Review Article

Clinical application of point of care transthoracic echocardiography in perioperative period

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ABSTRACT

Transthoracic echocardiography (TTE) has established its role for diagnosis and management in cardiology and is used by various other specialities in medicine, but it is not routinely practised by anaesthesiologists in the perioperative period including the pre-admission clinic/outpatient clinic. The last decade has seen the emerging role of anaesthesiologist as a 'Perioperative physician'. This review article highlights the potential role and clinical utility, education, teaching and limitations of point of care (POC) TTE modality in perioperative care. Various echocardiography society guidelines and endorsements, diagnostic protocols and limitations are enumerated. This article also discusses some of the possibilities for future education and development related to clinical ultrasound including POC TTE in anaesthetic training curriculum.

Key words: Anaesthesia, perioperative, point of care, transthoracic echocardiography

INTRODUCTION

Point of care (POC) transthoracic echocardiography (TTE) is a limited bedside investigation done and interpreted by a physician. POC TTE is a safe and cost-effective tool for non-invasive examination of the real-time cardiac status, which can be repeated for its diagnostic and therapeutic responses as and when required. It can precisely answer some of the important clinical questions in perioperative patient management. TTE is traditionally owned, dominated and practised by cardiologists. However, the role of echocardiography (echo) has now extended to other specialities including anaesthesia, critical care and emergency medicine including pre-hospital setting.[1,2]

A comprehensive or formal TTE is a thorough cardiac assessment done at a single point of time. It does not give us an idea about the changing haemodynamic conditions unless stress echo is done with similar intention. Myocardial ischaemia or infarction, hypovolaemia, cardiac tamponade, hydropneumothorax and thromboembolism are major causes of haemodynamic disturbances in the perioperative period. TTE has an advantage of better visualisation of right-sided/anterior structures, namely the right ventricle and tricuspid valve pathologies and is less prone for foreshortening of left ventricular apex. Chronic obstructive pulmonary diseases (COPD), surgical dressings and artificial ventilation all make visualisation of heart structures difficult.[1-3] However, acceptable acquisitions of echo images are possible at least in one window which can be useful for clinical management and therapeutic intervention.[3]

This article deals with perioperative clinical applications, examination techniques, haemodynamic calculations, and available resources for training and education. Various uses of ultrasound in anaesthesia and critical care practise, ultrasound physics and principles are already discussed and reviewed extensively in the literature and are not addressed in this article.[2]

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HANDHELD ULTRASOUND DEVICES

Over the past decade, handheld ultrasound devices are available from various manufacturers for clinical use. The utility and clinical applications of POC-TTE have been widely used in elective and emergency situations.[4] It has proven potential in clinical application for rapid assessment and diagnosis of cardiac function.[5] The American Society of Echocardiography (ASE) task force document gives an overview of handheld ultrasound devices, their utility, application and level of training in detail [Table 1]. These devices are miniature forms of traditional ultrasound machines with capability to display two-dimensional and colour echo and are affordable with comparable clarity.[6]

CLINICAL APPLICATION

Pre-operative period

The pre-operative utility of POC TTE extends from patient's admission to discharge including the pre-anaesthetic clinic. Pre-anaesthetic evaluation before induction of anaesthesia includes focussed history, physical examination and non-invasive assessment of basic haemodynamic variables, namely, heart rate, blood pressure, respiratory rate, temperature and urine output if possible. However, these primary variables and the physical examination have repeatedly proven insufficient and inaccurate for haemodynamic evaluation and assessment of occult diseases in healthy patients and in high-risk and critically ill patients. Besides a detailed bedside clinical history and physical examination, POC TTE will be complementary and valuable in the pre-operative setting.[3] TTE helps in pre-operative assessment of undiagnosed or undifferentiated murmurs, and shortness of breath in known or suspected valvular heart disease patients. It is useful to assess the severity of the valvular disease in elderly hip fracture patients who are poor historians, and in patients who are shocked, sick, intubated patients where the delay in surgery is associated with an increase in morbidity and mortality. TTE has been demonstrated to be an adjunct tool for detailed pre-operative evaluation of the cardiovascular status and rapid assessment in critically ill or rapidly deteriorating patients.[3]

In trained and experienced operators' hand, POC TTE is easy to use, non-invasive and can be repeated in real time. It can be used as a cardiorespiratory monitor for screening, diagnosis and therapeutic interventions in the perioperative period. Availability of standard ultrasound machines for vascular and regional anaesthesia makes it easy to upgrade to TTE with the addition of cardiac probe.

