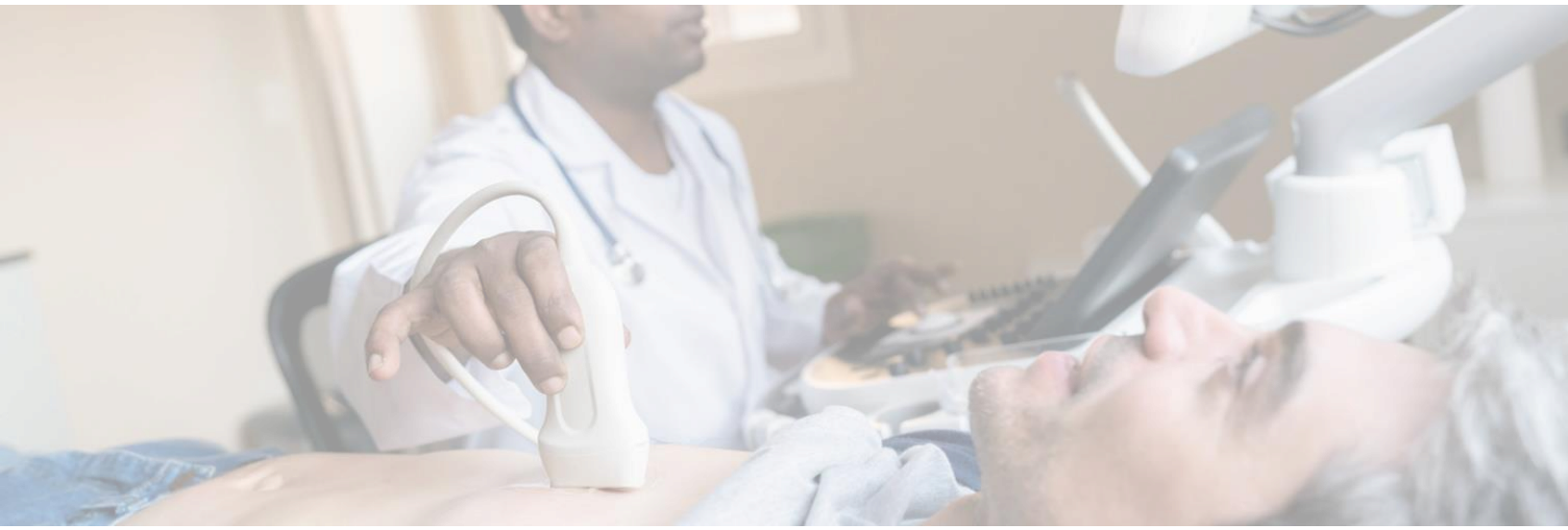
CorHealth Ontario

Advancing cardiac, stroke and vascular care



Standards for Provision of Echocardiography in Ontario

April 2021

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Message from the CEO of CorHealth Ontario and the Chair of the Echocardiography Advisory Panel

CorHealth Ontario (CorHealth) is an organization formed by the merger of the Cardiac Care Network of Ontario (CCN) and the Ontario Stroke Network (OSN). Our core mission is to provide the Ministry of Health (MOH), Regions, hospitals, and care providers with reliable information and robust processes that will improve the quality, efficiency, accessibility, and equity of cardiac, stroke and vascular services for patients across Ontario.

The history of echocardiography over the past several decades is one of progressive technical development, occurring in tandem with increasing clinical relevance. It is now an essential component in the assessment and management of patients presenting with a wide variety of cardiac and respiratory illness. It is also being increasingly used to identify patients who may benefit from an expanding array of medical and procedural therapies. These expanded applications have resulted in an increased demand for echocardiography and a call from both clinical and administrative stakeholders for a more robust framework to ensure quality and appropriate utilization.

It was in this context that we were asked jointly by the MOH and Ontario Medical Association (OMA) in 2010 to develop standards of practice and accreditation criteria for echocardiography in Ontario. We convened an Echocardiography Advisory Panel that was chaired by Dr. Anthony Sanfilippo, and included clinical experts and representatives from the MOH and OMA. In April 2012, based on a review of existing standards and guidelines, the Panel released Standards for Provision of Echocardiography in Ontario. In that same year, the Echocardiography Quality Improvement (EQI) Program was also established to support facilities in achieving the Standards for Provision of Echocardiography in Ontario. Four years later, in 2016, participation in the EQI Program became a requirement for physicians to bill the Ontario Health Insurance Plan (OHIP) for echocardiography services.

To accommodate the ever-changing evidence and the knowledge gained through the EQI Program, we have again, refreshed the Standards for Provision of Echocardiography in Ontario in March/April 2021.

We thank the members of the Echocardiography Advisory Panel for their continued commitment and contribution to echocardiography quality in Ontario. We have appreciated the ongoing consultation provided by the Ontario Association of Cardiologists. We look forward to continuing to engage the cardiology community to ensure Ontarians receive quality, timely, and clinically appropriate echocardiographic examinations.

Yours truly,

Anthony Sanfilippo MD, FRCPC
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Professor of Medicine and Associate Dean
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Sheila Jarvis
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Introduction

For the purposes of this document, the term “Echocardiographic Laboratory” will be defined as a facility whose primary purpose is to provide echocardiographic examinations.

An Echocardiographic Laboratory:

- Shall have a Medical Director and Technical Director
- May also have additional physicians and sonographers performing and/or interpreting transthoracic echocardiography
- May perform stress or transesophageal echocardiography

Such facilities may vary greatly in size (single to multiple imaging systems), site (office, clinic, hospital) and scope of examinations provided (inpatient, outpatient, and/or emergent services), but will be characterized by the following features:

- Provision of full transthoracic adult examinations
- Acceptance of referrals for echocardiographic examinations
- Space, equipment, and procedures appropriate to provide such examinations
- Engagement of appropriately trained personnel to carry out and assist with the provision of echocardiographic examinations
- Engagement of appropriately trained physicians to interpret and supervise examinations
- Recording and reporting of the results of those examinations

In addition, some laboratories may also provide the following services, which require additional service and professional considerations:

- Paediatric echocardiographic examinations
- Transesophageal echocardiography
- Intraoperative transesophageal echocardiography
- Stress echocardiography

Scope

This document specifies required practices for **adult** transthoracic, stress and transesophageal echocardiography. It is not applicable to intraoperative, paediatric nor Congenital echocardiographic examinations.

A note about Paediatric and Congenital Echocardiography
Standards regarding Paediatric and Congenital Echocardiography were developed by the Paediatric Echocardiography Working Group, as convened by the Provincial Council for Maternal and Child Health. They are presently voluntary, and no external review process is in place. They have been included in the Appendix for reference only.

2021 Revisions

The Standards for Provision of Echocardiography in Ontario have been refreshed to provide greater clarification and align content to reflect current practice.

Key revisions have been noted below; however, it is important that the Standards be reviewed in their entirety.

- A quantitative measurement of Ejection Fraction (preferably quantitated by Simpson's biplane Method of Discs) shall be now performed as part of the stress echocardiographic screening exam under **Standard ES2.2: Required Measurement.**
- Capability to share exams externally with interpreting physicians, and other health care providers to ensure continuity of care is an expectation now captured in **Standard F7b: Capability to Share Exams Externally**.
- **Standard P7: Qualifications of Medical Staff** has been updated to include requirement for recent Level 2 or 3 echocardiography training, or supervised practice at an accredited facility.
- **Under Standard P10: Technical Staff Requirements**, the Technical Staff meet the qualification requirements by achieving 1) appropriate credentials, or 2) successful completion of an accredited Echocardiography training program, or 3) recently completed an accredited echocardiography training prior to qualifying for American Registry for Diagnostic Medical Sonography (ARDMS) or Sonography Canada, or equivalent credentialing.
- Providing patient-centered care is best practice, therefore, a mechanism to monitor patient satisfaction is an expectation now included in **Standard Q7: Patient Satisfaction.**
- Additional requirements have been included under the following Standards:
    - Standard E4: Standard Measurements
    - Standard ES2: Established Protocols for the Screening Examination
    - Standard ES3.1: Pharmacologic Stress Echocardiography
    - Standard ES4: Additional Important Considerations
    - Standard F1: Examining Room Requirements
    - Standard F3: Maintenance Requirements
    - Standard P1.1: Additional Qualifications for Stress Echocardiography (Medical Director)
    - Standard P7.1: Additional Qualifications for Stress Echocardiography (Medical Staff)

Framework

The framework of this document is structured by the following requirements:

Section 1	Standards Regarding the Echocardiographic Examination
Section 2	Standards Regarding Echocardiographic Facilities, Equipment and Standard Operating Procedures
Section 3	Standards for Reporting of Echocardiographic Examinations
Section 4	Standards Regarding Laboratory Type and Personnel Involved in Echocardiographic Examinations
Section 5	Indications for Echocardiographic Examinations
Section 6	Continuing Quality Assurance in the Echocardiographic Laboratory
Appendix A	The Standard Echocardiographic Report
Appendix B	Indications for Echocardiography – Standards 2012 (Updated 2018)
Appendix C	Standards Regarding Paediatric and Congenital Echocardiographic Examinations and Indications for Echocardiography
Appendix D	Summary of Standards

Within each of the first six sections, a description of specific characteristics of optimal service provision is included. In addition, standards will be described, which are defined as **demonstrable performance characteristics that could provide evidence of quality service provision**. In their entirety, standards provide a means of identifying appropriate service and ensuring all patients receive timely and effective assessment.

Within this document the term "shall" is used to express a requirement that Echocardiography facilities are obliged to satisfy in order to comply with the Standard.

The term "should" is used to express a recommendation or a suggested action.

The term "may" is used to express an action that is permissible.

Section 1

Standards Regarding the Echocardiographic Examination

1.1 Overview

The echocardiographic examination utilizes the full complement of imaging and non-imaging modalities to provide a comprehensive assessment of cardiac structure and function. Fundamental and harmonic imaging is used to optimize visualization of cardiac structures. When the imaging is suboptimal, the use of an echocardiographic contrast agent can be used to enhance visualization.

Cardiac function and intracardiac hemodynamics are assessed by a comprehensive Doppler examination including pulsed-wave, continuous-wave, and colour flow. Tissue Doppler imaging should be considered in most cases to provide additional information on systolic and diastolic function.

A **comprehensive (complete) study** is the goal in every patient. A complete study is defined as one that examines all the cardiac chambers and valves and the great vessels from multiple views, complemented by Doppler examination of every cardiac valve for antegrade and retrograde flow, and the atrial and ventricular septa. When a specific view or Doppler signal is unavailable, the reason shall be documented.

A **focused study** is an examination limited to a single component of the cardiac assessment usually performed in an emergency situation to guide immediate management or to re-assess a specific and active clinical issue.

Proper performance of the study shall include adequate explanation of the procedure and respectful interaction with the patient. Although the sequence of views may vary according to local practice, the full complement of views including Doppler tracings and measurements should be obtained and recorded in every patient. Specific comments on the quality of study are included with comments on technical deficiencies such as foreshortening and inadequate alignment in relation to Doppler assessment.

