EFSUMB Course Book, 2nd Edition

Editor: Christoph F. Dietrich

Basics in transthoracic echocardiography and standard documentation

Andreas Hagendorff, Stephan Stoebe

[1]Department of Cardiology and Angiology, University of Leipzig

Corresponding author:

Prof. Dr. Andreas Hagendorff

Department of Cardiology and Angiology

University of Leipzig

04103 Leipzig, Germany

email: Andreas.Hagendorff@medizin.uni-leipzig.de

Introduction

A special subdiscipline of sonography is echocardiography. The characteristics of echocardiography are the different features of the echocardiographic units and settings in comparison to other ultrasound machines, the orientation of sectional scan planes in relation to the coordinates of the axis of the left ventricle and the necessity of cardiologists to analyse the two-dimensional and colour-coded cineloops as well as the Doppler spectra to measure and calculate multiple parameters for the interpretation of the cardiovascular state of the patient. These findings have to be directly integrated into the current diagnostic and therapeutic scenarios. The scenario of practical echocardiography requires - especially in emergency settings - the necessity of clinical experience of cardiovascular disorders and diseases and the knowledge about pathophysiological alterations and their effects on cardiovascular function with the prerequisite of adequate technical skills of the method.

The consequence of this complex situation is the fact that there are different opinions how to perform and to teach echocardiography. On the one hand there are one day courses, internet education and other short-term procedures promising the complete learning and understanding of echocardiography, on the other hand there are concepts of long-term educational procedures with theoretical courses and practical traineeships. These differences can be explained by the majority view of different medical faculties being concerned with echocardiography like cardiologists, cardiac surgeons, anesthesiologists, emergency medicine specialists, general practitioners and sonographers.

If echocardiography is only considered as a method which enables the user to detect basic entities like "the heart is beating", "the heart function seems to be normal", "the right heart seems to be enlarged", "there are turbulences at the heart valves", "there is some fluid around the heart" or "there are some hints for hypervolemia", echocardiography can be very helpful in emergency situations, but this simple attitude to perform echocardiography will endanger the technique and will be detrimental to communicate the potentials of this method - especially with respect to the modern features.

Thus, echocardiography has to be taught with caution and in detail to enable the users to become familiar with all options of this method in order to use its potentials correctly. Scanning is only the methodological aspect, being entitled to acquire the images with the optimal image quality is more than methodology, it is something like art. With respect to the diagnostic challenges it should not be the goal to produce just any image by echocardiography. It should be mandatory to accomplish the goal of producing the best images in terms of accuracy of the visible cardiovascular structures and in terms of standardisation of imaging. Standardisation is the prerequisite - especially if measurements and calculations are based on images - for minimising observer variability and for reliable comparisons of the documentations in follow-up investigations [(1;2)].

The following chapter will introduce the reader on how to get a structured approach and an artistic disposition into the technical understanding of the basics in transthoracic echocardiography.

Principles

The learning of a new technical method like echocardiography starts with the instruction of handling the instrument. It is like trying to play a new music instrument. Thus, the hand position of the transducer and the handling of the transducer are essential for acquiring good images in echocardiography.

The first principle of scanning is to get the feeling for the corresponding scan plane. The scan plane has to be automatically implemented into the coordination of handling the transducer and the arrangement of cardiac structures on the monitor. This eye-brain-hand interaction is essential for making important corrections of the transducer position for adjusting the correct view. In practice, one defined sectional plane of the heart - and this sectional plane is the long axis view of the left ventricle - has to be coordinated with a certain hand position of the transducer to get a starting or home position for the following echocardiographic investigation. The second important principle is the stereotactic mode of scanning. To be able to visualise the cardiac structures well-aimed, the transducer position has to be altered only in one single plane of space. That implies that the transducer has to be tilted towards the short edge of the transducer without flipping towards the long edge of the transducer and without rotating the transducer - or has to be flipped towards the long edge of the transducer without tilting towards the short edge of the transducer and without rotating the transducer - or has to be rotated without tilting and flipping the transducer. Using these two principles the scanning procedure can be systematically performed in an objectively guided and highly standardised approach.