Pre-operative assessment of right and left ventricular function, valvular pathologies, intravascular volume status, pericardial effusion, pleural effusion, pneumothorax, pulmonary hypertension, thromboembolism and regional wall motion abnormalities can be done effectively. Therefore, pre-operative POC TTE helps in the process of decision-making, informed consent and better patient care by providing additional prognostic information. New diagnostic findings can assist in avoiding delays for the operating theatre by appropriate referral and consultation. Formal in-depth TTE examination with the cardiologist in a timely manner is needed for optimisation of cardiac conditions before scheduling to the operating theatre. POC TTE has been described and published for its usefulness, utility and feasibility in various settings for high-risk patients for pre-operative evaluation. Table 2 lists the established risk factors

Table 1: Nomenclature of ultrasound examinations

Name of the examination	Other similar/parallel names of same examination technique	Description
Handheld ultrasound examination	Hand carried Mobile (mobile gadget connected) TTE	This is limited echo study done in limited time and performed by basic or intermediate or advanced users Limited use of echo modes (2D, colour Doppler)
Point of care transthoracic echo	Focus TTE Limited TTE Goal-directed TTE Bedside TTE Rapid assessment TTE Portable TTE	This is limited echo study in limited time, done by basic, or intermediate or advanced users Limited use of echo modes (2D, colour Doppler)
Complete transthoracic echo	Comprehensive TTE Formal TTE	This is detailed complete echo study done by expert and advanced echocardiogrpaher only Use of all echo modes (2D, colour and spectral Doppler and advanced modes and study protocols)

2D – Two-dimensional; TTE – Transthoracic echocardiography; Echo – Echocardiography

on post-operative mortality.[7] In asymptomatic or undiagnosed patients with chronic dyspnoea or in poor historians, POC TTE is helpful in the diagnosis of conditions enumerated in Table 3.

Intra-operative period

The operating theatre is a unique environment of changing physiological milieu with dramatic, acute and unstable situations. POC TTE can be done in addition to other focussed ultrasound protocols for the airway, lung and abdomen. Moreover, merging TTE evaluation with any available clinical algorithms is easy, repeatable and non-invasive.[1-7] Utilising this tool in a timely manner can help in troubleshooting the causes of tachycardia, hypotension and hypoxia when time and situation demand. This modality not only helps in the diagnosis but can also help in monitoring the therapeutic intervention by the patients' clinical response and to titrate the therapy appropriately. Some of the limitations of TTE and poor echo window in the intra- and post-operative period are access to patients' chest due to unconventional positioning, surgical dressing, electrocardiography leads, drapes and body habitus

POC TTE is a safe and easily accessible diagnostic tool to aid in the investigation of arterial hypoxaemia in critically ill patients. It can be used to diagnose both cardiac and non-cardiac causes of arterial hypoxaemia and along with the haemodynamic data it can facilitate early correction to ensure optimal resuscitation and tissue oxygenation [Table 4]. Transoesophageal echo (TOE) can be an adjunct to obtain good windows in difficult situations due to positioning in critically ill and anaesthetised patients.

Routine intra-operative transthoracic echocardiography monitoring

Real-time routine perioperative TTE in non-cardiac surgery could be ideal, as history and monitoring may not provide the answer to an underlying cardiovascular status in the haemodynamically stable patients. TTE before anaesthesia or even in elective outpatient pre-admission anaesthetic clinics can help clinician in actual decision-making at the critical time for appropriate management.[7-10] Conventional first-line management of a patient in an unstable condition with fluid and vasopressor administration will work most of the times. However, in an unresponsive and unstable haemodynamic situation, TTE can provide information required for a rational approach for definitive clinical treatment. This practice possibly can become a new gold standard for anaesthetic monitoring and an adjunct to anaesthesia armamentarium. The important limitations are challenging ergonomics and acquisition of images in non-standard positions whilst on the operating table. Lack of clinical expertise and resources makes it difficult and limits its utility. However, the routine POC TTE practice can create good clinical