1.2 Standards Regarding the Transthoracic Echocardiographic Examination

Standard E1: Established Protocols

Echocardiographic facilities shall have established protocols that describe the components of the comprehensive transthoracic examination (TTE):

- Laboratories shall establish protocols for the acquisition and recording of echocardiographic examinations
- These protocols shall be reviewed and accepted by all sonographers and physicians involved and shall be made available to all and reviewed on a regular basis

Evaluations of Transthoracic Study quality include:

- Display of standard on axis views without foreshortening
- Evaluation of endocardium - well visualized, poorly visualized, and contrast if administered, was used properly
- Evaluation of Doppler signals and measurements

Standard E2: Required Imaging Components

The comprehensive transthoracic echocardiographic examination shall contain the following imaging components:

- Parasternal long axis of the left ventricle, left atrium, and aorta
- Parasternal short axis consisting of at least three short - axis cuts of the left ventricle (base, mid, apex), pulmonary artery view and aortic valve view
- Right ventricular focused view
- Right ventricular inflow view
- Right ventricular outflow view
- Apical four - chamber view
- Apical two - chamber view
- Apical three - chamber view (long-axis view)
- Apical five - chamber view
- Apical imaging with particular attention the left ventricular (LV) apex
- Subcostal long - axis view
- Subcostal short - axis view
- Subcostal inferior vena cava view
- Suprasternal views of the aorta

Note: The intention of ventricular imaging is to ensure that all left ventricular segments are imaged properly.

Standard E3: Required Doppler Components

The comprehensive transthoracic echocardiographic examination shall contain the following Doppler components:

- Parasternal long - axis two-dimensional (2D) with colour screening for aortic insufficiency and mitral regurgitation
- Parasternal short - axis 2D with pulmonary artery colour and pulsed wave Doppler
- Right ventricle inflow view 2D with colour for tricuspid regurgitation
- Apical - four chamber view 2D with colour for mitral regurgitation and tricuspid regurgitation; pulsed and continuous wave
- Apical five - chamber view with colour for aortic and mitral regurgitation and pulsed/continuous wave Doppler of the aortic flow velocity
- Apical three - chamber (long-axis) view 2D with colour and aortic flow velocity
- Apical two - chamber with colour flow Doppler of the mitral valve
- Subcostal view with colour Doppler of the interatrial septum
- Suprasternal view with colour and pulsed wave/continuous wave Doppler of the descending aorta

Standard E4: Standard Measurements

The comprehensive transthoracic echocardiographic examination shall contain the following standard measurements:

The following standard measurements shall be obtained and recorded for all studies. Either M-mode or two-dimensional (2D) can be used to obtain the measurements at end expiration, based on their respective strengths and limitations in specific situations.

- Blood pressure and heart rate
- Left ventricular systolic and diastolic dimensions
- Left ventricular diastolic wall thickness (septum and posterior wall)
- Ejection fraction and the method used shall be identified
    - Ejection fraction should be quantitated whenever technically possible by one of the validated methods, preferably by Simpson’s biplane Method of Discs
    - Visual estimation should be reserved for cases in which quantitative assessment is not technically feasible, or would be potentially inaccurate
- Transvalvular aortic flow velocity

- Pulmonary valve velocity
- Diastolic parameters should be determined according to the current guidelines.
    - Diastolic function classified into categories of normal, mild dysfunction (impaired relaxation), moderate dysfunction (pseudo-normalization) and severe dysfunction (restriction).

      This assessment is based on consideration of the relevant parameters available from the Echocardiographic examination which can include:
        - mitral inflow velocities,
        - mitral deceleration time,
        - isovolumic relaxation time,
        - pulmonary venous systolic and diastolic velocities, and
        - tissue Doppler assessment of mitral annular motion.
- Tricuspid regurgitation velocity to calculate right ventricular (RV) systolic pressure
- RV functional assessment to include Tricuspid annular plane systolic excursion TAPSE and/or Tissue Velocity Imaging (TVI)
- Measurements of the aortic root and ascending aorta (sinuses of Valsalva and proximal ascending aorta) and to include the annulus if indicated
- Left atrial antero-posterior dimensions and volumes
- A measure of right atrial size (e.g., dimensions, areas, or volumes)

Standard E5: Additional Information

The facility shall have established procedures to provide the following additional information where clinical indications or findings warrant.

Transvalvular mean and maximal gradients with continuous wave Doppler for stenotic valves and valvular prostheses, including views from multiple windows, such as the suprasternal and right sternal border.

- Spectral display of complete envelope of continuous wave Doppler signal of valvular regurgitation
- Proximal isovelocity surface area calculation or other quantitative methods for assessment of valvular regurgitation
- Respiratory variation of mitral and tricuspid inflow Doppler (e.g., pericardial disease)
- Hepatic venous flow pattern and inferior vena cava collapse
- Shunt calculation
- Descending aortic velocity and presence of flow reversal, for assessment of aortic coarctation and regurgitation

- Protocols to address the assessment of patients with technically inadequate images that do not allow for reliable evaluation of the clinical issue in question. This should include any or all of the following:
  - Saline contrast injection
  - Use of contrast agents to improve endocardial visualization
  - Referral to a reference laboratory
  - Referral to alternative available imaging modalities including stress and/or transesophageal echocardiography

1.3 Standards Regarding the Stress Echocardiographic Examination

Standard ES1: Established Protocols

Laboratories shall establish protocols for the acquisition and recording of stress echocardiographic examinations and shall specify all imaging planes and required views.

These protocols shall be reviewed and accepted by all sonographers and physicians involved and shall be made available to all and reviewed on a regular basis.

The screening exam shall be carried out as part of the stress echocardiographic examination.

Standard ES2: Established Protocols for the Screening Examination

A screening examination is an integral part of the stress echocardiogram. Its purpose is to identify pathology that may preclude the stress examination; however, it does not contain all the elements of a comprehensive assessment. The screening examination shall contain the following imaging components:

- Parasternal long axis of the left ventricle, left atrium, and aorta
- Parasternal short axis consisting of at least three short-axis cuts of the left ventricle (base, mid, apex), pulmonary artery view and aortic valve view
- Apical four chamber view
- Apical two chamber view
- Apical three chamber view (long-axis view)
- Apical five chamber view
- Apical imaging of all segments, with particular attention to left ventricular apex imaging

Standard ES2.1: Required Doppler Components for the Screening Examination

The stress echocardiographic screening examination shall contain the following Doppler components:

- Parasternal long axis two-dimensional (2D) with colour screening for aortic insufficiency and mitral regurgitation
- Parasternal short axis 2D with pulmonary artery colour and pulsed wave Doppler
- Apical four-chamber view 2D with colour for mitral regurgitation and tricuspid regurgitation; continuous wave Doppler for right ventricular systolic pressure (RVSP)
- Apical five chamber view with colour for aortic and mitral regurgitation and aortic flow velocity
- Apical three chamber (long axis) view 2D with colour
- Apical two chamber with colour flow Doppler of the mitral valve

Standard ES2.2: Required Measurement

The stress echocardiographic screening examination shall contain a quantitative measurement of Ejection Fraction (preferably quantitated by Simpson's biplane Method of Discs).

Standard ES3: Required Imaging Components

The comprehensive stress echocardiographic examination shall contain the following components, as defined by the facility:

Standard ES3.1: Pharmacologic Stress Echocardiography

Acquisition of rest images and three other stages of the pharmacologic stress echocardiogram are obtained. Standard images include:

- Rest image
- Low dose
- Peak
- Recovery

OR

- Rest
- Low dose
- Pre-peak
- Peak
- Recovery

Standard ES3.2: Treadmill / Bike Stress Echocardiography

- Images are acquired at rest, immediately post exercise and after recovery
- Parasternal long axis of the left ventricle, left atrium, and aorta
- Parasternal short axis consisting of at least three short-axis cuts of the left ventricle (base, mid, apex), pulmonary artery view and aortic valve view
- Apical four chamber
- Apical two chamber
- Apical three chamber view (long-axis view)
- Other view combinations as set by the facility protocol
- All segments of the left ventricle need to be visualized in multiple views to allow for proper evaluation. Baseline/Rest images to Peak and/or Recovery images will be compared side by side

Standard ES3.3: Viability Pharmacologic Views

- Parasternal long axis
- Parasternal short axis
- Apical four chamber
- Apical two chamber
- Apical three chamber

Standard ES4: Additional Important Considerations

Appropriate acquisition times:

- Pharmacologic stress - images shall be obtained within the last 90 seconds of each stage
- Treadmill stress - post stress images shall be obtained within 90 seconds of peak stress

- If image acquisition time is greater than 90 seconds in duration, documentation is required in the report
    - Time from the cessation of exercise should be measured and always be displayed
- Shall have comprehensive capture capabilities and obtain minimum of three cardiac cycles of each view at rest, peak and recovery

Additional documentation for Stress Echocardiography reports shall include the following:

- Electrocardiogram - rhythm, heart rate and rhythm at rest and each stage of exercise
- Target heart rate
- Blood pressure and heart rate at each stage
- Description of patient symptoms (e.g., fatigue), reason for termination, and workload achieved
- When contrast is indicated but not utilized, document the rationale in the report
- If the stress echo study is of suboptimal diagnostic quality, recommendation for contrast use or other imaging modality shall be included in the report
- Pertinent abnormal findings of the screening echo should be included in the report

1.4 Standards Regarding the Transesophageal Echocardiographic Examination

Standard ET1: Established Protocols

Laboratories shall establish protocols for the acquisition and recording of transesophageal echocardiographic (TEE) examinations and shall specify all imaging planes and required views. If specific views, e.g., transgastric views, are not obtained, the omission shall be documented.

These protocols shall be reviewed and accepted by all sonographers and physicians involved and shall be made available to all and reviewed on a regular basis.

The views in the following Standards are to be in accordance with the sequence of the facility's written protocol.

Standard ET2: Required Imaging Components

Mid-esophageal Views:

- 5-Chamber view - Aortic Valve, Left Ventricular Outflow Tract, Left Atrium/Right Atrium, Left Ventricle/Right Ventricle, Mitral Valve (A2, A1, P1), Tricuspid Valve
- 4-Chamber view - Left Atrium, Right Atrium, Interatrial Septum, Left Ventricle, Right Ventricle, Mitral Valve (A3, A2, P2, P1), Tricuspid Valve
- 2-Chamber view - Left Ventricle, Left Atrium, Left Atrial Appendage, Mitral Valve (P3, A3, A2, A1)
- Commissural view - Mitral Valve (P3, A3, A2, A1, P1), Papillary Muscles, Chordae Tendinae, Coronary Sinus, Left Ventricle
- Long axis view - Left Ventricle, Left Ventricular Outflow Tract, Mitral Valve (P2, A2), Left Atrium, Aortic Valve and Aortic Root
- Short axis view - (25 - 45 degrees) Aortic Valve, Right Atrium, Left Atrium, Superior Interatrial Septum, Right Ventricular Outflow Tract, Pulmonary Valve
- Bi-caval view - (50 - 70 degrees) Right Atrium, Left Atrium, Mid-Interatrial Septum, Tricuspid Valve, Superior Vena Cava, Inferior Vena Cava, Coronary Sinus
- Bi-caval view - (90 - 110 degrees) Left Atrium, Right Atrium, Right Atrial Appendage Interatrial Septum, Superior Vena Cava, Inferior Vena Cava
- Left Atrial Appendage view - Left Atrial Appendage, Left Upper Pulmonary Vein

Upper-esophageal Views:

- Long axis view - (90 - 110 degrees) Mid Ascending Aorta, Right Pulmonary Artery.
- Short axis view - (0 - 30 degrees) Mid Ascending Aorta, Main Pulmonary Artery/ Bifurcation, Superior Vena Cava.
- Pulmonary Vein view - Mid Ascending Aorta, Superior Vena Cava, Right Pulmonary Vein
- Right/Left Upper Pulmonary Vein view - Pulmonary Vein - upper/lower, Pulmonary Artery

Transgastric Views:

- Short axis view - Basal Left Ventricle, Basal Right Ventricle, SAX - Mitral Valve/Tricuspid Valve
- Mid Left Ventricle, Papillary Muscles, Mid Right Ventricle
- Apex Left Ventricle, Apex Right Ventricle
- 2 Chamber view - Left Ventricle, Left Atrium, Left Atrial Appendage, Mitral Valve
- Long axis view - Left Ventricle, Left Ventricular Outflow Tract, Right Ventricle (RV), Aortic Valve, Aortic Root, Mitral Valve
- RV Basal view - Mid Left Ventricle/Right Ventricle, Right Ventricular Outflow Tract, Short axis - Tricuspid Valve, Pulmonary Valve
- RV Inflow/Outflow view - Right Atrium, Right Ventricle, Right Ventricular Outflow Tract, Pulmonary Valve, Tricuspid Valve
- 5 chamber view - Left Ventricle, Left Ventricular Outflow Tract, Right Ventricle, Aortic Valve, Aortic Root, Mitral Valve
- RV Inflow view - Right Ventricle, Right Atrium, Tricuspid Valve

Descending Thoracic Aorta:

- Descending Aorta Short axis view - Descending Aorta
- Long axis view - Descending Aorta
- Long axis view Aortic Arch view - Aortic Arch
- Short axis view Aortic Arch view - Aortic Arch

Note: Agitated saline may be required to assess shunting at the level of the inter-atrial septum.

