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Standards of Practice

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Guidelines, Policies and Statements

Education Protocol:

Competences Required of Cardiac Sonographers Who Practice Adult Transthoracic Cardiac Ultrasound Examinations

Adopted by Council March 2006

Revised March 2012, September 2015

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1. Introduction

The Australasian Society for Ultrasound in Medicine (ASUM) is a multidisciplinary society whose mission is to advance the clinical practice of diagnostic medical ultrasound for the highest standards of patient care. A primary aim of ASUM is to promote, educate and disseminate standards of ultrasound practice in this continually developing specialty.

1.1. Purpose

The following echocardiography protocol outlines what competences a cardiac sonographer should be able to demonstrate and apply as appropriate in the examination of patients with cardiac disease.

This protocol represents a minimum standard adult echocardiographic acquisition and analysis protocol and should be extended according to the clinical features and findings. It is recognised that examination protocols, while a useful tool for standardisation of practice, may vary from laboratory to laboratory. Adherence to a simple protocol cannot substitute for competent acquisition, analysis and reporting of echocardiographic images.

All personnel performing cardiac ultrasound examinations should be qualified cardiac sonographers, student cardiac sonographers or suitably qualified medical practitioners. A complete echocardiographic examination should be conducted of each patient referred for echocardiography. There are some accepted clinical indications for abbreviated studies.

The cardiac sonographer should assess the clinical indications and patient history prior to conducting the echocardiogram and form an examination plan. If the indications are unclear or outside the capabilities of the procedure, sonographer or laboratory, the cardiac sonographer should seek further information and/or consult the supervising or referring physician.
It is recommended that blood pressure, height and weight of all patients referred for echocardiography be measured and recorded at the time of examination.

2. Definitions

A complete adult transthoracic echocardiographic examination - an adult transthoracic echocardiographic examination with multi-modal diagnostic ultrasonic examination of the adult heart and associated anatomy from multiple transthoracic acoustic windows, including the sub-xiphoid and supra-sternal windows. This includes two-dimensional (2D) imaging, M-mode and Doppler (spectral, colour and Doppler tissue modalities) imaging and analysis. 2D imaging without colour flow and spectral Doppler is not acceptable.

A complete echocardiographic examination - comprehensive multi-modal evaluation of all cardiac and morphology and haemodynamics from multiple transthoracic acoustic windows.

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A limited echocardiographic examination (also called a problem/clinically directed, screening, focused or modified examination) - an adult transthoracic echocardiographic examination that, in exceptional circumstances, is modified according to clinical indications to acquire specific information, or answer a specific clinical question. A limited examination does not include all of the detail of a complete comprehensive study and may be a component of a specialised procedure such as stress echocardiography, pericardiocentesis or be related to post-surgical or emergency evaluation. It is usual for a limited examination to be performed in patients with a recent previous comprehensive examination.

3. Examination Duration

- Patient exposure to ultrasound should be minimised in all circumstances.[1]
- A complete echocardiographic examination will take 45-60 minutes from patient encounter to patient departure. [2]
- A limited echocardiographic examination may take less than 45 minutes from patient encounter to patient departure, although when the limited examination is a component of a specialised procedure the overall duration may be greater than 45 minutes.
- Multiple patient-specific and pathology-specific variables determine the examination duration and it is recognised that examinations of shorter than recommended duration may be adequate while examinations of longer duration may be essential.

4. Documentation of the Echocardiographic Examination

The cardiac sonographer is responsible for the documentation of the echocardiographic examination. This includes:

- Completion of the departmental log of the examination, including patient name, examination date, examination type, file particulars, and indications and observations.
- Recording of all images and measurements via digital storage media. Recorded images must display the patient identification, examination date and institution in which the study was performed and/or reported. Annotation is recommended for non-imaging continuous wave (CW) and unconventional views. The permanent record should consist of representative real-time images of all cardiac chambers, valves and great vessels using 2D imaging, colour and spectral Doppler imaging, and other modalities (e.g. M-mode, DTI) as clinically indicated. Recordings should include pertinent evidence of diagnostic abnormalities and support the overall findings of the examination.

The requirements for storage of images and patient records varies. You should conform to your local authority.

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5. Conventional Transducer Locations and Patient Positioning

The following conventional acoustic windows and patient positions are recommended but should be used in conjunction with out-of-plane medial, lateral, anterior and posterior angulated scanning and unconventional positioning as required for a comprehensive evaluation of the heart and associated anatomy.

- Left parasternal - left lateral decubitus position
- Apical - left lateral decubitus position
- Subcostal - supine with knees flexed
- Suprasternal - supine with neck hyperextended over a pillow
- Right parasternal - right lateral decubitus position

ECG monitoring: Lead II is recommended with adequate R wave amplitude.

Respiration monitoring: Recommended for complex Doppler examinations of pericardial disease.