Table 2: Established conditions/risk factors for post-operative mortality diagnosed by point of care transthoracic echocardiography

Systolic dysfunction
RWMA
Valvular heart disease particularly severe aortic stenosis, mitral stenosis, mitral regurgitation
Diastolic heart failure
Hypovolaemia
Severe LV hypertrophy
Large and grossly visible intracardiac masses

RWMA – Regional wall motion abnormalities; LV – Left ventricular

Table 3: Conditions diagnosed on point of care transthoracic echocardiography

Poor global LV function
Significant aortic stenosis and other valvular heart diseases
Adult congenital heart diseases
Undiagnosed shunts
Pericardial diseases
Diastolic dysfunction
Pulmonary arterial and vascular and thromboembolism diseases
Right ventricular failure
Pleural effusion
Haemo/pneumo or haemopneumothorax
Hypovolaemia
Severe right heart enlargement and high RVSP suggesting pulmonary embolism
Vasodilatation e.g., anaphylaxis
Pericardial effusion
Diagnosis of cardiogenic shock
Peri-arrest situations

RVSP – Right ventricular systolic pressure; LV – Left ventricular

Table 4: Cardiac conditions causing hypoxia diagnosed on point of care transthoracic echocardiography

RV failure secondary to volume and pressure overload
Pulmonary hypertension
Left heart failure (poor LV EF)
Intracardiac shunts
Primary ASD
Secondary ASD
Patent foramen ovale
Undiagnosed adult congenital heart diseases
Pulmonary embolism-air, fat, gas and clots
Undiagnosed asymptomatic mitral valve disease
Pericardial and or pleural effusion
Newly diagnosed perioperative myocardial infarction or ischaemia with new onset RWMA

ASD – Atrial septal defect; RV – Right ventricle; EF – Ejection fraction; RWMA – Regional wall motion abnormalities; LV – Left ventricular

experience without patient harm which will be useful in clinically demanding circumstances.[10] With limited teaching and education, non-cardiologist physicians and medical students' performance was found to have good accuracy and agreement with cardiologists' clinical accuracy after addition of TTE.[11,12]

Post-operative period

An algorithm-based approach for hypotension in post-operative period can help to identify the true causes of hypotension.[13,14] Causes of hypotension after any surgery are likely due to vasodilatation secondary to anaesthetics or other medications, or intra-operative hypovolaemia. Rare causes of unresponsive hypotension in high-risk patients are mentioned in Table 4.

POC TTE is helpful to differentiate the above causes in diagnosis and management immediately after surgery in the post-anaesthesia care unit.

POC TTE can be a useful and excellent adjunct to TOE, as it can be done at the bedside and has advantage in interrogating right heart structures and in situations where TOE is contraindicated. It can be used during weaning studies as well as in patients undergoing extracorporeal membrane oxygenation and in anticoagulated patients.[15]

Procedures related to intracardiac devices, pacing wires, prosthetic valves and pacemakers are potential sources of traumatic pericardial effusion and haemodynamic compromise in the post-operative period. However, TTE can be helpful in diagnosing these conditions very quickly and assist in pericardiocentesis, particularly in angiography suites, cardiac catheterisation and electrophysiology laboratory where patients are likely to be anticoagulated with heparin and/or have active antiplatelet agents on board. These locations may be unfamiliar or hostile and remote locations with limited resources and help. Although TTE and TOE are within the cardiologist's domain and expertise, the anaesthetist with echo skills can enhance rapid diagnosis and treatment.

Table 5 shows some of the clinical indications where POC TTE can be effectively used as adjunct to other monitoring before or after cardiac surgery.