Standard ET3: Required Doppler Components

- Colour flow of all four valves and the interatrial septum (IAS)
- Spectral and continuous wave when right ventricle systolic pressure, diastolic left ventricle (LV) function, valve gradients, Pulmonary Venous Flow or Left Atrial Appendage velocities are necessary
- Pulsed Wave Doppler of the pulmonary veins to assess Mitral Regurgitation severity, diastolic function, and pulmonary vein stenosis post ablation
- Pulsed Wave Doppler of the arch vessels to assess stenosis or to identify the left subclavian artery
- Pulsed Wave Doppler to determine types of arrhythmia and to assess left atrial appendage function
- Continuous Wave Doppler to assess Pulmonary Stenosis, Tricuspid Regurgitation, Aortic Stenosis, Mitral Stenosis and Mitral Regurgitation as clinically indicated particularly if the TTE is suboptimal
- Mid esophageal 4-chamber view colour and Pulsed Wave Doppler for mitral stenosis/regurgitation and tricuspid stenosis/regurgitation and pulmonary venous flows
- Mid esophageal 2-chamber view Colour and Pulsed Wave Doppler for mitral stenosis/regurgitation
- Mid esophageal long axis view - Colour Doppler to assess for mitral and aortic regurgitation
- Transgastric 2-chamber view - Colour Doppler to assess for mitral regurgitation
- Transgastric basal short axis view
- Mid esophageal mitral commissural view Colour flow Doppler to assess origin of regurgitation
- Mid esophageal aortic short axis view - Colour Doppler to assess for aortic regurgitation
- Mid esophageal aortic long axis view - Colour Doppler to assess for aortic regurgitation, flow velocities across the left ventricular outflow tract
- Transgastric long axis view - Colour Doppler to assess aorta and regurgitation. Continuous Wave Doppler to assess aortic velocities and Pulsed Wave Doppler for Left Ventricle Outflow Tract velocities
- Deep Transgastric long axis view - Colour Doppler to assess aorta and regurgitation. Continuous Wave Doppler to assess aortic velocities and Pulsed Wave Doppler for Left Ventricle Outflow Tract velocities

Section 2

Standards Regarding Echocardiographic Facilities, Equipment and Standard Operating Procedures

2.1 Overview

A complete transthoracic echocardiographic examination takes between 30 and 60 minutes. During this time, patient privacy and comfort shall be maintained.

In addition, the sonographer shall carry out the examination in a manner that minimizes physical stress and the risk of repetitive stress injury to themselves.

Infection control practices shall be in place.

Standard F1: Examining Room Requirements

- Approximately 120 – 150 square feet of patient care space with adequate ventilation and temperature control
- An adjustable examining bed for acquisition of specific images. The surfaces of the bed shall be durable and compatible with the cleaning and disinfecting methods used in the facility
- Adjustable ergonomic chairs with back support for the sonographer
- Patient privacy shall be assured with the use of curtains and/or doors, as appropriate
- A sink with antiseptic soap and/or a hand hygiene dispenser must be readily available for hand washing in accordance with the infection control policy of the facility
- A bed with provision for cutouts is recommended

2.2 Echocardiographic Imaging Systems

Fully equipped, highly functioning and well-maintained equipment is essential if optimal examinations are to be produced. Because echocardiography has been and continues to be the subject of rapid technological advances, the definition of "state of the art" is a moving target. In addition, although multiple manufacturers are known to produce excellent equipment, there is considerable variation as to configuration and specific analysis packages available.

Standard F2: Imaging System Requirements

Ultrasound instruments utilized for diagnostic studies shall include, at a minimum, hardware and software to perform:

- M-Mode imaging
- Two-dimensional (2D) imaging. The system must include harmonic imaging capabilities and should also include instrument settings to enable optimization of ultrasound contrast agents
- Spectral display for Pulsed Wave (PW) and Continuous Wave (CW) Doppler studies. There should be a system setting to display low frequency Doppler filtering for tissue Doppler display
- Monitoring or other display method of suitable size and quality for observation and interpretation of all modalities
- Continuous electrocardiogram (ECG) display
- Where data are derived from a given line of interrogation (e.g., M-Mode or PW Doppler), a reference image should be available on the screen within a frozen 2-D image, except for non-imaging CW Doppler
- Range or depth markers shall be available on all displays
- Capabilities to measure the distance between two points, an area on a 2D image, blood flow velocities, time intervals, and peak and mean gradients from spectral Doppler studies
- At least two imaging transducers, one of low frequency (2 - 2.5 MHz) and one of high frequency (3.5 MHz or higher); or a multi-frequency transducer which includes a range of frequencies specific to the clinical needs in adult echocardiography. A transducer dedicated to the performance of non-imaging continuous wave Doppler shall be readily available at each site and for each machine
- An audible output shall be present at the time of acquisition. A permanent recording of the Doppler waveform and corresponding image that utilizes a digital image storage method that should be compatible with Digital Imaging and Communications in Medicine (DICOM) standards
- Respirometry for selected indications

- Laptop-designed ultrasound/imaging systems shall be structured and positioned to optimize image acquisition and ergonomics

Note: Imaging systems regardless of manufacturer, model, size, or configuration shall meet all of the above criteria.

Standard F3: Maintenance Requirements

The accuracy of the data collected by ultrasound instruments is paramount to the interpretation and diagnostic utilization of the information collected. Regular equipment maintenance by appropriately trained individuals is essential. This can be carried out either through maintenance and service agreements with manufacturers, or by other appropriately trained personnel and maintenance and service records shall be available onsite.

Equipment maintenance shall include, but are not limited to, the following:

- Recording of the method and frequency of maintenance of ultrasound instrumentation and digitizing equipment
- Establishment of and adherence to a policy regarding routine safety inspections and testing of all laboratory electrical equipment
- Establishment of and adherence to an instrument cleaning schedule that includes routine cleaning of equipment parts, including filters and transducers, according to the specifications of the manufacturer

2.3 Standard Operating Procedures

Echocardiographic examinations provide information important to patient management. In some cases, the findings are unexpected and can be critical to patient care. It is therefore essential that examinations be documented appropriately, sufficient time be provided to acquire full information, and reports be provided to referring physicians in a timely fashion.

Standard F4: Ordering of Echocardiographic Studies

All orders or requisitions for echocardiographic procedures shall include at a minimum:

- The specific type of study to be performed (e.g., transthoracic, transesophageal, or stress echocardiography)
- A brief clinical history
- A standard indication (refer to Appendix B)
- The name of the referring physician

Standard F5: Providing Sufficient Time for Examinations

- For a complete (imaging and Doppler) transthoracic examination, 30 to 45 minutes from patient encounter to departure is allotted
- An additional 10 to 15 minutes is generally required for offline measurements and analysis, preliminary report generation, and preparation for the next examination
- Due to additional patient and technical considerations, an additional 10 to 20 minutes may be needed in preparation for treadmill/bike and pharmacologic stress examinations

Standard F6: Timeframes for Reporting

A written policy shall be in place to specify the below requirements.

Echocardiographic reports shall be provided within the following timeframes.

Inpatient and Urgent Outpatient Studies: Next Day
Inpatient and urgent outpatient studies shall be interpreted, and the report made available to the referring physician by the end of the next working day from completion of the examination, and preferably by the end of the day of the exam.

Outpatient Studies: Five Days
Outpatient studies shall be interpreted by a qualified physician and be made available to referring physicians within five working days of the examination.

Unexpected High-Risk Findings: Immediately
Unexpected high-risk findings shall be communicated immediately by the interpreting physician to the referring physician.

Standard F7a: Storage of Echocardiographic Examination Data

Studies shall be stored and available for future reference and comparison to subsequent examinations. Storage facilities shall ensure patient confidentiality.

Echocardiographic data (images, measurements, and final reports) obtained for diagnostic purposes shall be:

- Recorded, stored, and archived securely, in a format that ensures ready retrieval, complete review, clear communication and patient confidentiality
- Ready retrieval: such that the parameters outlined in Standard F6 are met

Standard F7b: Capability to Share Examinations Externally

For facilities that do not have an interpreting physician continually on premises, a capability and process shall be in place for the immediate review of studies, such that the parameters outlined in Standard F6 are met.

Every facility should have the capability and process in place to share examinations externally with other health care providers to ensure continuity of care.

Standard F8: Record Retention

A permanent record of the images and interpretation shall be made and retained in accordance with provincial guidelines for medical records.

Standard F9: Communication of High-Risk Findings

Laboratories shall have protocols whereby unexpected high-risk findings are communicated immediately by the interpreting physician to the referring physician and managed as required by the interpreting/responsible echocardiographic cardiologist.

Standard F10: Infection Prevention and Control

Echocardiography Laboratories shall have Infection Prevention and Control (IPAC) Policies and Protocols in place.

All health care providers shall follow Routine IPAC Practices for all patients during all care in all echocardiography laboratory settings.

Protocols shall contain the following elements of routine IPAC Practices:

- Hand Hygiene
- Risk Assessment
- Personal Protective Equipment (PPE)
- Control of the Environment
- Cleaning the Environment
- Safe Administration of Injectable Medications, if a facility performs agitated saline or contrast studies
- Cleaning of Medical Equipment
- Healthy Workplace Policy

2.4 Stress Echocardiography

Standard FS1: Personnel for Stress Studies

Appropriately trained, qualified and credentialed personnel are required to:

- Monitor the patient
- Operate the treadmill or supine bicycle
- Record the electrocardiogram
- In the case of pharmacologic stress echocardiography, administer medication

The individual(s) carrying out the examination shall not be expected to provide these functions. A sonographer performing the imaging cannot be the same person that is monitoring the patient during the stress examination.

Standard FS2: Informed Consent for Stress Studies

- All stress procedures shall be explained to the patient and/or the substitute decision maker of those unable to give informed consent
- Consent shall be obtained in a manner consistent with the rules and regulations outlined by the hospital or facility

Standard FS3: Space Requirements for Stress Studies

Larger rooms shall be provided to perform stress echocardiogram, in order to accommodate extra equipment, personnel and potential resuscitation procedures. It is recommended that the procedure room be a minimum of 150 to 200 square feet.

Standard FS4: Facilities for Observation and Recovery of Patients

Facilities and procedures shall be available for observation and recovery of patients by appropriately trained and qualified personnel prior to the patient's discharge home or back to their referring location.