The standardised transthoracic investigation

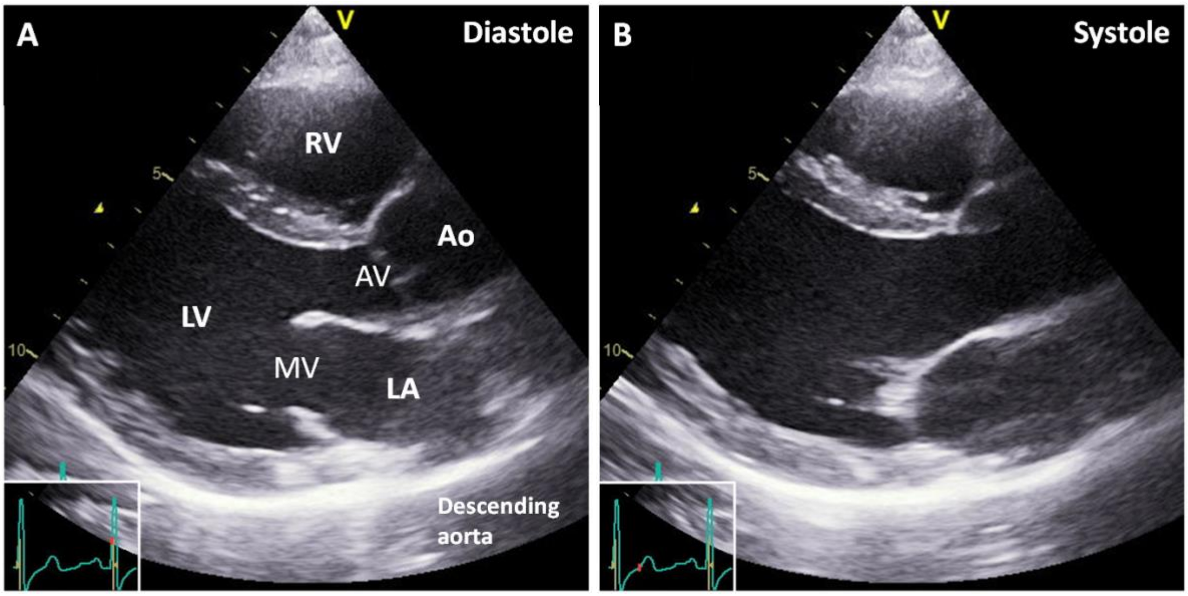
The transthoracic echocardiographic approach to the heart is enabled by different acoustic windows. In left lateral position of the patient the left parasternal acoustic window is located near the anterior mid-clavicular line normally between the third and fifth intercostal space. The apical acoustic window is lateral at the left lower costal arch directly above the apex of the left ventricle. In supine position of the patient the subcostal window is directly below the xiphoid process and the suprasternal window is directly at the jugulum. In rare conditions, e.g. for diagnosis of aortic valve stenosis the right parasternal acoustic window can be helpful. It is located in extreme right lateral position near the right sternal border between the first and second intercostal space.

The standardised echocardiographic views are characterised by specific cardiac structures and their arrangement in the scanning sector.

The documentation taking the left parasternal acoustic window as the starting point

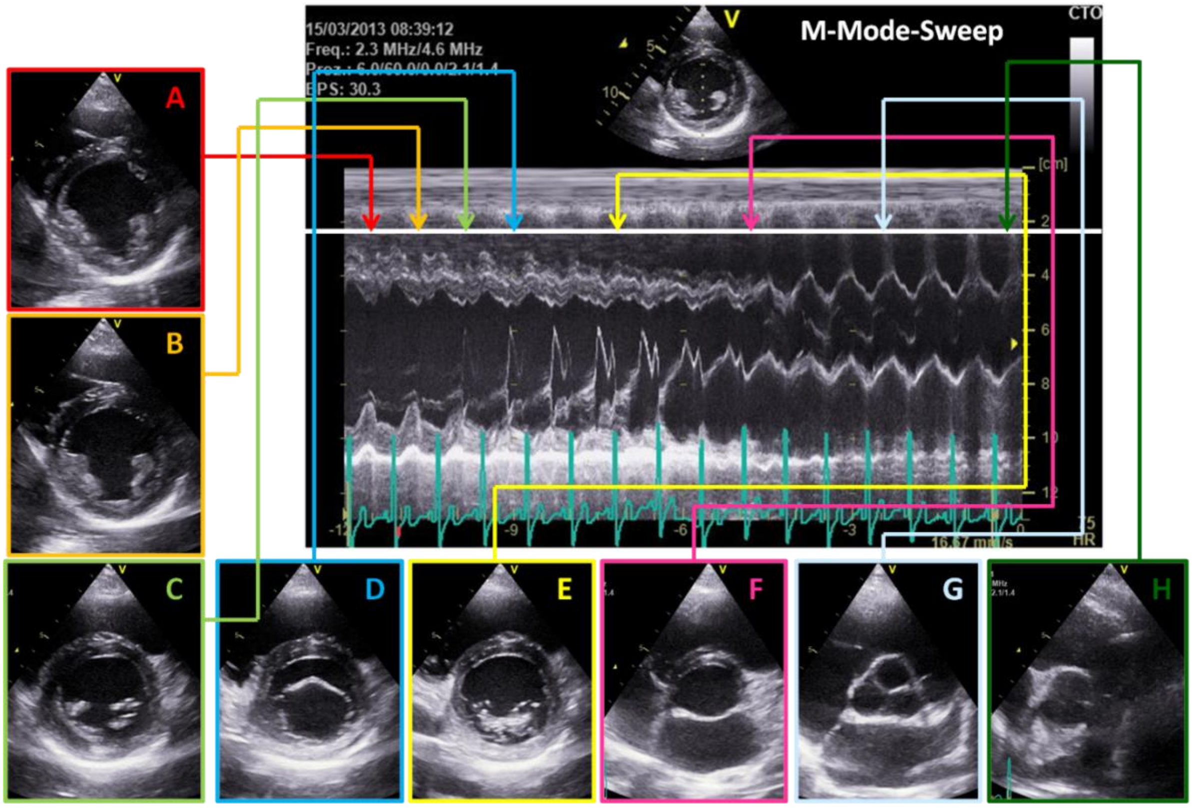
The first and the most important view for the orientation of the transducer position and the handling as well as the understanding of the individual coordinates of the heart is the parasternal long axis view. This view is characterised by the centre of the mitral valve, the centre of the aortic valve and the left ventricular apex. Because the tip of the left ventricular cavity cannot be visualised from the left parasternal window the correct sectional plane in the centre of the left ventricular cavity is documented by the anteroseptal and posterior midbasal left ventricular wall arranged in parallel without the intersection of papillary muscles during diastole and systole. In addition, the free right ventricular wall, the section of the right ventricular outflow tract, the aortic root and the proximal part of the ascending aorta and the cross section of the descending aorta is visualised. The standardised parasternal long axis view is additionally characterised by the arrangement of the heart in the sector. The ventral border of the mid anteroseptal left ventricular wall at the left side of the sector and the ventral border of the ascending aorta at the right side of the sector have to be in a horizontal line if the mitral valve is centred in the sector [Figure 1].