Point of care transthoracic echocardiography in trauma and resuscitation

Focussed TTE ultrasound is currently recommended by ASE and American College of Emergency Physicians (ACEP) in cardiac arrest situation without interruption of standard advanced cardiac life support algorithm. It helps to differentiate between pseudo- and true pulseless electrical activity (PEA) by diagnosing potentially treatable causes, namely, cardiac tamponade, tension pneumothorax and pulmonary embolism. Echo has been used to confirm the diagnosis of pseudo-PEA and shown to have a better outcome than true PEA in out of hospital cardiac arrest patients.[16]

Rapid and accurate diagnosis is vital, particularly during the 'golden hour' of trauma resuscitation. Critical care experts and emergency physicians are using POC TTE for the diagnosis of haemodynamic instability, hypoxia and reversible causes of peri-arrest situations such as pulmonary embolism and cardiac tamponade. Focussed assessment with sonography in trauma (FAST) examination can diagnose poor cardiac contractility, penetrating chest injuries, cardiac contusions and tamponade. Now, FAST scan is an important integral part of advanced life support (advanced trauma life support) algorithm. POC TTE can be very helpful to diagnose the causes of hypotension and shock in addition to facilitate lifesaving procedure and interventions.[16-18]

Education and training opportunities

Various short courses and hands-on workshop opportunities are available for non-cardiology specialists to learn TTE in India and abroad. These post-graduate courses are available for certification, accreditation and reaccreditation. Haemodynamic echo assessment in real-time (HEART) scan is conducted by University of Melbourne, Australia.[19] This comprehensive on-line educational resource is offering certificate courses, diploma and master degree which is available at physician's doorstep through distance education, that one can study at their own pace, time and location. In India, Perioperative and Intensive Care Echocardiography and Ultrasonography foundation also has similar type of collaboration with USabcd Organisation (Denmark)

Table 5: Transthoracic echocardiography indications in patients for cardiac surgery

Bedside assessment of haemodynamic status in non-intubated patient before induction
Hypovolaemia
Pericardial tamponade in pre- and post-operative period
For ECMO cannulation and weaning study
Acute STEMI and aortic dissection
Acute cardiogenic shock
Post-operative cardiac surgical patients

ECMO – Extracorporeal membrane oxygenation; STEMI – ST-elevation myocardial infarction

and conducts basic echo workshop, Focus Assessed Transthoracic Echo (FATE) course with online e-reading material, complimented with simulator and hands-on human model workshop.[20,21] Indian Academy of Echocardiography[22] and World Interactive Network Focused on Critical Ultrasound[23] also have extensive e-learning, pre-reading materials, courses, workshops, conferences, certification and fellowships programmes.

Society guidelines and endorsement

International Liaison Committee on Focused Cardiac Ultrasound (FoCUS) for the International Conference on FoCUS has released extensive international evidence-based recommendations for FoCUS in 2014 and emphasises extensively on clinical application, teaching, benefits, education and certification principles.[24] Emergency physician training in echo for trauma patients, FAST[25] and FOCUS[24] is endorsed by ASE and American College of Emergency Physicians in their position statement.[26] There are various endorsements and emphasis for the inclusion of echo training and teaching curriculum by the critical care colleges, namely, American College of Critical Care, European College of Critical Care and Australian and New Zealand College of Anaesthetists.[24-28] The position statement and guidelines emphasise on acquisition of images and interpretation of a certain number of cases. From an Indian doctors' clinical practise perspective, statutory permissions as per Pre-Conception and Pre-Natal Diagnostic Techniques Act 1994 should be obtained by an individual/organisation for the use of ultrasound of any use in any format. In this scenario, a radiologist or a cardiologist's opinion, in writing or that of a certified echocardiographer, only will stand in a court of law.