Standard FS5: Equipment Requirements for Stress Studies

In addition to the echocardiographic imaging system requirements, as outlined above, echocardiography equipment utilized for stress echocardiographic studies shall:

- Allow for accurate “triggered” acquisition of images and side-by-side image display
- Ensure adequate memory to allow performance of multi-stage stress echocardiogram studies
- Have the capability of side-by-side comparison of images from baseline and different stages of stress. Side-by-side review may be accomplished within the ultrasound stress package or on a dedicated offline workstation

Standard FS6: Laboratory Requirements for Stress Studies

In addition to the features outlined in F1, laboratories providing stress echocardiographic examinations require the following additional items in the procedure room:

- Treadmill/bicycle ECG monitoring
- Vital signs monitor for blood pressure, heart rate and oxygen saturation monitoring
- Medical oxygen
- Emergency cart containing a defibrillator, airway management equipment, emergency medications and other related equipment shall be located in or immediately outside the examination room so that it is easily accessed in the event of an emergency
- Available intravenous equipment
- A means of rapidly calling for help with an unstable patient (e.g., phone, intercom, arrest buzzer)

2.5 Transesophageal Echocardiography

Standard FT1: Personnel for Transesophageal Studies

- Appropriately trained and qualified personnel are required to provide sedation and monitoring of the patient through the procedure and recovery
- The individual(s) carrying out the examination shall not be expected to provide this monitoring function during the procedure
- A minimum of one staff member shall be trained and dedicated to ensuring the patients' airway and oxygen saturation level is maintained during the procedure
- Recommend a minimum of one staff involved with each transesophageal echocardiographic (TEE) procedure is Advance Cardiac Life Support (ACLS) certified

Standard FT2: Informed Consent for Transesophageal Studies

- All TEE procedures shall be explained to the patient and/or the substitute decision maker and understanding confirmed prior to obtaining informed consent
- Consent shall be obtained in a manner consistent with the rules and regulations outlined by the hospital or facility
- Where sonographers are involved in the consent process, procedures shall be in keeping with the provisions of their credentialing body as well as relevant scope of practice principles established by the hospital or facility

Standard FT3: Equipment for Transesophageal Studies

In addition to the echocardiographic imaging system requirements as outlined in Standard F2, transesophageal transducers shall be available and meet the following requirements:

- Transesophageal ultrasound transducers shall be those manufactured for the ultrasound system of the laboratory
- Transesophageal ultrasound transducers shall incorporate multiplane imaging capabilities

Standard FT4: Space Requirements for Transesophageal Studies

Larger rooms shall be provided to perform transesophageal examinations, in order to accommodate extra equipment, personnel and potential resuscitation procedures. It is recommended that these procedure rooms have a minimum of 150 to 200 square feet available.

Standard FT5: Laboratory Requirements for Transesophageal Studies

In addition to the standard features required to perform transesophageal examinations, laboratories providing transesophageal echocardiographic examinations shall have the following additional requirements in the procedure room:

- Vital signs monitor for blood pressure, heart rate and oxygen saturation monitoring
- Suction
- Medical oxygen
- Emergency cart containing a defibrillator, airway management equipment, emergency medications and other related equipment shall be located in or immediately outside the examination room so that it is easily accessed in the event of an emergency
- Available Intravenous equipment
- Lockable cabinet for controlled drugs
- A means of rapidly calling for help with an unstable patient (e.g., phone, intercom, arrest buzzer)
- A large sink for rinsing probes and/or a process for handling of used (“dirty”) probes

Standard FT6: Cleaning and Maintenance of Transesophageal Probes

The echocardiography laboratory shall follow proper cleaning, disinfection, and maintenance procedures as stipulated by manufacturer and hospital or facility policies which meet Public Health Ontario Standards (see Standard F10).

Standard FT7: Facilities for Observation and Recovery of Patients

Physical space and procedures shall be available to support the observation and recovery of patients by appropriately trained and qualified personnel, prior to the patient’s discharge home or back to their referring location.

Section 3

Standards for Reporting of Echocardiographic Examinations

3.1 Overview

Echocardiography reporting shall be standardized in the laboratory.

All physicians interpreting echocardiograms in the laboratory shall agree on uniform diagnostic criteria and a standardized report process and format.

The final report shall be completely typewritten. The final report shall be approved by the interpreting physician.

Standard R1: Content of Echocardiographic Reports

The echocardiographic report shall provide specific information for the referring physician, including the key elements of:

- Demographics,
- complete echocardiographic findings,
- a summary/interpretation statement, and
- is provided in a clinically relevant, useful, and timely manner.

All echocardiographic reports shall include the information outlined in Appendix A.

Standard R2: Content Relevant to Presenting Problems

In addition to the standard information outlined in Appendix A, specific evaluation shall be provided regarding the presenting problem.

- Specific indications or pathology require further targeted imaging and/or hemodynamic assessment
- Stated findings shall be consistent with the quantitative data
- A full review of the specific data required for evaluation of all possible pathologies is beyond the scope of this document, and the reader is referred to one of the many excellent comprehensive texts available

Standard R3: Assessment of Study Quality and Limitations

An assessment of study quality shall be included in every report and, where appropriate, a statement regarding any study limitations.

It is recognized that echocardiography is sensitive to various technologic limitations and the acquisition of a full set of interpretable data may not be possible for all patients. It is

therefore important that such limitations and their cause be clearly stated within the report, in order to avoid the assumption of normality by the referring physician and to clarify technical issues for subsequent examinations. Statements such as “imaging was suboptimal or impossible” or “reliable interpretation not possible” shall be used where appropriate.

Note: Examples of such statements would include:

- Pectus
- Breast implants
- Chest abnormality
- Access to imaging windows

Standard R4: Amended Reports

Amended reports shall be identified as such and shall include the date and time of the change, as well as the specific changes from the original report.

Standard R5: Requirement for Conclusions

Final reports should be consistent in format and completed only after full review of all acquired data and necessary re-measurement and shall include:

- Overall interpretation/summary of findings, including any pertinent positive and negative findings, as it relates to the assessment of the presenting issue/reason for study
- Consistent with the qualitative and quantitative data elements
- Findings of other significant pathology
- Relevant comparisons to prior studies or reports as available, whether they are or are not available
- Study limitations
- Recommendations regarding alternative or additional investigations where appropriate
- Routine patient demographics, including Blood Pressure, Heart Rate and Rhythm, and Body Surface Area (BSA)

Note: If standard views are not acquired, the deficiency and rationale shall be documented in the report.

Standard R6: Reporting of Urgent Findings

Mechanisms shall be in place for immediate communication of urgent findings (Preliminary Reporting).

In order to avoid delays in transmitting valuable information (especially findings that immediately impact patient care) to referring physicians, it is imperative that a mechanism exists for the immediate communication of echocardiographic findings.

Such mechanisms shall be developed within each laboratory and hospital setting, in accordance with local practices.

In doing so, it shall be recognized that it is not the responsibility of the sonographer to generate final reports, nor shall they be compelled to report preliminary findings if they are not confident or comfortable in doing so for any reason. In addition, such a mechanism shall in no way be interpreted as a substitute for urgent access to physician backup and interpretation.

Section 4

Standards Regarding Laboratory Type and Personnel Involved in Echocardiographic Examinations

4.1 Overview

An echocardiography laboratory is composed of at least one ultrasound instrument, a Medical Director and a Technical Director performing and/or interpreting transthoracic echocardiography, encompassing a single or multiple geographic site. When multiple sites are utilized, it is understood that all sites fall under a common governance structure and fulfill all standards. There may be additional physicians and sonographers. The laboratory may also perform stress and/or transesophageal echocardiographic examinations. Smaller facilities may have one person fulfilling both the Medical and Technical Director positions.

An echocardiography laboratory requires the interpreting physicians and practicing sonographers to be adequately trained and experienced to interpret and perform echocardiograms.

Published documents recognize that echocardiography requires considerable training and expertise. Although published opinions vary with regard to the absolute numbers necessary for attaining and maintaining competence in echocardiography, all agree that numbers of studies performed or interpreted are not sufficient by themselves to assure clinical competence. In developing these standards, the Canadian Cardiovascular Society/Canadian Society of Echocardiology Guidelines for Training and Maintenance of Competency in Adult Echocardiography (Burwash IG et al, Can J Cardiol 2011; 27: 862 - 4) were utilized, including definitions of Level 2 and 3 training.

4.2 Standards Regarding the Medical Director

Standard P1: Medical Director Requirements and Qualifications

The echocardiographic laboratory will have a designated Medical Director, who shall be a licensed physician and holds one of the following qualifications:

- Level 3 training in echocardiography; or
- Level 2 training in echocardiography and continuing echocardiography practice including interpretation of at least 1800 Echo/Doppler examinations over the previous three years at a certified laboratory.

Standard P1.1: Additional Qualifications for Stress Echocardiography

- Level 3 training at an accredited echocardiography facility; or
- Level 2 training at an accredited echocardiography facility with an additional three months of full-time training (which could be extended over a six-month period) dedicated to stress echocardiography, during which supervision and interpretation of at least 100 stress examinations occurred and included no fewer than 25 documented abnormal exams.

Standard P1.2: Additional Qualifications for Transesophageal Echocardiography

- Level 3 training at an accredited echocardiography facility; or
- Level 2 training at an accredited echocardiography facility with an additional three months of full-time training (which could be extended over a six-month period) dedicated to transesophageal echocardiography, during which supervision and interpretation of at least 100 transesophageal and included no fewer than 25 documented abnormal exams.

Standard P2: Medical Director Responsibilities

The Medical Director carries out and/or has oversight for the following:

- All clinical services provided, and determination of the quality and appropriateness of care provided
- Assuring compliance of the medical and technical staff to these standards and the supervision of their work
- Personal and direct supervision and interpretation of studies performed in the laboratory at a minimum once per quarter (every three months)
- For laboratories with multiple/mobile sites, the Medical Director is responsible to ensure all standards are consistently followed at all sites

Standard P3: Continuing Medical Education Requirements for Medical Director

To ensure continuing maintenance of competence, the Medical Director attends at least 24 hours of accredited Continued Medical Education (CME) activities relevant to echocardiography over a period of two years and interprets at least 400 transthoracic echocardiographic studies per year.

Note: 400 transthoracic echocardiographic studies per year can include studies that are reviewed as part of the QI process as per the 2010 CCS/CSE Guidelines for Physician Training and Maintenance of Competence in Adult Echocardiography for the recommended number of studies required to maintain competency.

For laboratories providing stress echocardiography, the Medical Director must interpret at least 75 stress echocardiography examinations per year.

For laboratories carrying out transesophageal echocardiogram, the Medical Director must perform and interpret at least 25 transesophageal examinations per year.

4.3 Standards Regarding the Technical Director

Standard P4: Technical Director Requirement and Qualifications

The laboratory shall have a designated Technical Director who has credentialing from the American Registry of Diagnostic Medical Sonography (ARDMS), Sonography Canada, or equivalent credential, and experience as assessed and approved by the Medical Director. In laboratories with no appropriately qualified sonographers, a physician assumes the role of Technical Director and shall have Level 2 or 3 training.

Standard P5: Technical Director Responsibilities

The Technical Director shall carry out and provide active oversight for the following responsibilities at all sites:

- Performance of echocardiographic examinations
- General supervision of the technical and support staff
- The delegation, where appropriate, of specific responsibilities to the technical or support staff
- Daily administration of the laboratory (scheduling, record keeping)
- Operation and maintenance of laboratory equipment
- The compliance of technical staff to these standards
- Maintenance of quality patient care
- Technical training and mentorship of all staff

Standard P6: Continuing Medical Education Requirements for Technical Director

To ensure continuing maintenance of competence, the Technical Director shall attend at least 30 hours of Continued Medical Education activities, as approved by credentialing body, relevant to echocardiography over a period of three years.

