By the Working Group Echocardiography and Cardiac Imaging of the Swiss Society of Cardiology

What is a standard transthoracic echocardiogram performed by a cardiologist?

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Introduction

The first "Guidelines for quality maintenance in echocardiography" were published by the Working Group of Echocardiography of the Swiss Society of Cardiology in 1999, then revised in 2009 [1].

The Board of the Swiss Society of Cardiology, pursuing a new quality strategy, mandated the Working Group of Echocardiography and Cardiac Imaging to redefine the standards of an *adult trans-thoracic echocardiographic examination performed by a cardiologist*.

The *transthoracic echocardiographic examination performed by a cardiologist* is not only expected to be of high technical quality and accuracy (through education and training), but also *complete*. Therefore, image acquisition and analysis as well as the final report have to be strictly standardised. Moreover, quantitative Echocardiography should be the rule when feasible and will include extra time for measurements and post-processing, which has to be taken into account in the clinical workflow of an echolab. The echocardiographic examination has to be performed according to the guidelines of the European Society of Cardiology mentioned at the end of this document 2–12 and available on the site of the Working Group (swissecho.ch/Documents).

Solid knowledge of cardiac anatomy, physiology and pathophysiology is a pre-requisite for correct interpretation of a transthoracic echocardiogram.

In this document, the WG will specify in detail: (1.) the image acquisition protocol; (2.) the post-processing of the images, including quantitative or semi-quantitative analysis and measurements; (3.) contents of a comprehensive and structured report of a standard transthoracic echocardiographic examination performed by a cardiologist for all subjects being scanned. Recommendations reported in this document represent the standard requirements of a routine examination. Detection of specific abnormalities may need supplementary dedicated views and analyses.

A conclusion will finalise this report, highlighting the abnormal findings in a hierarchic way and establishing the final diagnosis by an integration of imaging and clinical data. This integration is the reason why the WG still *strongly* has the opinion that a diagnostic transthoracic echocardiographic examination should be performed exclusively by cardiologists based on their expertise in cardiac physiology and diseases.

Indications

The indication for echocardiography has to comply with the appropriateness criteria published in the literature [2].

Equipment

All cardiologists should use an echocardiography machine offering 2D imaging including second harmonic, M-mode, continuous wave/pulsed wave and colour Doppler/tissue Doppler and an *optimal ECG gating system*. The use of speckle tracking imaging and 3D imaging is encouraged because both can provide additional and more accurate information. A storage system for the cine-loops and still frames is mandatory for archiving. Digitised archiving in dicom format is the preferred standard.

Image acquisition

- *First ensure that the ECG tracing is optimal.*
- *Blood pressure needs to be obtained at the time of the exam, as it is important for the interpretation of findings.*
- *Before recording, optimise the quality of your images for each view and modality (sector width and depth, frame rate, frequency of the probe, gain settings).*
- *In case of any abnormality, additional views in zoom mode (with and without colour) have to be acquired.*
- *For Doppler, alignment of the ultrasound beam with the structure / flow of interest should be optimised (maximal 15 degree angle).*

The following tables list the views that should be acquired for a complete transthoracic echocardiography. It should be noted that not in every patient, every view is indispensable and the extent to which this list is followed remains at the discretion of the examining cardiologist. However, it is the opinion of the board that the vast majority of the following views should be acquired in most patients. More acquisitions may be indicated in case of specific findings.

Table 1: Parasternal views.

Parasternal long axis (LAX) of the LV*	2D: left ventricle (LV), mitral valve (MV), aortic valve (AV), left atrium (LA), aorta (AO) and right ventricle (RV)
	Colour flow on AV
	Colour flow on MV
	M-mode: LV only if optimal alignment perpendicular to the long axis
	M-mode: aortic root and LA if optimal alignment
Parasternal LAX – RV inflow	2D: RV, tricuspid valve (TV), right atrium (RA)
	Colour flow: TV flow
	Continuous wave (CW) Doppler: tricuspid regurgitation (TR) maximal velocity
Parasternal short axis (SAX)	2D: TV, AV, pulmonary valve (PV), right ventricular outflow tract (RVOT), RA, LA, pulmonary artery (PA)
	Colour flow on AV
	2D oriented on PA
	Colour flow: PA and PV
	Pulsed wave Doppler (PW): PA systolic flow
	CW Doppler: PV regurgitation + PVmax velocity
	2D oriented on tricuspid valve
	Colour flow: TV regurgitation
	CW Doppler: TV regurgitation
	2D of interatrial septum (oriented on the septum) Colour flow of the interatrial septum (with adaptation of the Nyquist limit)
Parasternal SAX – LV	2D: LV at the level of the mitral valve
	2D: zoom on the MV with and without colour Doppler
	2D: LV at the papillary muscle level
	2D: LV at the apex

