparisons should search for changes in ventricular and atrial dimensions, ventricular global and regional systolic function, valve pathology, and hemodynamics.

Learning from SCMR Reporting Guidelines

The Society for Cardiovascular Magnetic Resonance (SCMR) recently updated their guidelines for reporting CMR examinations.[40] There are many commonalities between these two noninvasive diagnostic modalities including overlapping appropriateness indications for acquisition and highly comprehensive assessment capabilities that include structure and function. Therefore, similar recommendations for standardized reporting would seem logical.

Common to CMR reporting and less often included in echo reporting are disease-specific reporting protocols. There may come a time when this approach is more commonly recommended for echocardiography. As echo labs evolve and increasingly become overwhelmed with the high volume of requests, and the need for rapid throughput, coupled with the additional time requirements for the acquisition of advanced parameters, disease-specific protocols may offer a solution. Potential CMR reporting protocols that may be worthwhile to consider for echo reporting include chronic ischemic heart disease, cardiomyopathies, heart transplantation, diseases of the aorta, and valvular heart diseases.

Finally, important to all noninvasive imaging reports including CMR and echocardiography is that the summary statement specifically relates the relevant findings to the study indication. With the goal of linking the report to clinical management and outcomes, the summary should provide enough information for the referring clinician to consider appropriate.

Report Summary Statement

A summary statement should be included in each echocardiography report. For consistency, the term "summary statement" is preferred by consensus over "concluding statement" or "conclusions." The summary statement should be placed at the top of a report (e.g., immediately following the demographics and indications sections). The summary statement for a comprehensive TTE report should encompass five essential elements: 1) assessment of left and right ventricular function, 2) presence or absence of significant valvular abnormalities, 3) clinically important positive findings, 4) pertinent negative findings (when applicable), and 5) a comparison statement. For TEE reports and limited TTE reports, the summary statement may be more focused, encompassing key clinically important positive findings and pertinent negative findings related to the study's indication. For stress echocardiography reports, the summary statement should include the overall study interpretation (normal, ischemia, fixed wall motion abnormality, or combination [ischemia exams] or as appropriate for structural heart disease exams).

The summary should present these findings in clear, straightforward sentences or bullet points that can be interpreted independently and should not simply reproduce whole sections of the body of the report. It must highlight key positive or pertinent negative findings that address the clinical questions related to the study's indication (e.g., "Valvular vegetations are not evident"), with critical findings clearly labeled (Table 12). Documentation of any communication of these critical results to the care team should be included within the summary (e.g., "Critical result was communicated to the requesting team"). The specific wording of critical result communication and documentation is under the discretion of an individual laboratory.

A comparison is recommended in all summary statements. The comparison statement should provide details on how the current study compares with previous echocardiographic studies or other imaging results, noting whether any clinically significant changes are observed (Table 13). It should specify whether the comparison was made by reviewing prior study images or reports (e.g., "By direct side-by-side comparison of images with the previous study dated 01/01/2020, the LV systolic function has normalized"). While it is not mandatory to recommend serial echocardiography studies, additional imaging, or clinical consultation, it should be considered based on the clinical context.

Integration of Adult Congenital Heart Disease Findings

To date, there are no published standards for comprehensive TTE and TEE echocardiographic reporting of congenital heart disease (CHD). The IAC has provided basic standards for adult congenital heart disease (ACHD) echo reporting that are intentionally not all inclusive. This is because there are more than thirty discrete types of CHD ranging in complexity from a simple atrial septal defect (ASD) to complex forms of heterotaxy and single ventricle syndromes. There are 367 congenital cardiac terms included in the 11th revision of the International Classification of Diseases involving defects at every level of cardiac segmental anatomy and dueling nomenclature systems that are continuing to progress towards harmonization.[41] A comprehensive reporting scheme for ACHD is outside the scope of this adult reporting standards document and will be the focus of a future ASE standards document.