4.4 Standards Regarding Medical Staff

Standard P7: Medical Staff Qualifications

Members of Medical Staff shall be licensed physicians who hold one of the following qualifications:

- Level 2 or 3 training in adult echocardiography within the past five years. If five years has elapsed since training, then the individual shall have, within the past two years, supervised practice (of at least one month) within an accredited facility during which at least 75 reports are generated, or
- Documented performance in an established laboratory, with interpretation of at least 400 Echocardiographic/Doppler studies per year and maintenance of competence as defined in Standard P3 for the preceding three years.

Standard P7.1: Additional Qualifications for Stress Echocardiography

Additional qualifications for Medical Staff at sites interpreting stress echocardiographic examinations:

- Level 3 training; or
- Level 2 training with an additional three months of full-time training (which could be extended over a six-month period) dedicated to stress echocardiography, during which supervision and interpretation of at least 100 stress examinations occurs; or
- Documented performance in an established stress echocardiographic laboratory, with interpretation of at least 75 stress echocardiographic studies per year and maintenance of competence as defined in Standard P3 for the preceding three years.

Standard P7.2: Additional Qualification for Transesophageal Echocardiography

Additional qualifications for Medical Staff at sites interpreting transesophageal echocardiographic examinations:

- Level 3 training; or
- Level 2 training with an additional three months of full-time training (which could be extended over a six-month period) dedicated to transesophageal echocardiography,

during which performance and interpretation of at least 50 transesophageal examinations occurs.

Standard P8: Medical Staff Responsibilities

Members of Medical Staff are responsible for:

- Interpretation of examinations
- Reporting of examinations
- Triaging of emergency requests
- Supervision and support of sonographers carrying out examinations, to include availability for review of patients or acquired information before the patient is discharged from the facility
- In laboratories providing procedural echocardiography, carrying out or supervising transesophageal and ensuring appropriate supervision of stress echocardiography studies
- Providing emergency assistance for patients as required

Standard P9: Continuing Medical Education Requirements for Medical Staff

Members of Medical Staff shall undertake and document continuing maintenance of competence. This includes at least 24 hours of accredited Continued Medical Education (CME) activities relevant to echocardiography over a period of two years and interpreting at least 400 transthoracic echocardiographic studies per year.

For laboratories providing stress echocardiography, Medical Staff must interpret at least 75 stress echocardiography examinations per year.

For laboratories carrying out transesophageal echocardiography, the Medical Staff must perform and interpret at least 25 transesophageal examinations per year.

4.5 Standards Regarding Technical Staff

Standard P10: Technical Staff Requirements

All Technical staff performing echocardiographic examinations shall meet one of the following criteria:

- Appropriate credentialing from ARDMS and Sonography Canada or equivalent credential, which contains both a practical and academic component, as approved by the Medical and Technical Directors
- Successful completion of an accredited echocardiography training program which includes both didactic teaching and supervised clinical experience
- Sonographers who have recently completed an accredited echocardiography training program may be engaged in echocardiography for two years prior to qualifying for ARDMS or Sonography Canada, or equivalent credentialing. After this time, obtaining credentials is required

Standard P10.1: Additional Qualifications for Stress Echocardiography

Additional qualifications for technical staff (sonographers) performing stress echocardiography:

- Documentation of dedicated training is required, in a laboratory actively engaged in stress echocardiography, for a period of at least 4 weeks, during which a minimum of at least 30 stress echocardiograms are performed independently

Standard P10.2: Additional Qualifications for Transesophageal Echocardiography

Qualifications for technical staff (sonographers) participating in transesophageal echocardiography:

- Documentation of dedicated training is required, in a laboratory actively engaged in transesophageal echocardiography, during which a minimum of 10 transesophageal echocardiograms are observed prior to participating

Standard P11: Technical Staff Responsibilities

Technical staff work under the direction of the Technical Director and are, in general, responsible for:

- Ensuring patient identity and documentation of information
- Ensuring patient comfort and safety
- Acquisition and recording of all echocardiographic images and data as defined by established laboratory protocols
- Alerting supervising physicians as to any technical deficiencies in study acquisition
- Alerting the supervising physician as to any urgent conditions identified in the course of the examination
- Alerting the supervising physician as to any significant symptoms or distress experienced by the patient during the course of the examination or while in the echocardiography laboratory

Standard P12: Continuing Medical Education Requirements for Technical Staff

To ensure continuing maintenance of competence, Technical Staff shall attend at least 30 hours of Continued Medical Education activities, as approved by credentialing body, relevant to echocardiography over a period of three years.

Section 5

Indications for Echocardiographic Examinations

5.1 Overview

Echocardiography is a non-invasive, non-toxic, portable diagnostic technique that provides a great deal of imaging and quantitative information relevant to cardiac structure and function. It has therefore taken on a key role in the assessment of patients presenting with numerous clinical problems. Responsible utilization of this technology requires regular assessment of its appropriate indications. Such assessment should be based, where possible, on objective evidence supporting a significant impact on clinical practice. The absence of such evidence does not exclude benefit. Therefore, where such evidence is lacking, justification shall be based on accumulated clinical experience.

Appendix B lists conditions in which echocardiography is known to have such an impact and is therefore indicated in the care of affected patients.

In developing this list, the authors were cognizant of the primary role of the treating physician in determining test utility and did not wish to either deny patients potential benefit of this technique, nor suggest that all patients presenting with particular issues would necessarily benefit from echocardiographic assessment.

Note: As a guiding and overriding principle, the Authors advocate the use of echocardiography if, and only if, results have potential to influence clinical decisions and patient management.

Standard I1: Documentation of Indication for All Referrals

Echocardiographic Laboratories will have mechanisms which ensure that a standard indication (as per Appendix B) is documented as a component of every referral.

Standard I2: Mechanism to Process Studies Order Without A Stated Indication

For referrals without a standard indication (as per Appendix B), laboratories will have mechanisms whereby referring physicians are contacted for clarification before the study is carried out. Based on that clarification, the study will be carried out at the discretion of the supervising physician.

Standard I3: Tracking Indications

Echocardiographic Laboratories will have mechanisms to:

- Track indications of completed studies
- Ensure that at least 95% of studies carried out meet standard indications (as per Appendix B)
- Provide education of referring physicians regarding appropriate indication for echocardiography examinations

Section 6

Continuing Quality Assurance in the Echocardiographic Laboratory

6.1 Overview

Quality assurance (QA) is seminal to all medical activities and is particularly central to procedural activities such as echocardiography, which are frequently pivotal to high-impact clinical decisions. Every echocardiographic laboratory is expected to develop, describe, and make available its own internal QA program, or partner with a reference laboratory with an established QA program.

The QA program of the laboratory shall include methodology, implementation, documentation, and review that address the following standards:

Standard Q1: Examination Completeness and Quality

Regular review of study acquisition conducted by the Medical and/or Technical Director, and include:

- The quality and completeness of the images and the accuracy of the measurements by each sonographer
- Regular review of a set number of random studies over a set time-interval using a pre-defined point-score system
- Pre-set standards of accuracy under the auspices of the Laboratory Director or a designate

Standard Q2: Study Interpretation

Peer review of study interpretation to include:

- The accuracy, completeness, and timeliness of the reports of each interpreting physician
- Constructive feedback
- A regular review of a set number of random interpretive reports over a set time-interval (at least bi-annually) using a pre-defined point-score system
- Pre-set standards of accuracy by the Medical Director or his/her peer designate(s)
- A procedure established by the laboratory to follow in the event the peer review uncovers a discordance of diagnosis

Peer review can be achieved through comparison among in-house physicians in facilities with three or more interpreting physicians, or through the use of an external reviewer. The external reviewer must either be Level 3-qualified, or an active Medical Director in a currently accredited laboratory.

Standard Q3: Staff Meetings

Staff meetings to review and discuss the results of the QA process and introduce system-wide remedial or improvement measures. Documentation of these meetings and results.

Standard Q4: (Removed)

Standard Q4: External Review was removed in the 2021 release of the Standards for the Provision of Echocardiography in Ontario.

Standard Q5: Validation of Findings

Validation against other diagnostic modalities: A process for validating test findings by correlating them with other available diagnostic procedures, such as hemodynamic results from coronary angiography, nuclear perfusion studies, MRI and intra-operative findings and pathology.

Standard Q6: Case Review and Rounds

Organization of, and/or attendance at rounds, and/or conferences focused on interesting case reports or series cases, or specific disease entities with an instructional content relevant to the activities of the laboratory.

Note: The Personal Health Information Protection Act is applicable whenever echocardiography case studies are shared for the purpose of quality assurance and/or education.

Standard Q7: Patient Satisfaction

Echocardiography laboratories in Ontario shall have mechanisms in place to monitor patient satisfaction.

Note: The Personal Health Information Protection Act is applicable whenever echocardiography case studies are shared for the purpose of quality assurance and/or education.

Appendices

Appendix A: The Standard Echocardiographic Report

BASIC INFORMATION

- Name and/or identifier of the laboratory, location, contact information
- Study date
- Patient identification and demographics, date of birth +/- age, gender
- Patient location (inpatient vs. outpatient), study location (echocardiography lab, portable – intensive care unit (ICU), Emergency Room (ER), etc.)
- Height, weight, body surface area
- Rhythm and heart rate
- Blood pressure
- Study indication.
- Referring physician identification
- Interpreting physician identification
- Sonographer identification
- Type of study (e.g., adult TTE, neonatal TTE, TEE, stress echocardiographic etc.).
- Study technical quality (e.g., quality, good, fair, poor, incomplete) and limitations.

CARDIAC DIMENSIONS – MEASUREMENTS

- Left ventricular internal systolic and diastolic dimensions
- Left ventricular (basal) septal and posterior wall thickness
- Left atrial size (anteroposterior dimension)
- Aortic root and ascending aorta dimensions

Note: Normal ranges should be included in the report. The text of the report should comment on whether a given dimension is within normal limits, or if abnormal, to what extent.

EVALUATION OF STRUCTURE AND FUNCTION

Evaluation of the structure and function of the anatomic components of the examination, to be included in the standard report, include the following:

Left Ventricle

- Assessment of left ventricular dimensions, wall thickness, global left ventricular systolic function, and ejection fraction (and method used), and presence or absence of regional wall motion abnormalities
- Evaluation of left ventricular diastolic function (if relevant to the clinical indication)
- Ejection fraction (this should be quantitated whenever technically possible by one of the validated methods, preferably by Simpson's biplane Method of Discs). Reports should either contain the quantitated ejection fraction or a 5% range given the accuracy of the methods available to make these estimations. Several methods may be used and compared to come to a final decision. The method(s) used should always be specified in the report. In addition to reporting a numeric value or range, the ejection fraction should be described as normal or if abnormal the severity should be specified

Right Ventricle

- Assessment of right ventricular size and systolic function, presence of right ventricular hypertrophy

Left Atrium

- Assessment of size

Right Atrium

- Assessment of size

Aortic Valve

- Aortic valve cusp morphology, presence and severity of stenosis or regurgitation
- Evaluation of gradients (peak and mean) and valve area, if stenotic

Mitral Valve

- Mitral valve leaflet morphology, presence and severity of stenosis or regurgitation
- Evaluation of gradients (peak and mean) and valve area, if stenotic

Tricuspid Valve

- Tricuspid valve leaflet morphology, presence and severity of stenosis or regurgitation
- Evaluation of gradients (peak and mean), if stenotic
- Estimation of right ventricular systolic pressure, if sufficient tricuspid regurgitation is present

Pulmonic Valve

- Pulmonic valve morphology, presence and severity of stenosis or regurgitation
- Evaluation of gradients (peak and mean), if stenotic

Aorta (including aortic root and ascending aorta)

- Dimensions

Interatrial Septum

- Intact – presence or absence of atrial septal defect (ASD)/shunt

Pericardium

- Presence and size of pericardial effusion, assessment of hemodynamic effects of pericardial effusion (if present)

Appendix B: Indications for Echocardiography

1. Heart Murmurs

1.1 Initial evaluation of a murmur in a patient with cardiorespiratory symptoms.

1.2 A murmur in an asymptomatic patient where structural heart disease cannot be excluded by clinical assessment.

1.3 Re-evaluation of known valvular disease with a change in clinical status or cardiac exam.

2. Native Valvular Stenosis

2.1 Initial assessment of etiology, severity, chamber dimensions, ventricular systolic function, and overall hemodynamic impact.