Figure 1 The standardised parasternal long axis view is characterised by the following cardiac structures: the free right ventricular wall near to the transducer in front of the right ventricular cavity (RV), the basal and mid anteroseptal region of the left ventricle (LV), the left ventricular cavity in the long axis, the basal and mid posterior region of the left ventricle, the mitral valve (MV) sliced in the centre of the valve annulus, the aortic valve (AV) sliced in the centre of the valve annulus, the long axis of the initial portion of the aortic root and the ascending aorta (Ao), the longitudinal section of the left atrium (LA) and a cross section of the descending aorta at the far side of the left atrium. In (A) the parasternal long axis view is shown during late diastole, in (B) during mid systole.



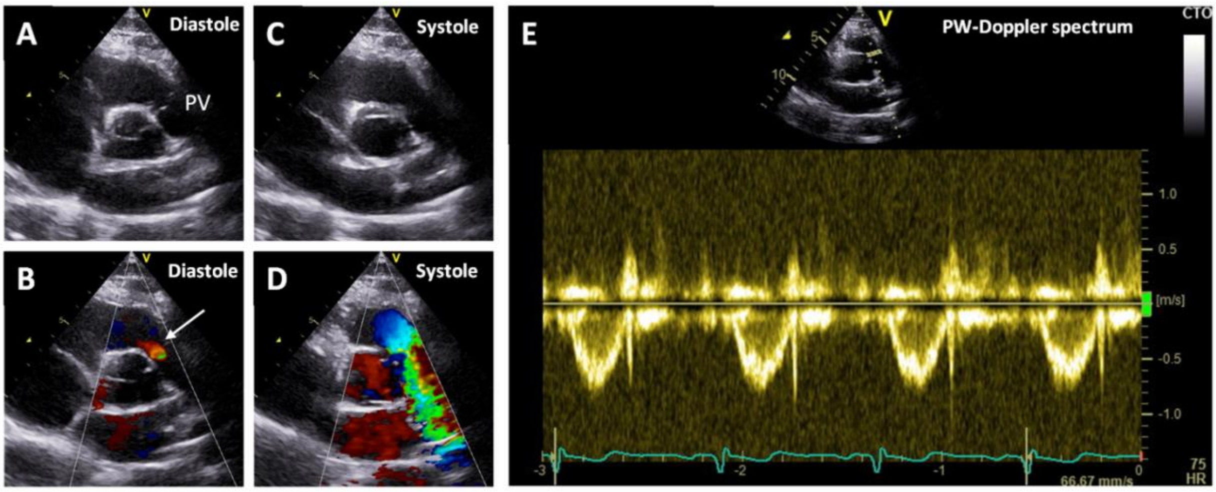
By an isolated clockwise 90° rotation of the transducer short axis views of the left ventricle will be obtained. The caudal short axis view of the left ventricle illustrates the main bundles of the papillary muscles as well as the anteroseptal, anterior, lateral, posterior, inferior and inferoseptal regions of the left ventricle (clockwise starting with the ventral region). With cranial flipping towards the long edge of the transducer the chords of the mitral valve, the mitral valve itself, the interatrial septum and the cross section of the left ventricular outflow tract, the aortic valve annulus and at least the long axis view of the pulmonary trunk is visualised. The documentation of a cineloop of the left ventricle with the papillary muscles, the mitral valve as well as the aortic valve is mandatory according to the European standard of documentation. A suitable approach for a standardised documentation of all short axis cineloops is the acquisition of a standardised M-Mode sweep [Figure 2] during 8-12 cardiac cycles with the possibility of analysing the complete two-dimensional cineloops by post-processing. The M-Mode sweep acquisition using the short axis views displays the correct cursor position through the centre of the left ventricle as well as the correct transducer position during the acquisition by a horizontal line between the ventral border of the mid anteroseptal left ventricular wall and the ventral border of the ascending aorta. Thus, correct measurements of wall thickness and cavity dimensions of the left ventricle can be performed. Oblique cuts and secants can be avoided by a correct M-Mode sweep documentation.