* The interventricular septum should be perpendicular to the beam for optimal axial resolution and linear measurement.

Table 2: Apical views*

Apical 4 chamber view	2D: overview of LV, LA, RV and RA
	Colour Doppler: MV flow
	PW Doppler: mitral flow velocity with sample volume at the tip of the mitral leaflet (E/A velocity) and at the annulus level in end expiratory phase (for A duration)
	(in case of mitral regurgitation: CW for Vmax and adjustment of the baseline of color Doppler velocity for measurement of PISA radius)
	Colour Doppler: flow of the pulmonary vein
	PW Doppler: pulmonary vein velocity in the end expiratory phase
	TDI: velocity recording of the basal septum and basal lateral wall
Modified 4 chamber view for RV	2D: centred on RV and RA
	Colour Doppler: TV flow
	CW Doppler: if TV regurgitation
	M-mode: TAPSE in zoom mode
	TDI: velocity recording of the basal RV lateral wall
Apical 5 chamber view	2D: overview of LV, LVOT with aortic valve
	Colour Doppler: LVOT flow
	PW Doppler: LVOT flow velocity with sample volume in LVOT
	CW Doppler: transaortic flow velocity
Apical 2 chamber view	2D: LV, LA
	Colour Doppler: MV flow
Apical 3 chamber view	2D: LV, LVOT, AV and MV
	Colour Doppler: LVOT flow and MV

* Maintain the same sector depth for the 3 apical views
TDI = tissue Doppler imaging; PISA = proximal iso-velocity surface area

Table 3: Subcostal and suprasternal views.

Subcostal 4 chamber view	2D: RA, TV, RV, LV, LA, interatrial septum
	Colour Doppler: interatrial septum, search for shunt (reduce Nyquist limit)
Inferior vena cava (IVC)	2D: IVC entering RA
	2D: Zoom on the IVC (optional)
	M-mode: measurement of IVC diameter during normal breathing and after a sniff test
	PW Doppler of the hepatic veins: if TV insufficiency, suspicion of constrictive pericarditis or pulmonary hypertension
Suprasternal views of the aorta	2D: Aortic arch (including the take-off of supra-aortic arteries)
	2D: oriented on descending aorta
	Colour flow: descending aorta
	CW Doppler: flow velocity in the descending aorta
	PW Doppler: if AV insufficiency, flow recording of the descending aorta (presence and severity of flow reversal during diastole

Speckle tracking (optional)
- Optimal frame rate is >60 Hz (adjustment of sector width and depth in order to increase frame rate may be necessary)
- Image acquisition in respiratory hold in order to reduce translational motion of the heart during the respiratory cycle
- Acquisition of 3 cycles

Record the LV in 4C, 2C and 3C apical view by 2D / 3D
Record the RV in modified 4C view

Measurements

All measurements should be carried out according to ESC/ASE recommendations.

Table 4: Measurements.