2.2 Assessment of patients with known valvular stenosis of any severity and changing clinical status or discrepancy between clinical and echocardiographic severity.

2.3 Reassessment within 6 - 12 months of patients with an initial echocardiographic assessment indicating valvular stenosis of any severity.

2.4 Reassessment (>2 yr.) of mild valvular stenosis without a change in clinical status or cardiac exam.

2.5 Reassessment (>1 yr.) of moderate valvular stenosis without a change in clinical status or cardiac exam.

2.6 Reassessment (>6 mos.) of severe valvular stenosis without a change in clinical status or cardiac exam.

3. Native Valvular Regurgitation

3.1 Initial assessment of etiology, severity, chamber dimensions, ventricular systolic function, and overall hemodynamic impact.

3.2 Assessment of patient with known valvular regurgitation of any severity and changing clinical status or discrepancy between clinical and echocardiographic severity.

3.3 Reassessment (>1 yr.) of patients with asymptomatic moderate valvular regurgitation.

3.4 Reassessment (>6 mos.) of patients with asymptomatic severe valvular regurgitation.

4. Known or Suspected Mitral Valve Prolapse

4.1 Diagnosis and assessment of hemodynamic severity, leaflet morphology, ventricular cavity size and function in patients with physical findings of mitral valve prolapsed.

4.2 Patients with previous diagnosis of mitral valve prolapse and changing clinical status or physical findings suggestive of progressive valvular dysfunction.

4.3 To re-evaluate patients with prior echocardiographic diagnosis but no supporting physical findings.

4.4 Reassessment (>2 yrs.) of patients with significant leaflet thickening or redundancy.

4.5 Periodic reassessment as required by severity of regurgitation (as per section 3).

5. Congenital or Inherited Cardiac Structural Disease

(Including Bicuspid Aortic Valve, Marfan's Syndrome, Atrial Septal Defect, Ventricular Septal Defect, Ehler's Danlos Syndrome)

5.1 Patients with known congenital or inherited structural heart disease and changing clinical status or symptoms.

5.2 Patients in whom clinical findings, the results of other investigations, or family history would suggest the presence of a congenital or Inherited Cardiac Structural Disease.

5.3 Reassessment (>2 yrs.) of asymptomatic individuals with previously diagnosed congenital or Inherited Cardiac Structural Disease.

6. Prosthetic Heart Valves

6.1 Assessment of a newly implanted prosthetic heart valve (baseline assessment).

6.2 Re-assessment (> 1 years) in asymptomatic, hemodynamically stable patients if no known or suspected prosthetic valve dysfunction.

6.3 Assessment of a prosthetic heart valve in patients with symptoms, clinical findings, or prior echocardiogram suggestive of prosthetic valve dysfunction.

7. Infective Endocarditis

7.1 Patients in whom endocarditis is suspected clinically.

7.2 In a patient with clinically proven or suspected endocarditis to assess the severity and hemodynamic impact of valvular lesions, and to detect other high-risk lesions (e.g., fistulae, abscesses).

7.3 Re - assessment of patients at high risk for complications or with a change in clinical status or cardiac exam.

7.4 Reassessment in a clinically stable patient with prior echocardiographic evaluation to assess response to therapy or detect clinically silent disease progression.

8. Pericardial Disease

8.1 Evaluation of patients with suspected pericarditis, pericardial effusion, tamponade, or constriction.

8.2 Initial follow-up of patients with no change in clinical status but a pericardial effusion of suspected clinical significance.

8.3 Follow up of any pericardial effusion in patients with changing clinical status suspected related to the effusion.

8.4 Reassessment at yearly intervals in patients with moderate or large pericardial effusion.

8.5 Echocardiographic guidance of pericardiocentesis for diagnostic or therapeutic purposes.

9. Cardiac Masses

9.1 Evaluation of patients with clinical syndromes suspicious for an underlying cardiac mass.

9.2 Follow up following surgical removal of masses/tumours, intervals to be determined by the pathology, patient clinical status and known natural history of the lesion.

9.3 Patients with malignancies when echocardiographic assessment for cardiac involvement is part of the standard disease staging process.

9.4 Evaluation of cardiac mass detected by other imaging modalities.

10. Interventional Procedures

10.1 To assist pre and peri - procedural decision making for percutaneous interventional and electrophysiologic procedures (e.g., valvuloplasty, closure device insertion, catheter ablation, mitral valve repair).

10.2 Post - intervention baseline studies for valve function, closure device placement and stability, and ventricular remodeling (e.g., within 3 months).

10.3 Re - evaluation of patients post interventional procedure with suspected surgical complication (e.g., valvular dysfunction, closure device erosion/migration, perforation).

11. Pulmonary Diseases

11.1 Evaluation of suspected or established pulmonary hypertension.

11.2 Reassessment of pulmonary hypertension to evaluate response to treatment.

11.3 Evaluation of suspected acute pulmonary embolism.

11.4 Reassessment after initial treatment of pulmonary embolism.

11.5 Patients being considered for lung transplantation or other surgical procedures for advanced lung disease to exclude possible cardiac disease.

11.6 Patients with known chronic lung disease and unexplained desaturation.

12. Chest Pain and Coronary Artery Disease

12.1 Evaluation of suspected aortic dissection.

12.2 Chest pain with hemodynamic instability.

12.3 Chest pain or ischemic equivalent suggestive of underlying coronary artery disease.

12.4 Heart murmur associated with acute or recent myocardial infarction.

12.5 Assessment of infarct size and baseline LV systolic function post myocardial infarction.

12.6 Assessment of LV function post revascularization.

12.7 As a component of periodic (≥1 yr.) reassessment of patients with known ischemic LV dysfunction.

12.8 Periodic (≥6 mos.) reassessment of LV function to guide or modify therapy in patients with known severe ischemic LV dysfunction.

13. Dyspnea, Edema and Cardiomyopathy

13.1 Assessment of patients with suspected heart failure.

13.2 Clinically suspected cardiomyopathy.

13.3 Patients with clinically unexplained hypotension.

13.4 Assessment of baseline LV function and periodic review when using cardiotoxic drugs.

13.5 Re-evaluation of LV function in patients with documented cardiomyopathy and change in clinical status or undergoing procedures that could potentially affect function such as alcohol septal ablation or surgical myomectomy.

13.6 Reassessment of patients with known cardiomyopathy to evaluate significance of symptoms and guide therapy.

13.7 Screening of relatives potentially affected by inherited cardiomyopathy.

13.8 Reassessment (> 1 yr.) of asymptomatic cardiomyopathy patients for disease progression in order to assess suitability for medical or device treatment.

14. Hypertension

14.1 Suspected left ventricular dysfunction.

14.2 Evaluation of left ventricular hypertrophy that may influence management.

15. Thoracic Aortic Disease

15.1 Suspected aortic dissection.

15.2 Suspected aortic rupture/trauma.

15.3 Suspected dilatation of aortic root or ascending aorta for any cause.

15.4 Evaluation patient with known aortic pathology and change in symptoms or clinical findings suggestive of progression.

15.5 Suspected or proven Marfan Syndrome or other connective tissue disorder in which aortic pathology is a potential feature.

15.6 Reassessment of asymptomatic patients with aortic aneurysm (frequency dependent on aortic dimensions and rate of progression).

15.7 Baseline and continuing reassessment (>1yr) of patients with prior surgical repair of aorta.

16. Neurologic or Other Possible Embolic Events

16.1 Patient of any age with abrupt occlusion of a major peripheral or visceral artery.

16.2 Stroke or transient ischemic attack (TIA) in the absence of established causative pathology.

17. Arrhythmias Syncope and Palpitations

17.1 Initial investigation of symptomatic arrhythmia.

17.2 Asymptomatic documented frequent premature atrial beats, chaotic atrial rhythm, paroxysmal or permanent atrial fibrillation or flutter, frequent ventricular premature beats, non-sustained ventricular tachycardia (VT), sustained VT.

17.3 Investigation of syncope of undetermined etiology.

17.4 Pre-procedural before electrophysiologic studies and procedures and before ICD or pacemaker implantation if not performed within 3 months.

17.5 Investigation of patients with left bundle branch block (LBBB), high grade atrioventricular (AV) block.

17.6 Investigation of patients with Wolff-Parkinson-White (WPW) syndrome pre-excitation.

17.7 Follow - up of patients with sustained tachycardia at risk for development of Cardiomyopathy.

18. Before Cardioversion

18.1 Patients with atrial fibrillation of more than 48 hours duration requiring cardioversion and not chronically or adequately anticoagulated.

18.2 Patients for whom atrial thrombus has been demonstrated in previous study.

18.3 Precardioversion evaluation of patients who have previous echocardiographic evidence of structural heart disease.

19. Suspected Structural Heart Disease

19.1 Where an investigation suggests possible structural heart disease and an echocardiographic study has not been previously performed or the finding has not been previously identified.

20. Indications for Transesophageal Echocardiography

20.1 Non-diagnostic transthoracic study, either due to technical limitations or failure to fully characterize a potentially significant finding.

20.2 Assessment of structure and function of cardiac valves to assess feasibility of surgery or catheter-based intervention.

20.3 Patient selection, guidance and monitoring of interventional procedures including but not limited to device closure of intra-cardiac shunt and radio-frequency ablation.

20.4 Detection of cardiac source of embolus in the absence of established causative pathology.

20.5 Evaluation of patients with suspected aortic dissection or aortic disease not fully evaluated by other imaging modalities.

20.6 Detection of atrial thrombus in patients prior to cardioversion or interventional procedures.

20.7 Moderate or high risk for endocarditis when TTE is negative or inconclusive.

20.8 Detection of valvular and peri-valvular complications in high risk endocarditis patients such as patients with staphylococcal bacteremia.

21. Indications for Stress Echocardiography

21.1 Typical or atypical chest pain or ischemic equivalent syndrome.

21.2 Possible acute coronary syndrome (ACS) with non-diagnostic ECG changes and negative or borderline significant troponin levels.

21.3 History of Congestive Heart Failure.

21.4 Known LV systolic dysfunction of unclear etiology.

21.5 Significant ventricular arrhythmia.

21.6 Syncope of unclear etiology.

21.7 Borderline or high troponin levels in a setting other than ACS.

21.8 Significant cerebrovascular or peripheral atherosclerosis.

21.9 Re-evaluation (≥1 yr.) in patients with significant cerebrovascular or peripheral atherosclerosis.

21.10 Equivocal or non-diagnostic results from other stress modalities.

21.11 Initial evaluation of patients at intermediate or high global coronary artery disease (CAD) risk.

21.12 Periodic (≥2 yrs.) re-evaluation of patients with intermediate or high global CAD Risk.

21.13 New or worsening chest pain or ischemic equivalent.

21.14 Post MI or ACS for risk stratification (within 3 months).

21.15 Viability in patients with known significant LV dysfunction post re-vascularization.

21.16 Periodic (≥1 yr.) re-evaluation of stable patients with known CAD (previous coronary angiography, Computed Tomographic Angiography (CTA)/Electron Beam Computed Tomography (EBCT), myocardial infarction (MI), ACS, or abnormal stress imaging).

21.17 For physiologic assessment and/or symptom correlation in patients with moderate or severe Aortic Stenosis, Mitral Stenosis, Mitral Regurgitation, Aortic Regurgitation, Hypertrophic Cardiomyopathy.