Figure 2 **The so-called M-mode sweep performed by tilting the exact parasternal short axis views from the mid left ventricular region between the papillary muscles into cranial direction to the region of the proximal ascending aorta summarises all possible parasternal short axis views. In (A-H) the corresponding short axis views are displayed. In (A) the sectional short axis view is shown at the level of the attachments of the papillary muscles, in (B) at the level of the segmentation of the papillary muscles into their two main proportions, in (C) at the level of the chords, in (D) at the level of the opened mitral valve, in (E) at the level of the mitral annulus at the closed mitral valve, in (F) at the level of the interatrial septum, in (G) at the level of the aortic valve and in (H) at the level of the long axis of the pulmonary trunk.**



The general documentation from the parasternal window includes a pulsed wave Doppler spectrum of the blood flow out of the right ventricle with the sample volume in the right ventricular outflow tract or the pulmonary valve [Figure 3]. The normal pulsed wave Doppler spectrum of the right ventricular outflow tract displays a monophasic parabolic flow profile with contours due to the detection of the maximum velocities by the central alignment of the cursor within the blood stream. If the right ventricle is abnormal or the valves of the right heart are diseased a continuous wave Doppler spectrum through the pulmonary valve should be added.

Figure 3 **The pulsed wave Doppler spectrum of the right ventricular outflow tract or the pulmonary valve is mandatory to be documented in the standardised transthoracic echocardiographic approach. The visualisation of the pulmonary valve (PV) perpendicular to the aortic valve annulus is shown in (A) during diastole. The colour-coded image of this short axis view with the documentation of a mild pulmonary regurgitation (arrow) is shown in (B). In (C) and (D) the corresponding images are shown during systole. The pulsed wave Doppler spectrum of the flow velocities of the right ventricular outflow tract or the pulmonary valve is shown in (E).**



In the presence of cardiac diseases and presumed cardiac disorders several additional sectional planes should be added from the left parasternal approach for a complete echocardiographic documentation.

The documentation taking the apical acoustic window as a starting point

One of the most important facts of standardisation in transthoracic echocardiography is the detection of the correct location of the apical transducer position. If the parasternal long axis view is accepted as the home position of the transducer the long axis view can be continuously tracked during the movement of the transducer on the skin of the patient towards the correct apical position [Figure 4]. The correct and standardised apical long axis view is characterised by the same cardiac structures depicted in the parasternal long axis view. The orientation of this view is given by the left ventricular cavity tip directly below the transducer surface and the centre of the left ventricle as well as the mitral valve within the centre of the sector. The advantage of the apical long axis view is the complete visualisation of the posterior (left side) and anteroseptal (right side) wall. The mitral valve is visualised in the mid posterior and anterior scallop (P2- and A2-scallop) [Figure 5].

Figure 4 The general understanding of transthoracic scanning is reasonably documented by the long axis view. The long axis of the left ventricle is a specific plane that can be represented in a standardised view from the parasternal approach (A), in non-standardised views between the correct transducer position of the parasternal and apical window (B,C) and in a standardised view from the apical approach (D). If the parasternal long axis view is accepted as the home position of the transducer the long axis view can be continuously tracked during the movement of the transducer on the skin of the patient towards the correct apical position.