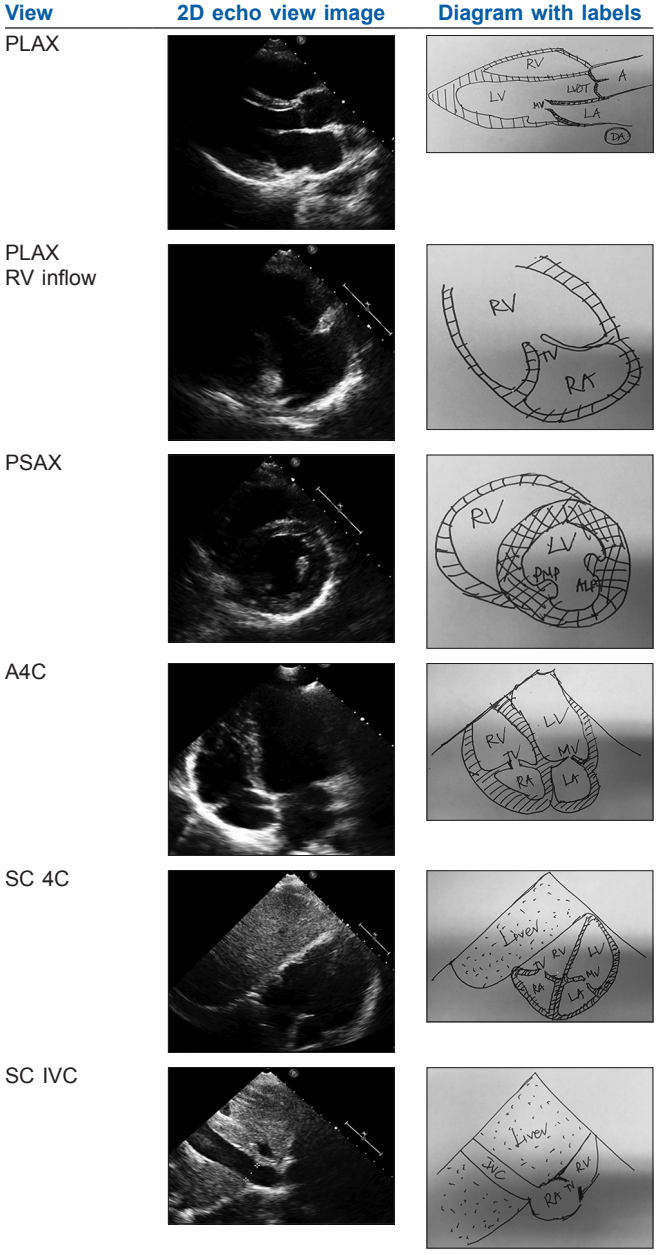
AVAILABLE POINT OF CARE TRANSTHORACIC ECHOCARDIOGRAPHY PROTOCOLS

In our opinion and training, HEART scan[29] and FATE[30] protocol can be easily merged with routine as well as emergency clinical anaesthesia practice. Peri-arrest algorithms and protocols are meant for life-threatening crisis situations and need different thinking, approach and training and cannot be generalised in elective situations. Currently, there is no evidence for recommendations for a fixed number of clinical cases and clinical hours for POC clinical ultrasound and/or echo. Appendices 1-3 and Figure 1 give good insight and overview of POC TTE.

LIMITATIONS AND SOLUTIONS

Currently, cost and lack of availability of this technology in remote and regional locations, particularly in third world countries may be limiting factors in its use in routine practice. In addition, unavailability of teaching expertise, courses, workshops and accredited university degrees are main concerns for lack of training and standards. Incorrect diagnosis or misdiagnosis is possible and can cause more patient harm than benefit. Rigorous standards and presence of credentialing

Figure 1: Window/View/Images



PLAX – Parasternal long axis; RV – Right ventricle; PSAX – Parasternal short axis; A4C – Apical four chamber; SC 4C – Subcostal four chamber; SC – Subcostal; IVC – Inferior vena cava; 2D – Two-dimensional; DA – Descending aorta

authority/licensing body are keys to maintain standards and meet medicolegal requirements. Reporting in standard format and cross-checking by experts from time to time will keep authentication and comparing with other imaging modalities for confirmation of diagnosis will avoid wrong diagnosis and helps in better patient management. Peer review, group discussion, continuous medical education, speciality conferences and maintaining a logbook will keep echocardiographer knowledge and skill up-to-date and also helps in maintenance of continuous professional development (CPD). This paradigm shift of POC assessment by non-cardiologist physician will improve the competency in managing complex patients. With the rapid development of technology and miniaturisation to handheld form of ultrasound machines, affordability and access is a reality in near future. Accuracy of POC TTE in the hands of novice is comparable with expert and has a positive impact on clinical situations.[7-11] It is also equally important to refer the findings of the patients appropriately and in timely fashion for long-term management and follow-up with cardiologists. Authors also acknowledge the huge task and responsibility of teaching and education of already practising anaesthetists. Unfortunately, current evidence is based on all retrospective data, experts' opinion, consensuses and case studies and prospective randomised studies would better assess its usefulness in routine practice.[31]