21.18 Assessment of established or latent pulmonary hypertension.

Appendix C: Standards Regarding Paediatric and Congenital Echocardiographic Examinations and Indications for Echocardiography

Introduction

In October 2010, the Paediatric Echocardiography Work Group (PE-WG), comprised of cardiac sonographers with expertise in paediatric and adult congenital cardiac conditions, paediatric cardiologists, and cardiologists with expertise in adult congenital cardiac conditions, from community and hospital-based settings, was convened by the Provincial Council for Maternal and Child Health (PCMCH) to identify issues and recommend opportunities and strategies for ensuring the consistent application of quality practices related to paediatric echocardiograms that are conducted in both community and hospital environments across the province. This stemmed from concerns raised by the Office of the Chief Coroner of Ontario (OCCO) regarding the circumstances surrounding the death of a paediatric patient whose clinical condition was not diagnosed despite a number of investigations. The report of the PE-WG was approved by PCMCH in June 2011 and submitted to the Ministry of Health and Long-Term Care and the OCCO. The PCMCH Paediatric Echocardiography Provincial Planning Committee (PEPP-C), comprised of cardiac sonographers and cardiologists with expertise in paediatric and adult congenital cardiac conditions, was convened in March 2012 to focus on implementation of the provincial recommendations, one of which pertained to the development of paediatric echocardiography laboratory standards. These standards, which were finalized in 2018, underwent an additional vetting process in March 2021. Note: Some of the following recommendations regarding paediatric laboratory standards are also applicable to adults with congenital heart disease, as specific knowledge and expertise is required to perform diagnostic echocardiograms in this patient population.

Congenital Heart Disease (CHD) and paediatric acquired cardiac disease present very differently than adult acquired diseases. Should the person conducting and/or interpreting the exam not have paediatric or specific congenital expertise, studies may be incomplete technically and/or may be interpreted by a physician with insufficient knowledge of congenital heart disease. Both scenarios can lead to:

- The need for repeat tests and/or inappropriate referrals and can lead to significant delays in appropriate treatment
- Missed diagnoses or misdiagnoses with the potential for serious morbidity or mortality

The consequences of missing one of the types of congenital heart diseases can lead to lifelong cardiac problems, compromise quality of care and quality of life, and even lead to death.

In order to ensure quality paediatric echocardiograms for Ontario's children and adults with CHD, the PE-WG recommended that paediatric and congenital echocardiograms are:

1. Conducted within accredited echocardiography laboratory facilities
   AND
2. Done on equipment appropriate for paediatric echocardiography
   AND
3. Performed and interpreted by those with the requisite skills and knowledge specific to paediatric and congenital echocardiography (based on training guidelines developed by the PE-WG)

The current recommendations to CorHealth Ontario regarding alignment of paediatric echocardiography and adult congenital laboratory standards with the adult echocardiography laboratory standards are based on the work of the PE-WG and PEPP-C and input from the adult congenital community.

Definition: Paediatric and Congenital Echocardiographic Examination

A paediatric echocardiographic examination is by definition any cardiac ultrasound (US) examination performed in a child between birth and 18 years of life.

A congenital echocardiographic examination is performed in a patient, regardless of their age, with (a) known congenital heart defect or (b) to rule out a congenital or acquired heart defect based on clinical suspicion. For both tests the operators and the reviewing physicians require specific training and expertise.

Section 1: Standards with Respect to the Paediatric/Congenital Echocardiographic Examination

Specific guidelines regarding the performance of a paediatric echocardiographic examination were published be the American Society of Echocardiography (Lai et al. 2006 (1). All first-time examinations performed in children and adults with congenital heart disease (CHD) must include a full segmental assessment of cardiac morphology. This implies that all first-time studies should include situs assessment, assessment of systemic and pulmonary venous connections, atrioventricular and ventriculo-arterial connections, the aortic arch, the pulmonary arteries, and coronary artery origins. The American Society of Echocardiography also published specific recommendations for quantification of Pediatric Echocardiography (2). Echocardiography laboratories performing paediatric and congenital echocardiograms (paediatric and adult congenital heart disease) should apply these recommendations and specific echocardiographic protocols should be available for paediatric and congenital echocardiography in the laboratories where children and/or adults with CHD are scanned.

Standard PE1:

Echocardiographic facilities performing studies in children and adult patients with CHD shall have established protocols that describe the components of the comprehensive Paediatric and Congenital transthoracic examination:

Laboratories shall establish protocols for the acquisition and recording of echocardiographic examinations in children and adult CHD. These protocols shall be reviewed and accepted by all sonographers and physicians involved and shall be made available to all and reviewed on a regular basis.

Evaluations of Paediatric Transthoracic Study quality include:

- Completeness of segmental assessment.
- Inclusion of subcostal and suprasternal views.
- Evaluation of Doppler signals and measurements, including utilization of z-score methods for the assessment of size.

Standard PE2:

The comprehensive paediatric and congenital transthoracic echocardiographic examination shall contain the following imaging components:

Complete M-Mode and 2-dimensional examination - Includes standard views from multiple planes including views of all cardiac structures and selected extracardiac structures. These include, but are not limited to:

- Right, left, or single ventricular anatomy and function

- Right, left, or single atrial anatomy and function
- Systemic and or pulmonary semilunar valve anatomy and function
- Ventricular and atrial septae
- Mitral, tricuspid, or single atrioventricular valve anatomy and function
- Ascending, transverse and descending aorta
- Main pulmonary artery and proximal branches
- Inferior and superior vena cavae and hepatic veins
- Pulmonary veins
- Coronary arteries when visible

The following views have to be obtained in a comprehensive examination:

- Subcostal long-axis and short-axis views (situs, atrial septum, atrioventricular and ventriculoarterial connections, right and left ventricular outflow tracts). Dynamic long-axis sweep from posterior to anterior; short-axis sweep from right to left.
- Subcostal IVC view (demonstrate connection IVC-RA) + view of abdominal aorta
- Subcostal SVC view (demonstrate connection SVC-RA; exclude superior sinus venosus defect and/or anomalous pulmonary venous connection of the right upper pulmonary vein)
- Parasternal long axis of the left ventricle, left atrium, and aorta.
- Parasternal short axis consisting of three short - axis cuts of the left ventricle (base, mid, apex), pulmonary artery view and aortic valve view.
- Right ventricular inflow view.
- Right ventricular outflow view.
- Apical four - chamber view.
- Apical two - chamber view.
- Apical three - chamber view (long-axis view).
- Apical five - chamber view.
- Apical imaging with particular attention the left ventricular (LV) apex.
- Suprasternal views of the aorta, superior vena cava. Short axis sweep to determine arch sidedness.

Standard PE3:

The comprehensive paediatric/congenital transthoracic echocardiographic examination shall contain the following Doppler components:

- Colour screening for atrial septal defects (ASD), ventricular septal defects (VSD), left and right ventricular outflow tracts from multiple views
- Subcostal colour +PW Doppler of IVC and abdominal aorta
- Colour screening, PW and CW Doppler screening of inflows and outflows. Look for stenosis and insufficiency of AV-valves and semilunar valves. Each valve should be assessed in at least two imaging planes. For pressure gradient estimation, multiple windows of interrogation must be used.
- Assessment of RV systolic pressure must be included when relevant.

- Colour screening of the great arteries (aorta, pulmonary arteries) looking for obstruction. Measure with PW/CW Doppler
- Colour Doppler and CW interrogation of the aortic arch including the descending aorta.
- Colour Doppler assessment of presence or absence patent ductus arteriosus using the ductal cut view.
- Colour Doppler interrogation of the pulmonary veins
- Colour screening for coronary artery origins.

Standard PE4:

The comprehensive paediatric/congenital transthoracic echocardiographic examination shall contain the following standard measurements:

The following standard measurements shall be obtained and recorded for all studies. Paediatric measurements should be expressed as z-scores when available for the measurement.

- Valve annulus dimensions
- LV end-diastolic and end-systolic dimensions
- LV diastolic wall thickness (septum and posterior wall).
- Ejection fraction (this should be quantitated whenever technically possible by one of the validated methods (preferably by Simpson's biplane Method of Discs or the area/length method) and the method used should always be identified. Visual estimation should be reserved for cases in which quantitative assessment is not technically feasible.
- Transvalvular aortic flow velocity.
- Pulmonary valve velocity.
- Mitral inflow velocities.
- Assessment of pulmonary venous flows in at least one pulmonary vein
- Tricuspid regurgitation velocity to calculate right ventricular (RV) systolic pressure.
- Measurements of the aortic root and ascending aorta (sinuses of Valsalva and proximal ascending aorta).
- Measurement of aortic arch dimensions (transverse arch, isthmus)
- Left atrial dimensions.
- Appropriate 2-D/M-Mode/Doppler evaluation of all areas of abnormality, including unrepaired and repaired/palliated congenital heart defects.

Standard PE5:

The facility shall have established procedures to provide the following additional information where clinical indications or findings warrant:

- Measurement of weight and height/length of the child to be able to calculate body surface area. Appropriate scales and length boards need to be available for measuring neonates and infants.
- Blood pressure (upper and lower limbs where indicated) and heart rate.
- Transvalvular mean and maximal gradients with continuous wave Doppler for stenotic valves and valvular prostheses, including views from multiple windows, such as the suprasternal and right sternal border.
- Spectral display of complete envelope of continuous wave Doppler signal of valvular regurgitation.
- Respiratory variation of mitral and tricuspid inflow Doppler (e.g., pericardial disease).
- Hepatic venous flow pattern and inferior vena cava collapse.
- Bubble study to exclude an intracardiac shunt when appropriate

Section 2: Standards Regarding Paediatric/Congenital Echocardiographic Facilities, Equipment, Operators and Standard Operating Procedures

2.1 The Examining Room

A complete Paediatric/Congenital transthoracic echocardiographic examination takes between 30 and 60 minutes. For children the room has to be equipped to provide maximal patient comfort, including tools for distraction and equipment for maintaining body temperature for small infants. For children below 3 years of age, sedation may be required for a full echocardiographic assessment. If the laboratory does not have sedation capability, the laboratory should refer to a Paediatric facility providing this service when indicated. At the start of the test the procedure must be explained to the child and accompanying parents/guardian or the patient.

2.2 Echocardiographic Imaging Systems

Specific requirements for Paediatric Echocardiography include:

a) Availability of age-appropriate transducers, including 4-8 mHz and 8-12 mHz transducers. The operators should be trained to select the best adjusted transducer for the patient. Paediatric patients should not be studied with low frequency probes only.
b) Digital Imaging and Communications in Medicine (DICOM) compatibility. Digital storage of images is essential for paediatric imaging and transfer of studies.

2.3 Standard Operating Procedures for Paediatric/Congenital Echocardiography

- The echocardiogram order and requisition must clearly indicate the type of study to be performed, the reason(s) for the study and the clinical question(s) to be answered. The order/requisition must be present in the medical record of the patient.
- Appropriateness of use criteria for outpatient echocardiograms in children have been published (3). Indications for outpatient echocardiograms should fulfill these criteria.
- Specific criteria for inpatient echocardiograms should be available for children and adults with congenital heart disease.
- For a complete paediatric/congenital transthoracic examination, 45 to 60 minutes from patient encounter to departure should be allotted. An additional 10 to 15 minutes is generally required for offline measurements and analysis, preliminary report generation, and preparation for the next examination. In case of complex congenital heart disease, additional time may be needed.
- Specific scanning protocols for paediatric/congenital patients should be available.

Section 3: Standards for Reporting of Paediatric/Congenital Echocardiographic Examinations

3.1 Standard Protocol for Reporting

A standard protocol for reporting congenital heart disease using the segmental approach should be available.