With improved survival for those born with CHD, the last few decades have seen a shift towards a greater number of ACHD patients. Echocardiograms for ACHD patients with complex conditions should ideally be reported by physicians with expertise in congenital heart disease, as understanding the imaging implications of their CHD and cardiac surgical procedure(s) requires specialized training. ACHD patients with certain common, isolated, and acyanotic defects can be accurately reported in most adult echocardiography labs with necessary report elements listed in Table 14. Recent updated reporting nomenclature recommendations for bicuspid aortic valve can be found elsewhere.[41,42]

Inevitably, adult echo labs without ACHD expertise will image complex ACHD as an initial diagnosis or in ACHD patients previously either lost to ACHD specialist follow-up or who have poor access to such facilities. In cases of complex ACHD cases, we recommend reporting on the anatomic structure and function at each level of segmental anatomy (Table 15) with subsequent referral to an adult congenital specialist, specifying this in the report.

> *Example: "Due to the complexity of the congenital heart disease, we recommend referral as soon as possible (or immediately) to a cardiology practice or center with specific expertise in adult congenital heart disease."*

In general, a comprehensive ACHD echocardiography report will include details on all cardiac segmental anatomy within the heart and surrounding vascular structures (Table 15), including critical 3D relationships only shown with appropriate image acquisition sweeps. Adequate ACHD echo reporting is dependent on the proper image acquisition (see ASE congenital echocardiographic guidelines) and detailed records of prior congenital cardiac surgeries that are often difficult to accurately report de novo from echocardiographic images, especially those obtained with limited imaging windows.[30,43]

Limited Study Reports

The contents and extent of a limited echocardiography protocol report depends upon the reason for the exam. The current IAC standards and guidelines stipulate a limited echocardiography study may be

performed when the patient has undergone a recent complete examination, and a limited exam is needed for surveillance of a previously identified condition with the extent of the exam depending upon the indication. The determination of the appropriate time interval between a comprehensive exam and a follow-up limited exam is dependent on the study indication and is under the discretion of the treating physicians and an individual laboratory.

A limited study examines a single area of the heart or answers a single clinical question.[9] This is within the realm of consultative echocardiography performed by echocardiographic laboratories. Reports for limited studies should include a statement that a comprehensive study was recently performed (including date of comprehensive TTE) or that the study was performed for additional or focused clinical information. The limited study report should include relevant structure and function comments on all images obtained and not solely comments related to the indications. For example, all visualized cardiac chambers and valves (though limited in extent) should be commented on, even if the exam was primarily to assess the amount of pericardial effusion present. Reporting should be limited to the extent of the exam. Redundancy should be avoided. However, a new incidental finding should be reported.

Overall, the components of the report should mirror the comprehensive echocardiogram, including quantitative elements that are typically confined to the component-specific descriptions to address a well-specified clinical concern. For example, using a limited quantitative echocardiogram is both appropriate and cost-effective for determining ejection fraction in patients with heart failure or patients undergoing cardiotoxic chemotherapy.[44]

Echocardiography Core Laboratories

Although this guideline is primarily intended for clinical practice echocardiography labs, most recommendations are also pertinent for laboratories related to echocardiography research—echo core laboratories (ECL).[45] ECLs are a critical part of the research infrastructure underlying clinical and translational studies. ECLs ensure the quality and reproducibility of echocardiographic measurements made as well as standardization of the measurement techniques employed to produce accurate and

valid results. An important aspect of ECL activities involves documentation of the methods used for obtaining measurements, the quality assurance (QA) checks that were employed, and the results of the underlying measurement activity.[46]