ULTRASOUND EDUCATION AND TRAINING

To improve ultrasound teaching and training, there is a need to incorporate an ultrasound curriculum within anaesthesia training from the foundation years.[31,32] Simulation can also be helpful for clinician certification and recertification process.[33,34]

CPD is mandatory and highly warranted. There should be departmental resource manual for the guidelines and mandatory policies related to available equipment, expected performance and annual skill level assessment.[35]

SUMMARY

POC TTE in perioperative settings is an excellent imaging and monitoring tool to guide and manage critically ill patients by the anaesthetist for the best clinical outcome. POC TTE is highly established clinical adjunct because of pattern recognition and helps in answering clinically important questions. It also helps in understanding the physiological state and reserve of cardiovascular system. The authors positively anticipate good results from future prospective randomised trials of POC TTE because of the non-invasive and focussed approach.

POC TTE is a useful investigation to promote a better standard of healthcare driven by diagnostic accuracy and efficiency. This will be possible by ensuring widespread availability of skill and knowledge by incorporating ultrasound education in undergraduate and graduate curriculum. 'Routine perioperative point of care transthoracic echocardiography' will be an exciting area of future research.

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Appendix 1: Quick guide to examination for point of care transthoracic echocardiography

Name of the window	Name of the view	Location	Position of the patient	Probe position	Structures need to see/look for	TTE modes	Calculations and pathologies
Parasternal	PLAX view	Left parasternal 4th intercostal space	Patient lying on left side on bed with left upper arm and forearm below the pillow so as to extend the intercostal space. Body exposed above waist	Orientation marker facing right shoulder	Pericardium LV Mitral valve Aortic valve LA DA in short axis	2D echo Colour Doppler M - Mode	FS FAC Look for Pericardial and -plural effusion
	PLAX RV inflow view	Left parasternal 4th intercostal space	As above	Orientation marker facing right shoulder and probe tilted towards patients pelvis/leg	RA RV	2D echo Colour Doppler	RVSP Look for Tricuspid regurgitation
	PSAX view	Left parasternal 4th intercostal space	As above	Orientation marker facing left shoulder	Pericardium RV LV Mitral valve	2D echo Colour Doppler M - Mode	FS FAC Look for Pericardial and -plural effusion
Apical	Apical 4/5 chamber view	Inframammary, approximately sixth intercostal space, corresponding to apex impulse	As above	Orientation marker facing left side of patient (imagine=ultrasound probe footprint facing from apex of the heart through so that fan of ultrasound is directed towards between shoulder blades)	Pericardium RV LV Mitral valve Aortic valve TV RA LA LVOT	2D echo Colour Doppler M - Mode	LVOT VTI CO visual estimation of EF FAC Look for Pericardial and pleural effusion Overall/gross LV and RV function any stenotic valvulopathies
SC	SC 4/5 chamber view	Sub Xiphisternal space, left of the midline	Patient lying flat on back, hands on side, body exposed above waist	Orientation marker facing left side of patient (imagine=ultrasound probe footprint facing from Xiphisternal area so that ultrasound footprint is directed towards between left shoulder and or left scapula)	Pericardium RV LV Mitral valve Aortic valve TV RA LA LVOT	2D echo Colour Doppler	LVOT VTI CO visual estimation of EF FAC Look for Pericardial and pleural effusion Overall/gross LV and RV function any stenotic valvulopathies
	SC IVC view and SC DA view	Sub Xiphisternal space	Patient lying flat on back, hands on side body exposed above waist	Orientation marker facing roof (imagine = ultrasound probe footprint facing from Xiphisternal area through so that USG footprint is directed towards posteriorly with some degree of anticlockwise rotation)	Pericardium RA TV RV IVC view DA	2D echo Colour Doppler	Preload calculation by IVC size - collapsibility index with respiration Look for DA flow, any abdominal aortic aneurysm Pericardial effusion

PLAX – Parasternal long axis; RV – Right ventricle; PSAX – Parasternal short axis; LV – Left ventricle; LVOT – Left ventricle outflow tract; TTE – Transthoracic echocardiography; 2D – Two-dimensional; FS – Fractional shortening; FAC=Fractional area change; RVSP – Right ventricular systolic pressure; VTI – Velocity time integral; IVC – Inferior vena cava; DA – Descending aorta; RA – Right atrium; USG – Ultrasonography; LA – Left atrium; TV – Tricuspid valve; EF – Ejection fraction; CO – Cardiac output; SC – Subcostal; Echo – Echocardiography