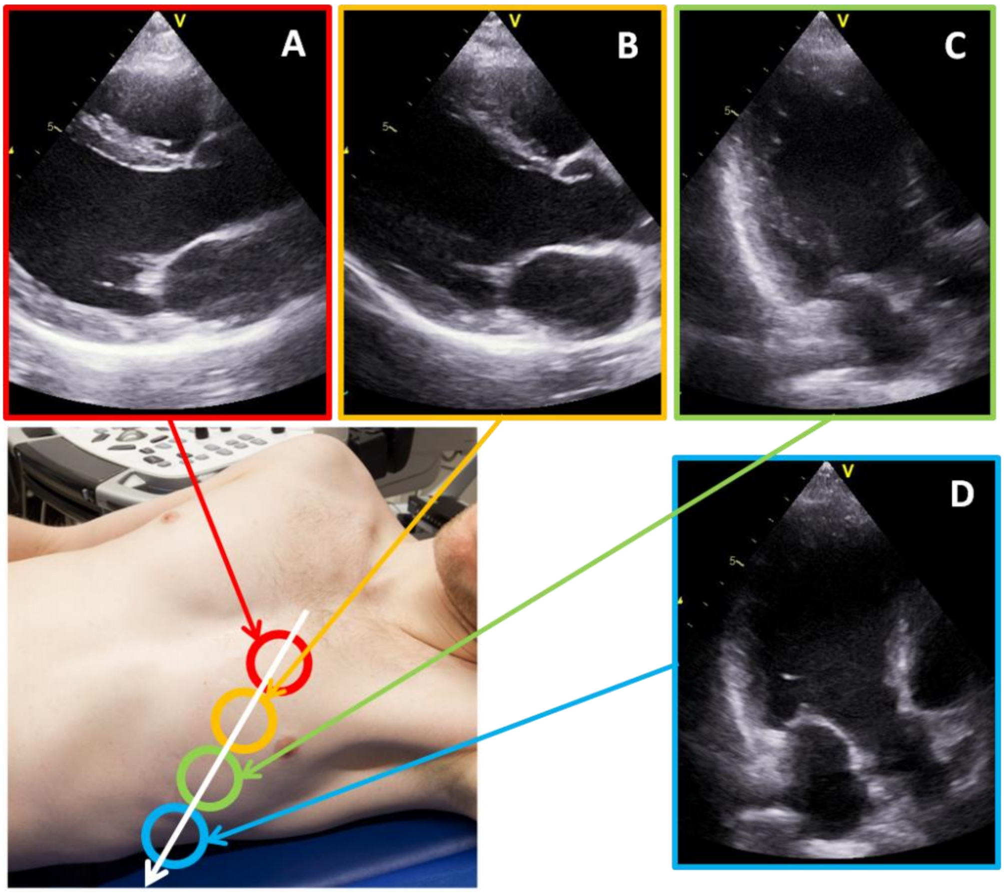
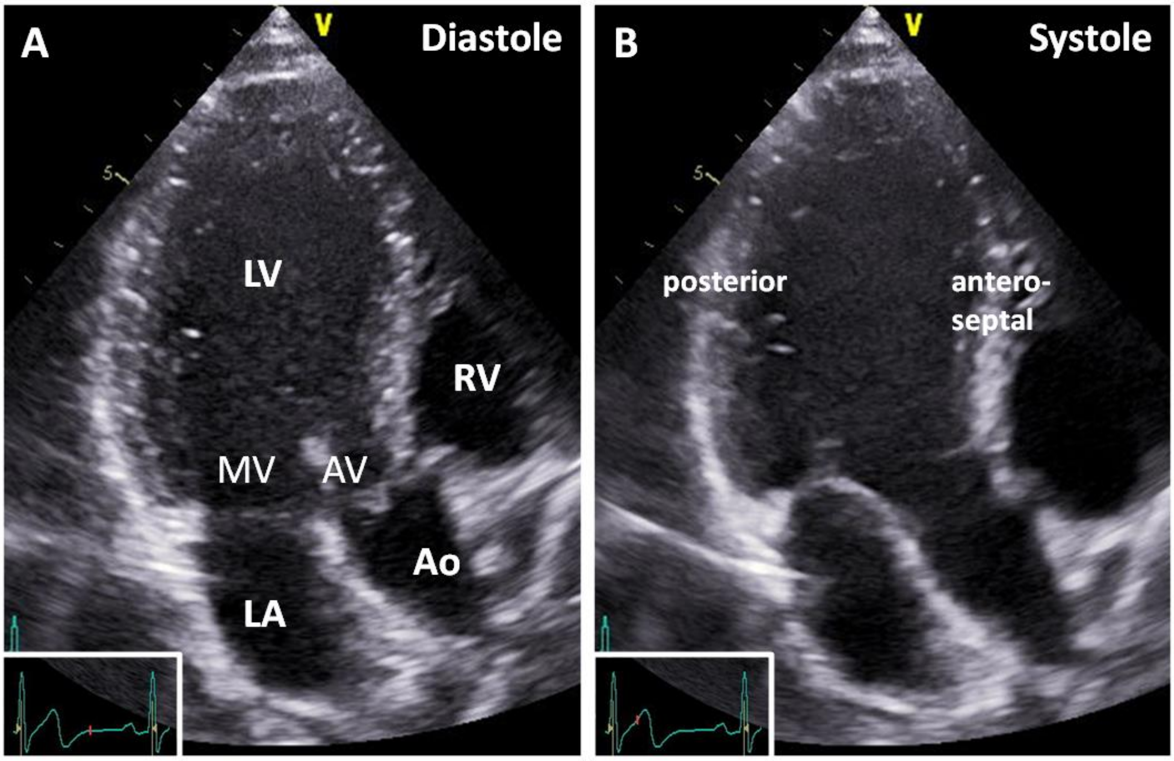