Left ventricle		End diastolic diameter: absolute + indexed to the body surface area (BSA)
		End systolic diameter: absolute + indexed to BSA (especially useful in case of MV and AV regurgitation)
		Septum and posterior wall thickness, Relative wall thickness, LV mass
		End-diastolic / end-systolic volume, ejection fraction (biplane Simpson)
	Optional	Strain analysis by speckle tracking
	Encouraged, but optional	Bull's eye representation of the qualitative assessment of the 17 segments when abnormal regional wall motion is observed
		M-mode mitral annulus (mitral annulus motion)
Diastolic function		E velocity, A velocity, E deceleration time, A duration and Ar duration if available, Septal and lateral e', E/e' ratio of septal and lateral wall
Left atrium		Anterior posterior diameter
		LA volume by area length method or Simpson biplane method, LA volume index to BSA
Aorta		LVOT diameter
		Valsalva sinus diameter + index to BSA
		Proximal ascending aorta at the level of the right pulmonary artery *(If enlarged, measure each portion of the aorta: annulus, sinus of valsalva, sino-tubular junction, ascending aorta, aortic arch, descending and abdominal aorta)*
Right ventricle – right atrium	*When normal*	RV diameter at the base (RVD1)
		Tricuspid anulus motion (TAPSE)
		S' of the basal lateral RV segment
	In case of dilatation and/ or dysfunction	RV diastolic and systolic area, fractional area change (FAC) measurement
		RV wall thickness (subcostal)
		RA area in an apical 4–chamber view
	Optional	RV diastolic function (RV e' by TDI and RV longitudinal strain)
Aortic valve (native, prosthesis)		Maximal transaortic velocity and VTI
		Max and mean pressure gradient by CW Doppler
	Stenosis present/ suspected	LVOT diameter
		Maximal LVOT velocity as well as systolic VTI (PW)
		Stroke volume / absolute and indexed to BSA when paradoxical low flow low gradient aortic stenosis is suspected
		Dimensionless VTI index when LVOT diameter cannot be measured reliably
		Aortic valve area calculation (continuity equation) using VTI / V max
		(Consider maximal AV flow velocity recording from suprasternal, right parasternal and subcostal windows.)
	Regurgitation more than mild	PHT of the regurgitant jet Late diastolic velocity of the regurgitant jet in the descending aorta (suprasternal view) Diastolic backflow in the descending and abdominal aorta (PW)
	If possible add:	Vena contracta width (mm)
		Effective regurgitant orifice area (EROA) and regurgitant volume
		Color flow jet width at the level of the LVOT
Mitral valve (native, prosthesis)	*Stenosis present/ suspected*	Mean diastolic pressure gradient (indicate heart rate)
		Mitral valve area by planimetry when feasible (SAX)
		Mitral valve area calculated by PHT
	Regurgitation more than mild	Vena contracta (mm)
		EROA and regurgitant volume
		Pulmonary venous flow: describe presence/absence of systolic flow blunting / reversal
		If appropriate add structural changes such as ruptured chord, flail gap, etc.
	Functional regurgitation more than mild	Annulus diameter (parasternal LAX, 3C apical view) in diastole
		Tenting area
		Tenting height
		Coaptation length
	Mitral valve prosthesis	Maximal transmitral velocity / diastolic pressure gradient (indicate heart rate and haemoglobin, especially in the postoperative setting)
Pulmonary valve		Maximal transpulmonary velocity / pressure gradient Acceleration time if SR and HR between 50–100 rate Proto- and end-diastolic PR velocity gradient in suspected pulmonary hypertension

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Table 4: Measurements (continued from page 149).

Tricuspid valve (native, prosthesis)		Maximal TR jet velocity
		TR jet maximal pressure gradient
	Stenosis present/ suspected	Mean transvalvular pressure gradient
	Regurgitation more than mild	Tricuspid annulus diameter in modified 4C view
		Vena contracta (mm)
		PISA radius with a Nyquist limit of 28 cm/s
		Hepatic venous flow: describe systolic blunting or reversal
Inferior Vena cava (IVC)		IVC diameter in expiration and with sniff test
Pericardium and pleura		If pericardial effusion, measurement of the extension at end diastole and indicate distribution
		If pleural effusion, indicate amount and on which side

Table 5: Items that should be included in a standard transthoracic echocardiogram report.