Appendix 2: Quick overview of haemodynamic point of care transthoracic echocardiography calculation

Cardiac status	Look for	Formula	How to calculate	Views and windows
Contractility	FS	FS = (LVEDD−LVESD/ LVEDD) × 100 (%)	Use M - Mode Measure the length in systole and diastole	Use PS LAX or PS SAX view
	FAC	FAC = (LVEDA-LVESA/LVEDA) × 100 (%)	Use M - Mode Measure the area in systole and diastole	PS SAX view
	Eyeball estimation of EFs			PS SAX PS LAX A4C
	RWMA			PS SAX PS LAX A4C
CO=HR×SV	SV=CSA × VTI	CSA × VTI Serially compare the VTI number provided HR remain same	Use PWD and place the pulse in LVOT Obtain PWD envelope	A5C view
	VTI	Serially compare the VTI number provided HR remain same	Same as above	A5C view
Volume status	LVEDA		Calculate area in diastole	PS SAX
	IVC size and variations with respiration (collapsibility index)		Measure the diameter in inspiration and expiration	SC IVC view

CSA – Cross-sectional area; SV – Stroke volume; CO – Cardiac output; HR – Heart rate; RWMA – Regional wall motion abnormalities; VTI – Velocity time integral; LVEDA – Left ventricular end diastolic area; LVEDD – Left ventricular end-diastolic dimension; LVESD – Left ventricular end systolic dimension; LVESA – Left ventricular end systolic area; PWD – Pulse wave Doppler; LVOT – Left ventricle outflow tract; SC – Subcostal; IVC – Inferior vena cava; PS – Parasternal; LAX – Long axis; SAX – Short axis; A4C – Apical 4 chamber; A5C – Apical 5 chamber

Appendix 3: Quick guide for gross pathologies		
Pathology	**Gross suggestive features**	**View and windows**
Poor LV systolic function	Poor/sluggish ventricle contraction	PS LAX
	Ventricle cavity dilatation	A4C
	Not uniform thickening of left ventricle walls	SC SAX
		SC 4C
Poor RV function	Poor/sluggish ventricle contraction	PS LAX
	Ventricle cavity dilatation more than left	A4C
	Right heart size more than left heart	PS LAX RV inflow
	ventricle apex is formed by RV	SC SAX
	Not uniform thickening of ventricle walls	SC 4C
Severe diastolic dysfunction	Large LA>4 cm	PS LAX
	Size of atrium is more than size of ventricle	A4C
	LV hypertrophy (>15 mm)	SC SAX
		SC 4C
Stenotic lesions	Leaflets movements are restricted	PS LAX
	Calcified annulus	A4C
	Subvalvular apparatus thickening and calcification	PS LAX RV inflow
		SC SAX
		SC 4C
Regurgitant lesions	No leaflets coaptation	PS LAX
	Floppy valve leaflets	A4C
	Colour Doppler shows mosaic pattern (flow acceleration) in expected previous/back chamber	PS LAX RV inflow
		SC SAX
		SC 4C
Thromboembolism	Any noticeable mass fix or floating in any chambers or on valves	PS LAX
		A4C/5C
		SC 4C
Hypovolemia	Vigorous ventricle contraction and small size LV (hyperkinetic)	PS SAX
	Papillary muscles (in extreme hypovolaemia - ventricle walls) touching each other	A4C/5C
Pericardial effusion	Pericardium is not lined up with ventricle wall and stretched with hypoechoic shadow suggesting fluid collection	PS LAX
		A4C
	Severe if it is >2 cm space around the heart (around 750 ml of fluid around the heart)	SC 4C
	Sign of right-sided chamber collapse and left sided in severe cases	

RV – Right ventricle; LV – Left ventricle; SC – Subcostal; LA – Left atrium; PS – Parasternal; LAX – Long axis; SAX – Short axis; A4C – Apical 4 chamber; SC 4C – Sub costal 4 chamber; A5C – Apical 5 chamber