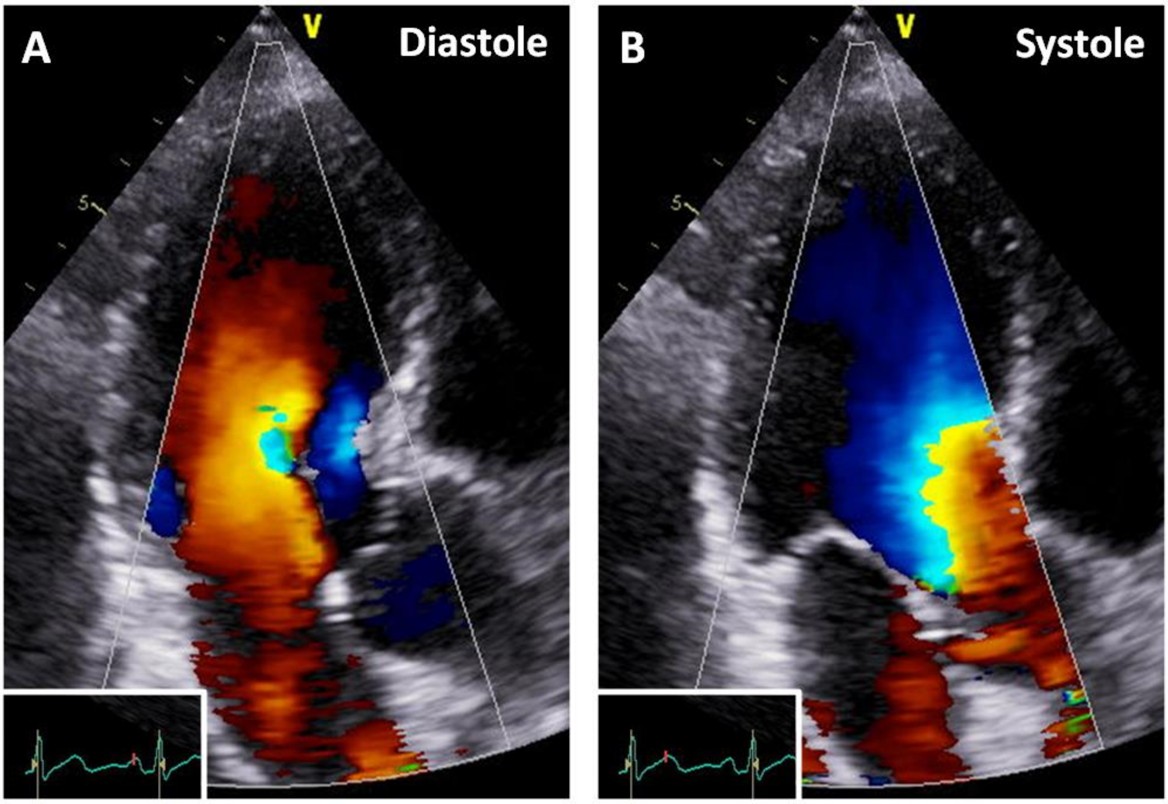
Figure 5 The standardised apical long axis view is characterised by the same cardiac structures like in the parasternal long axis view: the free right ventricular wall near to the right border of the sector near to the right ventricular cavity (RV), the tip of the left ventricular cavity at the top of the sector with tapered

configuration in healthy subjects and the complete posterior and anteroseptal region of the left ventricle (LV), the mitral valve (MV) sliced in the centre of the valve annulus, the aortic valve (AV) sliced in the centre of the valve annulus, the long axis of the initial portion of the aortic root and the ascending aorta (Ao) and the longitudinal section of the left atrium (LA). In (A) the apical long axis view is shown during early diastole, in (B) during mid systole.