3.2 Paediatric Measurements

Paediatric measurements should be reported with age-dependent normal ranges or as z-scores adjusting for body size.

3.3 Incomplete Evaluation

When not all cardiac segments could be evaluated during the echocardiographic examination, incompleteness of the anatomic evaluation should be included in the report.

Section 4: Standards Regarding Laboratory Type and Personnel Involved in Paediatric/Congenital Echocardiographic Examinations

An echocardiography laboratory performing and reporting paediatric/congenital echocardiograms requires the interpreting physicians and practicing sonographers to be adequately trained and experienced in paediatric and congenital echocardiography. Standard training in echocardiography does not meet quality requirements to perform or to interpret echocardiograms of patients with congenital heart disease of moderate or great complexity.

4.1 Technical Staff

The sonographer performing the paediatric/congenital exam should have specific training in paediatric and congenital echocardiography and must be familiar with the anatomy, pathophysiology of the unrepaired and repaired congenital heart defects and be familiar with the different type of interventional and surgical procedures. The training requires specific training in a Paediatric Echocardiography laboratory. Specific accreditation in Paediatric Echocardiography through ARMDS or Sonography Canada is recommended. In order to perform independent paediatric/congenital echocardiograms, the operator should have performed at least 150 paediatric/congenital studies under supervision.

Maintenance of competence has to be documented though performance of at least 50 paediatric or congenital studies/year and specific CME activities or training in Paediatric or Congenital Echocardiography laboratories.

Sonographers performing examinations in adults with congenital heart disease must have a dedicated training in congenital heart disease, under the supervision of a trained congenital cardiologist or a senior sonographer who is familiar with congenital heart disease. Standard training in echocardiography does not meet quality standards to scan congenital heart disease patients.

Echocardiograms in congenital heart disease patients with moderate or great complexity should be consolidated and performed by dedicated sonographers only.

4.2. Medical Staff

The cardiologists reporting the paediatric/congenital echocardiography must have specific training in paediatric or congenital cardiology. This includes a training of at least 4-6 months in a paediatric echocardiography laboratory or an adult laboratory with a high volume (>1500 congenital echos per year) of patients with adult congenital heart disease (ACHD centres) of moderate and great complexity. The reporting cardiologist should have performed at least 150 paediatric/congenital studies. Specific training needs to be documented.

Maintenance of competence requires performance of at least 100 paediatric/congenital studies of patients with moderate or great complexity/year and/or documentation in specific CME activities in paediatric/congenital echocardiography.

Studies of patients with congenital heart disease of moderate or great complexity should be consolidated and performed and read by a dedicated team of sonographers and readers to meet quality standards.

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Section 5: Indications for Echocardiography

Legend: A – Appropriate; M – May Be Appropriate; R – Rarely Appropriate

1. PALPITATIONS AND ARRHYTHMIAS

1.1 Palpitations with abnormal ECG M

1.2 Palpitations in a patient with known channelopathy M

1.3 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

1.4 Palpitations with family history of cardiomyopathy A

1.5 Palpitations in a patient with known cardiomyopathy A

1.6 Supraventricular tachycardia A

1.7 PVCs in the prenatal or neonatal period M

1.8 PVCs after the neonatal period M

1.9 Ventricular tachycardia A

2. SYNCOPE

2.1 Syncope with abnormal ECG A

2.2 Syncope with family history of channelopathy M

2.3 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

2.4 Syncope with family history of cardiomyopathy A

2.5 Unexplained pre-syncope M

2.6 Exertional syncope A

2.7 Unexplained post-exertional syncope A

3. CHEST PAIN

3.1 Chest pain with other symptoms or signs of cardiovascular disease, a benign family history, and a normal ECG M

3.2 Exertional chest pain A

3.3 Non-exertional chest pain with normal ECG R

3.4 Non-exertional chest pain with abnormal ECG A

3.5 Chest pain with family history of sudden unexplained death or cardiomyopathy A

3.6 Chest pain with family history of premature coronary artery disease M

3.7 Chest pain with recent onset of fever M

3.8 Chest pain with recent illicit drug use M

4. MURMUR

4.1 Presumptively innocent murmur with signs, symptoms, or findings of cardiovascular disease A

4.2 Pathologic murmur A

5. OTHER SYMPTOMS AND SIGNS

5.1. Symptoms and/or signs suggestive of congestive heart failure, including but not limited to respiratory distress, poor peripheral pulses, feeding difficulty, decreased urine output, edema, and/or hepatomegaly A

5.2. Chest wall deformities and scoliosis pre-operatively M

5.3 Signs and symptoms of endocarditis in the absence of blood culture data or a negative blood culture A

5.4 Unexplained fever without other evidence for cardiovascular or systemic involvement M

5.5 Central cyanosis A

6. PRIOR TEST RESULTS

6.1 Known channelopathy M

6.2 Genotype positive for cardiomyopathy A

6.3 Abnormal chest X-ray findings suggestive of cardiovascular disease A

6.4 Abnormal ECG without symptoms A

6.5 Desaturation based on pulse oximetry unexplained by respiratory pathology A

6.6 Previously normal echocardiogram with a change in cardiovascular status and/or a new family history suggestive of heritable heart disease A

6.7 Chromosomal abnormality known to be associated with cardiovascular disease A

6.8 Chromosomal abnormality with undefined risk for cardiovascular disease M

6.9 Positive blood cultures suggestive of infective endocarditis A

6.10 Abnormal cardiac biomarkers A

6.11 Abnormal barium swallow or bronchoscopy suggesting vascular ring A

7. SYSTEMATIC DISORDERS

7.1 Cancer without chemotherapy M

7.2 Prior to or during chemotherapy in cancer A

7.3 Sickle cell disease and other hemoglobinopathies A

7.4 Connective tissue disorder such as Marfan, Loeys Dietz, and other aortopathy syndromes A

7.5 Suspected connective tissue disorder A

7.6 Clinically suspected syndrome or extracardiac congenital anomaly known to be associated with congenital heart disease A

7.7 Human immunodeficiency virus infection A

7.8 Suspected or confirmed Kawasaki disease or MIS-C in the context of COVID-19 infection A

7.9 Suspected or confirmed Takayasu arteritis A

7.10 Suspected or confirmed acute rheumatic fever A

7.11 Systemic lupus erythematosis and autoimmune disorders A

7.12 Muscular dystrophy A

7.13 Systemic hypertension A

7.14 Renal failure A

7.15 Obesity with obstructive sleep apnea M

7.16 Obesity with other cardiovascular risk factors M

7.17 Stroke A

7.18 Suspected pulmonary hypertension A

7.19 Hepatic disorders M

7.20 Failure to thrive M

7.21 Storage diseases, mitochondrial and metabolic disorders A

7.22 Abnormalities of visceral or cardiac situs A

8. FAMILY HISTORY OF CARDIOVASCULAR DISEASE IN PATIENTS WITHOUT SIGNS OR SYMPTOMS AND WITHOUT CONFIRMED CARDIAC DIAGNOSIS

8.1. Unexplained sudden death before the age of 50 years M

8.2 Hypertrophic cardiomyopathy A

8.3 Non-ischemic dilated cardiomyopathy A

8.4 Other cardiomyopathies A

8.5 Genetic disorder at high risk for cardiovascular involvement A

8.6 Marfan or Loeys-Dietz syndrome A

8.7 Connective tissue disorder other than Marfan or Loeys Dietz syndrome M

8.8 Congenital left-sided heart lesion, including but not limited to mitral stenosis, left ventricular outflow tract obstruction, bicuspid aortic valve, aortic coarctation, and/or hypoplastic left heart syndrome A

8.9 Congenital heart disease other than the congenital left-sided heart lesions M

8.10 Idiopathic pulmonary arterial hypertension M

8.11 Heritable pulmonary arterial hypertension A

9. OUTPATIENT NEONATES WITHOUT POST-NATAL CARDIOLOGY EVALUATION

9.1. Suspected cardiovascular abnormality on fetal echocardiogram A (

9.2 Maternal infection during pregnancy or delivery with potential fetal/neonatal cardiac sequelae A

9.3 Maternal diabetes with no prior fetal echocardiogram M

9.4 Maternal diabetes with a normal fetal echocardiogram M

9.5 Maternal phenylketonuria A

9.6 Maternal autoimmune disorder M

9.7 Maternal teratogen exposure M

Appendix D: Summary of Standards

The Echocardiographic Examination

E1 Established Protocols
E2 Required Imaging Components
E3 Required Doppler Components
E4 Standard Measurements
E5 Additional Information

The Stress Echocardiographic Examination

ES1 Established Protocols
ES2 Established Protocols for the Screening Examination
ES2.1 Required Doppler Components for the Screening Examination
ES2.2 Required Measurement
ES3 Required Imaging Components
ES3.1 Pharmacologic Stress Echocardiography
ES3.2 Treadmill / Bike Stress Echocardiography
ES3.3 Viability Pharmacologic Views
ES4 Additional Important Considerations

The Transesophageal Echocardiographic Examination

ET1 Established Protocols
ET2 Required Imaging Components
ET3 Required Doppler Components

Echocardiographic Facilities, Equipment, Procedures

F1 Examining Room Requirements
F2 Imaging System Requirements
F3 Maintenance Requirements
F4 Ordering of Echocardiographic Studies
F5 Providing Sufficient Time for Examinations
F6 Timeframes for Reporting
F7a Storage of Echo Examination Data
F7b Capability to Share Examinations Externally
F8 Record Retention
F9 Communication of High-Risk Findings
F10 Infection Prevention and Control

FS1 Personnel for Stress Studies
FS2 Informed Consent for Stress Studies
FS3 Space Requirements for Stress Studies

FS4 Facilities for Observation and Recovery of Patients
FS5 Equipment Requirements for Stress Studies
FS6 Laboratory Requirements for Stress Studies

FT1 Personnel for Transesophageal Studies
FT2 Informed Consent for Transesophageal Studies
FT3 Equipment for Transesophageal Studies
FT4 Space Requirements for Transesophageal Studies
FT5 Laboratory Requirements for Transesophageal Studies
FT6 Cleaning and Maintenance of Transesophageal Probes
FT7 Facilities for Observation and Recovery of Patients

The Report

R1 Content of Echocardiographic Reports
R2 Content Relevant to Presenting Problem
R3 Assessment of Study Quality and Limitations
R4 Amended Reports
R5 Requirement for Conclusions
R6 Reporting of Urgent Findings

Personnel

P1 Medical Director Requirement and Qualifications
P1.1 Additional Qualifications for Stress Echocardiography
P1.2 Additional Qualifications for Transesophageal Echocardiography
P2 Medical Director Responsibilities
P3 Continuing Medical Education Requirements for Medical Director
P4 Technical Director Requirement and Qualification
P5 Technical Director Responsibilities
P6 Continuing Medical Education Requirements for Technical Director
P7 Medical Staff Qualifications
P7.1 Additional Qualifications for Stress Echocardiography
P7.2 Additional Qualification for Transesophageal Echocardiography
P8 Medical Staff Responsibilities
P9 Continuing Medical Education Requirements of Medical Staff
P10 Technical Staff Qualifications
P11 Technical Staff Responsibilities
P12 Continuing Education Requirements for Technical Staff

Indications

I1 Documentation of Indication for all Referrals
I2 Mechanisms to Process Studies Order Without a Stated Indication
I3 Tracking of Indications

Quality Assurance

Q1 Examination Completeness and Quality
Q2 Study Interpretation
Q3 Staff Meetings
Q4 *Removed for 2021 Edition*
Q5 Validation of Findings
Q6 Rounds and Conferences
Q7 Patient Satisfaction

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- Infection Prevention and Control: Out - of - Hospital Premises (OHP) and Independent Health Facilities (IHF)

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