LV morphology and function	LV size (indexed to body surface): Normal – mildly dilated – moderately dilated – severely dilated.
	LV mass (indexed to body surface): Normal – concentric remodelling – concentric hypertrophy – eccentric hypertrophy
	Ejection Fraction (EF %): Normal – mildly reduced – moderately reduced – severely reduced (EF must be given as a number, whenever possible based on measurement according to Simpson's biplane method)
	Specify the distribution and severity of the regional wall motion abnormalities: normal – hypokinesia – akinesia – dyskinesia (Bull's eye representation of the 17 segments encouraged)
	Assessment of LV filling pressure (abnormal pressure unlikely – possible – likely)
	Assessment of longitudinal contractility (DTI, strain if available) encouraged
	Intraventricular mass: Y – N
	Subaortic obstruction: Y – N (If yes, location and severity (max pressure gradient)
	Intracardiac shunt: Y – N (If yes, location and severity)
RV morphology and function	RV size: dilatation (Y – N)
	RV thickness: hypertrophy (Y – N)
	Systolic function: normal/impaired
Left/right atrial size and function	Absence/presence of dilatation (based on volume)
	Absence/presence of an intra-atrial mass or thrombus
Valve morphology and function (aortic, mitral, pulmonary, tricuspid) / prosthesis	Describe the morphology (number of cusps for the aortic valve, prolapse, thickening, calcification)
	Describe the function, as well as competence
	Describe the mechanism of regurgitation
	Assess the degree of stenosis or regurgitation based on a quantitative measurement
	Assess the presence or absence of mobile structures
Ascending aorta/aortic arch	Enlarged or normal
	If enlarged, describe the abnormalities in details (which portion, severity)
Vena cava and hepatic veins	Absence/presence of dilatation
	Change in diameter with respiratory maneuvers
	Give an estimate of central venous pressure (CVP)
Pulmonary artery pressure evaluation	Semi-quantitative evaluation of sPAP integrating the CVP from IVC pattern (caveat: pulmonary valve stenosis, severe tricuspid regurgitation)
	Pulmonary hypertension (PH) unlikely – PH possible – PH likely (refer to guidelines)
Pericardium	Absence/presence of a pericardial effusion
	If effusion is present describe localisation and extension
	Absence/presence of a haemodynamic impact if there is effusion
Interatrial septum	Normal or abnormal
	When abnormal, describe the lesions in detail
	Absence/presence of interatrial shunt (R-L, L-R) by colour Doppler or after contrast injection, under normal respiration or after valsalva manoeuvre
	Atrial mass: Y – N

Report

The following baseline parameters should figure in the report:

- First and last name
- Age and gender
- Weight, height, body surface area and body mass index
- Blood pressure
- Heart rate and rhythm
- Type of machine (optional)
- Contrast injected; type and dose
- Global image quality of the examination
- Indication for the study
- Past cardiac history including previous cardiac surgery.
- Types of any device or prosthetic valve implanted should be mentioned.

In case the patient has been examined in an intensive care unit, mention the respiratory status (intubated, free breathing, non-invasive ventilation) as well as the therapy (e.g., inotropes) with the dosage and/or other mechanical cardiac support.

Each the items in table 4 should either be described or mentioned as not correctly visualised. Whenever possible, try to classify findings as: normal – mildly abnormal – moderately abnormal – severely abnormal – not visualised.

Conclusions

Treatment strategies depend upon precise diagnostic evaluation. Echocardiography is one of the most effective diagnostic tools when the data are correctly acquired and reported. *A standard adult transthoracic echocardiographic examination performed by a cardiologist* is a mixture of technical skill, rigorous approach as well as perfect understanding of cardiac anatomy and physiopathology, which necessitates a dedicated long learning period in experienced centres.

Because ultrasound is a very efficient tool for the non-invasive diagnosis and is free of side effects, other specialists (intensive care and emergency care physicians) are increasingly using this technique for specific needs. While we acknowledge that there is a value for focused cardiac ultrasound in patients in emergency care/intensive care units, we would like to stress that focused cardiac ultrasound does NOT replace an echocardiography performed by a cardiologist, and that in most cases a focused cardiac ultrasound should be followed by a comprehensive quantitative diagnostic echocardiogram performed by a cardiologist.

As regard with the running quality programme, the WG of Echocardiography SSC/SSK will maintain high standards for the transthoracic echocardiographic examination and will make efforts to let every cardiologist acquire and maintain optimal skill in the field of cardiac echocardiography.

References

– The full list of references is included in the online version of the article at www.cardiovascmed.ch.

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