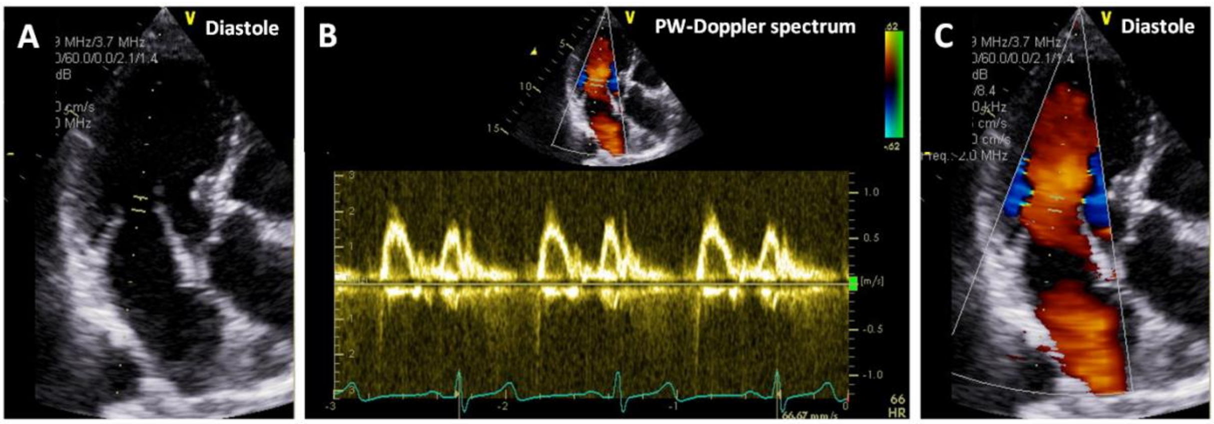
The apical long axis view should also be documented by two-dimensional colour-coded Doppler echocardiography [Figure 6]. This setting enables the analysis of the relay function of the anterior mitral leaflet documenting the complete left ventricle as an inflow chamber during diastole and as an outflow chamber during systole. In addition, turbulences at the valves of the left ventricle qualitatively document valvular disorders. Turbulences into the left ventricle during diastole at the mitral valve illustrate mitral stenosis, at the aortic valve aortic regurgitation. Turbulences during systole at the mitral valve into the left atrium illustrate mitral regurgitation, at the aortic valve into the aortic root aortic stenosis.

Figure 6 **The standardised apical colour-coded long axis view should be added to the documentation for qualitative assessment of mitral and aortic valve function. The anterior mitral valve leaflet is perpendicularly intersected. Thus, the intact relay function of the anterior mitral leaflet is shown by the division of the left ventricle into the inflow chamber during diastole (A) and outflow chamber during systole (B). Mitral regurgitations can be semi-quantitatively evaluated by systolic turbulences from the mitral valve into the left atrium. Aortic valve regurgitations can be semi-quantitatively evaluated by diastolic turbulences from the aortic valve into the left ventricle.**



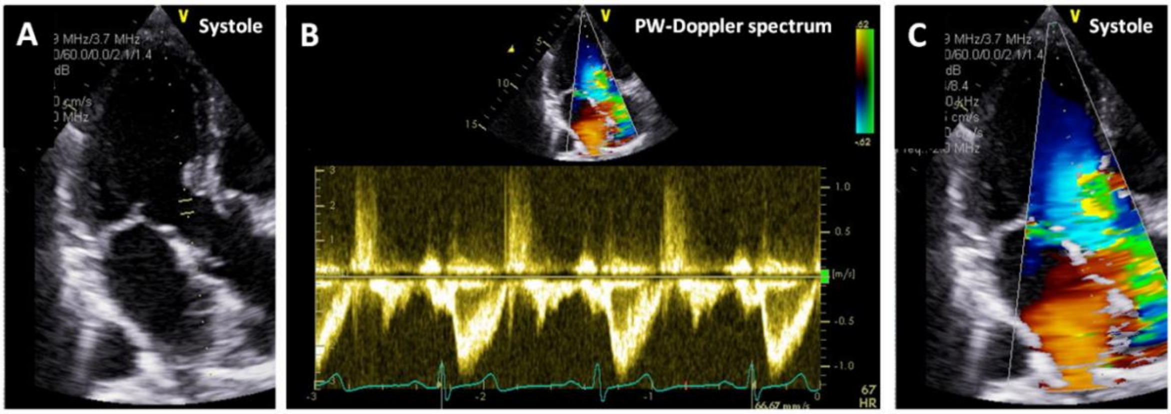
The general documentation from the apical window includes a pulsed wave Doppler spectrum of the blood flow into the left ventricle with the sample volume at the transition of the chords to the mitral leaflets at the tip of the mitral tenting area [Figure 7]. It is important to position the sample volume in the centre of the mitral inflow, documented by the main colour-coded inflow signal using two-dimensional colour-coded Doppler echocardiography prior to the pulsed wave Doppler mode. The normal pulsed wave Doppler spectrum of the left ventricular inflow during sinus rhythm displays a biphasic parabolic flow profile with contours due to the detection of the maximum velocities. If diastolic function should be additionally analysed a second atrial inflow pulsed wave Doppler spectrum should be documented with the position of the sample volume within the mitral annulus. If the mitral valve is abnormal and turbulences can be documented by two-dimensional colour-coded Doppler echocardiography a continuous wave Doppler spectrum through the mitral valve should be added.

Figure 7 The pulsed wave Doppler spectrum of the left ventricular inflow tract is mandatory to be documented in the standardised transthoracic echocardiographic approach. The sample volume has to be positioned in the region of the junction of the mitral leaflets to the chord strands approximately 10mm towards the left ventricle from the mitral annulus (A). The pulsed wave Doppler spectrum of the mitral flow has to be displayed with contours due to the maximum velocities in the centre of the inflow into the left ventricle (B). This is documented by the visual control of the central position of the sample volume in the left ventricular inflow tract at the tip of the mitral leaflets by the corresponding colour-coded long axis view (C).