6. 2D Examination and Recording

The following table includes a breakdown of the views that are commonly included in a full imaging protocol. This is a guideline only, and examinations should be extended where needed to incorporate additional imaging planes where clinically indicated.

Transducer	Imaging View	Structures Imaged
Parasternal	Long Axis of Left Heart	Left chambers, right ventricle, mitral valve, left atrium, aortic root, aortic valve and ascending aorta (higher intercostal space if needed). Descending aorta and the inferior pericardial space are also viewed in this window
	Long Axis of Right Ventricular Inflow	Right heart chambers and tricuspid valve
	Long Axis Right Ventricular Outflow	Pulmonary valve, pulmonary artery and right ventricular outflow tract
Parasternal	Short Axis Aortic Valve	Pulmonary valve, main pulmonary artery (MPA) and MPA bifurcation, aortic valve, tricuspid valve and interatrial septum
	Short Axis Left Ventricle	Sweep from mitral valve to apex showing posterior and anterior mitral valve leaflets, chordae, papillary muscles and apex
Apical	Apical Four Chamber	All four cardiac chambers, inter-atrial and inter-ventricular septa and tricuspid and mitral valves
	Apical Five Chamber	Aortic valve, left ventricular outflow tract and proximal aortic root

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	Apical Long Axis	Left heart chambers, right ventricle, mitral valve, left atrium, aortic valve, aortic root and ascending aorta
	Apical Two Chamber	Left heart chambers and mitral valve
Subcostal	Four Chamber	All four cardiac chambers, atrial and ventricular septa, tricuspid and mitral valves and pericardial anatomy
	Inferior Vena Cava	Right atrium, inferior vena cava and hepatic veins
	Abdominal Descending Aorta	Descending aorta
	Short Axis	Starting at the LV apex, sweep across all levels of the LV (apex, mid and basal levels), Aortic, pulmonary and tricuspid valves, interatrial septum, with focus on the inferior vena cava and hepatic veins
Suprasternal	Long Axis	Ascending aorta, aortic arch (including major neck/neck vessels), descending thoracic aorta and right pulmonary artery

6.1. 2D Measurements and Calculations [3-5]

The following two-dimensional measurements and calculations are recommended in accordance with the American Society of Echocardiography (ASE) guidelines.[1]

- Measurements of the great arteries. This includes quantitative 2D measurement of the dimension of various anatomical levels of the aorta (left ventricular outflow tract diameter, trans-sinus dimension, sinotubular junction dimension and ascending aorta dimension). Quantitative 2D measurement of the main pulmonary artery and associated branches should be performed where clinically indicated.
- Left heart dimensions (including ventricular wall thickness and internal chamber dimensions throughout the cardiac cycle including both 2D planar measurements and volume measurements). NOTE: it is not recommended to calculate ejection fraction of the left ventricle from these measurements. Estimation of the left atrial size via biplane volume measurement in all cases where optimal imaging permits.
- Right heart dimensions (including 2D planar and wall thickness measurements for the right ventricle, and estimation of right atrial size via cross-sectional area or volume measurement).
- Quantitative estimation of left ventricular systolic performance such as ejection fraction and left ventricular stroke volume for estimation of cardiac output (ventricular volume measurements and ejection fraction measurements should be quantitated by the Simpson's biplane method of discs in all cases where optimal imaging permits). Contrast may be used to improve endocardial definition.

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- Multiple parameters estimation of diastolic function based on Doppler, tissue Doppler and atrial size.
- Quantitative estimation of right ventricular systolic performance such as Doppler tissue imaging S' velocity, tricuspid annular plane systolic excursion (TAPSE)
- Various measurements as required for quantitative assessment of valvular pathology (e.g. PISA, stroke volumes).

7. M-Mode Examination

M-mode measurements of chamber size are no longer recommended by the ASE/ESC except in some clinical situations, such as to monitor the secondary effects of hypertension, particularly for the estimation of left ventricular mass. Nevertheless, some laboratories will still be using these and if so, the ASE/ESC 2005 guidelines provide reference values for this.

M-mode should still be utilised in conjunction with 2D and colour flow Doppler to aid and support the diagnosis of pathological presentations within the heart. For example, M-mode can be used to aid in the timing of haemodynamic events in the cardiac cycle (e.g. mitral flow propagation slope or duration of abnormal flow (e.g. shunts, regurgitation), movement of valves during the cardiac cycle (e.g. SAM in HOCM, mitral valve motion in MVP), assessment of high frequency mobile structures on valves throughout the cardiac cycle (e.g. vegetations, tumours).