Several key elements should be included in ECL documentation to ensure quality practices are met. First, an ECL should have a written standard operating procedure document that outlines both routine procedures employed by the laboratory, as well as any procedures that are specific to the given research project being conducted. If there are multiple associated clinical echo lab sites collecting or reviewing echocardiographic data to support ECL functions, standard operating procedures as well as the documentation supporting these procedures (e.g., site manuals) should be uniform across sites. This documentation should outline the procedures for 1) training and evaluating the performance of expert readers, 2) image receipt, storage, and tracking, 3) the actual measurements and techniques to be performed, 4) any QA efforts that are to be employed, and 5) how measurements or findings are recorded and verified for accuracy before reporting. Reports should clearly name and provide qualifications for the key personnel involved in interpretation of a research echocardiogram as well as any individuals overseeing the quality and conduct of those interpreting these studies. To the extent possible, measurements and findings should be reported in a manner mirroring the language and key elements of routine adult echocardiography reports (Table 6).[14,15,20] However, as the scope and specificity of ECL activities may extend beyond those data elements captured as part of routine adult echocardiogram interpretation, the ECL report should be dictated by the individual study goals and the language and elements customized to fulfill the research needs of the study.

A core element of ECL reporting involves documentation of QA efforts undertaken by laboratory staff. Pre-specified QA and review tasks should be performed by all ECLs. These may include training and oversight of ECL staff, determination of inter- and intra-rater variability measures to quantify the reproducibility, repeatability, and reliability of measurements, determination of temporal drift in repeated measurements performed across time, and periodic audits of a subset of the echocardiogram images and reports to verify adherence to best practices. The procedures for conducting these QA activities, the timing of their occurrences with respect to the study timeline, the involved personnel,

and the results of these activities should be clearly delineated, and these QA reports should be stored in a secure fashion to protect confidentiality.

Quality Improvement of Echo Reports

An essential component of a high-quality echocardiography lab is a well-designed QA or quality improvement (QI) program that ensures that each member is performing and interpreting studies in a consistent, uniform fashion that aligns with published guidelines when these documents are available. The IAC has published standards for QI that are recommended for all echocardiography labs.[9] An established and written QA or QI program is a mandatory standard for laboratory accreditation by the IAC that is supported by the ASE. At a minimum, it must include evaluation and documentation of test appropriateness, technical quality, interpretive quality, and report completeness and timeliness. Of note, the published IAC standards are the minimum that should be achieved. Echo labs performing special procedures or caring for complex patients may require a more rigorous QA or QI program. Each individual echo lab should therefore have an established QI program that meets or exceeds the IAC standards.

A quality echo report should provide a comprehensive yet concise assessment of the findings of each of the cardiac elements. Additionally, these studies should include:

- timely image acquisition and interpretation
- appropriate indication for the study
- compliance with IAC standards
- high technical image quality
- adherence to lab protocols
- a description of all elements in the structured report
- accurate interpretation of images
- date and time report was signed by the reader.

Additionally, each report should include a statement pertaining to the overall quality of the echo images followed by an explanation for the presence of suboptimal images. A reporting statement

regarding the diagnostic quality of one or more acoustic window(s) may be useful to support diagnostic uncertainties and to support alternate imaging recommendations. Recommended language for the echo exam quality statements is noted in Table 16. Comments related to technical image quality and diagnostic adequacy should be separated. In many cases, certain measurements, such as Doppler assessments, may be highly accurate even if the overall image quality is suboptimal.

Individual sections of the echo report should include a comment about each cardiac structure pertaining to that section. If a particular structure is not seen, a statement reflecting this should be included in the appropriate section. Inconsistencies and discrepancies should be avoided. In particular, the description of measurements should match guideline-based severity cut-offs of these measurements when available. It is recognized, however, that echocardiographic parameters used for the assessment of a single lesion may not be entirely concordant; expertise and clinical judgement should be employed to make the final decision. Discordant measurements should be explained in the report if possible. Data used to train augmented intelligence for echo reporting should be carefully curated.

The echo lab should strive for internal consistency in reporting echo findings among all readers in the lab according to ASE guidelines when available. To highlight key pathology, view or image numbers that best demonstrate the pathology should be included in the report. If feasible, key images can be embedded into the echo report. A summary statement should be included in each echo report.