8. Colour Flow Doppler Examination and Recording

Colour flow Doppler examination should be used in ALL of the above-mentioned imaging views and should be used to define both normal haemodynamic and pathologic findings in the following:

- Cardiac valvular function (in both stenosis and regurgitation)
- Blood flow characteristics within cardiac chambers
- Inflow and outflow vessels (aortic and pulmonary arteries, inferior vena cava and superior vena cava, pulmonary veins and hepatic veins)
- Aorta (aortic root, ascending aorta, aortic arch, descending aorta and abdominal aorta)
- Right ventricular outflow tract, pulmonary valve and pulmonary artery to bifurcation
- Inter-atrial and inter-ventricular septa

8.1. Colour Flow Doppler Measurements and Calculations

Colour Doppler provides immediate qualitative assessment of abnormalities (e.g. direction and location of flow), but quantitative measurements are required for the quantitative assessment of pathology, such as across shunts or native and prosthetic valves. [6-10]

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9. Spectral Doppler Examination and Recordings

Pulsed wave (PW) and continuous wave (CW) Doppler are used in combination to assess cardiac haemodynamic in a wide range of conditions. The choice of spectral mode depends on several factors; in general when a higher velocity is present, CW Doppler is needed, but when site-specific blood flow measurement is needed, PW Doppler is used. CW Doppler in either imaging or non-imaging mode is recommended to assess peak transvalvular flow profiles (stenotic and regurgitant) and any pathologic high velocity flow, greater than that which can be unambiguously measured by PW Doppler. It is specifically recommended that non-imaging CW Doppler (Pedoff) be used from multiple transducer locations to assess aortic stenosis and/or mechanical prosthetic aortic valves.

Spectral Doppler flow profiles should be acquired from the following:

- Transmitral inflow (PW for diastolic assessment and volume quantification, CW for gradients in the situation of stensois)
- Pulmonary venous inflow (PW)
- Medial and lateral mitral annulus (PW Doppler Tissue Imaging)
- Lateral tricuspid annulus (PW Doppler Tissue Imaging)
- Left ventricular outflow tract (PW for LVOT velocities, CW for valve gradient)
- Right ventricular outflow tract (PW for RVOT velocities, CW for valve gradient)
- Valves (PW for flow-volume quantification, CW for gradients)
- Shunts (either for timing, CW for gradient)

Additional signals may be acquired depending upon the clinical indication for the examination and pathological findings.

9.1. Spectral Doppler Measurements and Calculations

Spectral Doppler signals are ideally acquired when the ultrasound beam is aligned parallel to the blood flow/structure of interest. Timing of cardiac events can be achieved with reference to the simultaneously recorded electrocardiogram (ECG). Angle correction is not recommended; instead, off-axis imaging to align structure/flow parallel to the ultrasound beam should be used.

Parameters derived from spectral flow profiles include:

- Peak instantaneous velocity
- Peak instantaneous and mean pressure gradients
- Velocity time integrals (VTIs) (used to calculate volumetric flow in normal and pathologic haemodynamics)

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- Rate of pressure decay (e.g. the pressure half-time in specific pathologies such as aortic Regurgitation and mitral stenosis)
- Rate of pressure rise (e.g. dP/dT in mitral regurgitation)

Pulsed-wave Doppler measurements are recommended in the assessment of:

- Cardiac output (in conjunction with 2D measurements)
- Valves (in conjunction with 2D and continuous-wave Doppler)
- Left ventricular diastolic function

Continuous-wave Doppler measurements are recommended in the assessment of:

- Trans-aortic and trans-pulmonary flow
- Stenotic valves
- Regurgitant valves
- Prosthetic valves
- Right sided pressure estimates (pulmonary artery systolic pressure derived from peak tricuspid regurgitant velocity and right atrial pressure estimation based on IVC size and collapsibility index)

10. Body Size and Echocardiographic Measurements

When performing echocardiographic measurements, it is essential to record the patients' height and weight in order to index the measurements to take into account body size. Indexed measurements (divided by body surface area) should be compared to the gender-specific published values in the guidelines, to define pathology.

11. Ethnicity and Echocardiographic Measurements

When performing echocardiography in patients of different ethnic groups, operators should consider using ethnic-specific normal values.[9]

12. Equipment Recommendations

12.1. Ultrasound Equipment

- ECG monitoring (lead II recommended)
- The minimum recommended requirements for instrumentation are:

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- Two-dimensional imaging
- M-mode imaging
- Colour flow M-mode
- Colour flow Doppler imaging
- Pulsed-wave Doppler
- Imaging Continuous-wave Doppler
- Non-imaging Continuous-wave Doppler
- Doppler tissue imaging
- Harmonic imaging
- Phased array transducer construction
- Sector scan of at least 80 degrees
- Image depth at least 24 cm
- Fundamental/Harmonic transducer frequency range of 2.5 MHz -5MHz in single or multiple transducers
- System for permanently recording and reviewing studies
- Digital acquisition and storage with offline analysis capabilities are considered to be mandatory in new equipment purchases
- Harmonic imaging capabilities are mandatory in new equipment purchases

12.2. Examination Couches

Access to the apical transducer position via a removable section facilitating steep left lateral decubitus patient positioning is desirable. This issue is further covered in the section the Australasian Society for Ultrasound in Medicine (ASUM) Standards of Practice Document “Occupational Health and Safety”.

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