Electronic Storage of Echo Data

While no Digital Imaging and Communications in Medicine (DICOM) standard exists for report storage, echo measurements are currently stored and transferred to electronic health records in DICOM structured reporting files. For any parameter, the average, maximum, or minimum measurement may be stored and transferred since storage and file transfer settings are variable. Moreover, physician-adjusted measures that are reported in the final report may not be reflected in the DICOM structured reporting measures. Quality assurance of these settings and fields is not widely performed and this can have important ramifications when mining data for big data efforts.[47]

Artificial Intelligence Tools for Augmenting Echocardiography Reports and Future Directions

There is growing interest in leveraging artificial intelligence, particularly LLMs, for structured reporting in medical imaging.[48,49] LLMs have demonstrated remarkable proficiency in understanding and generating coherent, contextually relevant text, making them promising tools for automating impression generation in echocardiography reports. A few studies have explored their effectiveness in summarizing echocardiographic findings into structured impressions.[4,50,51]

In addition to artificial intelligence-driven models that directly extract standardized echocardiographic measurements from images, these tools can further enhance documentation by auto-populating structured fields and reducing redundant tasks for clinicians. Augmented reporting with artificial intelligence could involve several key steps, such as 1) populating correct measurements using prespecified rules, 2) flag inconsistencies or missing data points, reducing reporting errors and enhancing patient safety, 3) prompting users to verify or update critical information before finalizing reports, 4) seamlessly extracting and incorporate relevant patient history, ensuring a comprehensive diagnostic report that aligns with prior echocardiographic findings and cardiovascular imaging comparisons, 5) automated quality assurance tools and linking the decisions and displaying them with relevant guidelines, references, and differential diagnoses, 6) tailoring LLMs on echocardiographic reports for different audiences, generating detailed versions for specialists and simplified summaries for referring physicians and patients (5).

While the technology and clinical evidence continues to evolve, the current guidelines emphasize the need to integrate these techniques within a unified framework that improves clinical workflow. Enhancing the performance of LLMs while addressing their limitations—such as hallucinations, insufficient domain knowledge, and variability across diverse healthcare settings—will be important. Additionally, integrating LLMs with existing echocardiography reporting tools, electronic health record systems and reporting software, requiring robust information system integration, and rigorously validating their impact in clinical studies will be crucial.

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Guideline Conclusion

The practice of echocardiography and cardiovascular imaging has witnessed significant technological advancements and evolution over the past two decades, surpassing the parameters set forth in the 2002 Recommendations for a Standardized Report for Adult Transthoracic Echocardiography. The ASE Guideline for Standardization of Adult Echocardiographic Reporting reflects the contemporary state of the field, acknowledging the wealth of updated science and consensus-driven guidelines that have become integral to the practice of echocardiography.

The standardization of echo reporting enhances interoperability among healthcare systems ensuring efficient communication for timely decision making. Artificial intelligence algorithms in healthcare rely

on consistent, uniform, and well-organized data related to cardiac imaging for training and validation, which enables the integration of these technologies into clinical workflows.

Emphasizing the critical need for standardization and precision in reporting format and language, particularly concerning clinically actionable items, this guideline sets a new standard for clarity and consistency. Encompassing TTE, TEE, and stress echocardiography reporting, it thoroughly addresses the entire spectrum of communication: from preliminary to final reporting and from final report to clinical consultation. Addressing the complexities of reporting, this guideline provides guidance on comparing and correlating with other imaging modalities, learning from similar initiatives in imaging societies, and accommodates the nuances of simple adult CHD, and limited study reports.

Looking ahead, the guideline serves as a foundation for future endeavors, informing the development of guidelines for pediatric echocardiography and POCUS reporting. A call to action for stakeholders, including industry partners in imaging, to design reporting platforms to accommodate and comply with standards is imperative. By addressing these emerging areas, the ASE reaffirms its commitment to excellence, innovation, and standardized practices in the dynamic field of echocardiography.

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