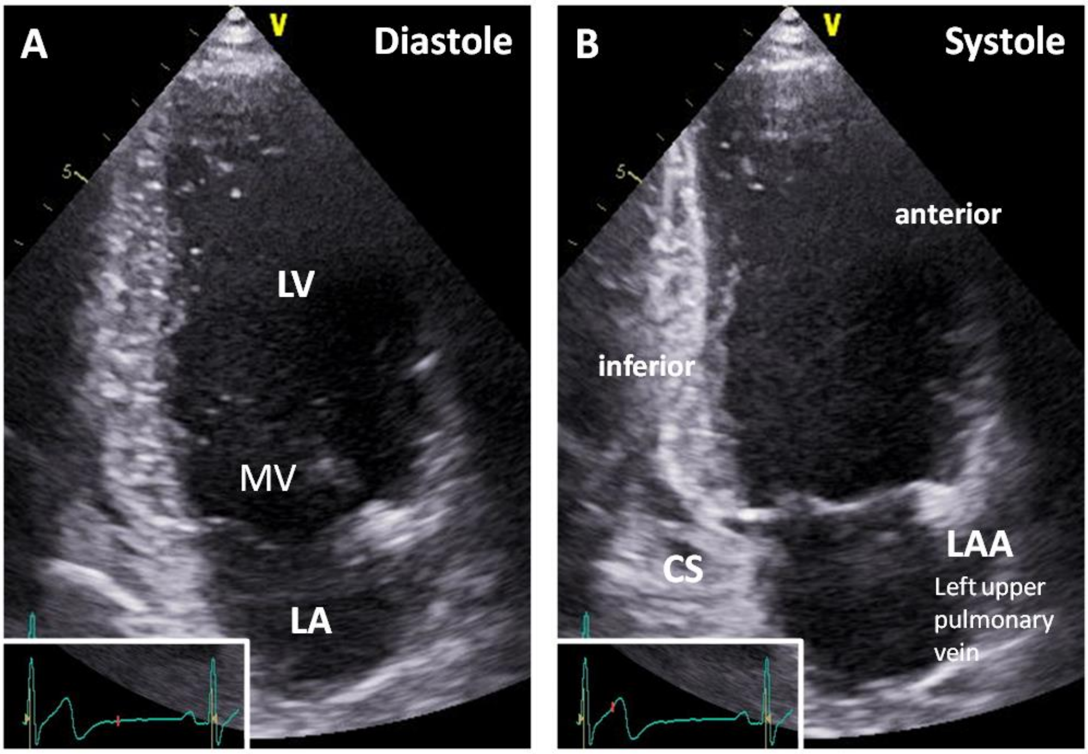
The pulsed wave Doppler spectrum of the blood flow in the left ventricular outflow tract with the sample volume approximately 5-10 mm apart the aortic valve annulus towards the ventricle is the second mandatory pulsed wave Doppler spectrum that has to be performed in the apical long axis view [Figure 8]. The advantage of deriving this spectrum in the apical long axis view is the obvious documentation of the correct position of the sample volume apart from the aortic valve within the left ventricular outflow tract which is not possible - especially for the non-expert - in the so-called 5-chamber view. The normal pulsed wave Doppler spectrum of the left ventricular outflow tract displays a monophasic parabolic flow profile with contours due to the detection of the maximum velocities by the central alignment of the cursor within the blood stream. In normal hearts the dimensions of the cross sectional area of the left ventricular outflow tract and the aortic valve are similar. Thus, in normal hearts there are no significant differences between the pulsed wave Doppler spectra of the left ventricular outflow tract and the aortic valve. If the aortic valve looks suspicious and turbulences can be documented by two-dimensional colour-coded Doppler echocardiography, a continuous wave Doppler spectrum through the aortic valve should be added. If turbulences of aortic valve stenosis or regurgitation can be better visualised in the so-called 5-chamber view, the continuous wave Doppler spectrum can also be derived in this view.

Figure 8 **The pulsed wave Doppler spectrum of the left ventricular outflow tract is mandatory to be documented in the standardised transthoracic echocardiographic approach. The sample volume has to be positioned in front of the aortic valve approximately 5 mm towards the left ventricle from the aortic valve (A). The pulsed wave Doppler spectrum of the flow of the left ventricular outflow tract has to be displayed with contours due to maximum velocities in the centre of the outflow tract (B). This is documented by the visual control of the central position of the sample volume in the left ventricular outflow tract by the corresponding colour-coded long axis view (C).**



By an isolated clockwise 60° rotation of the transducer the apical 2-chamber view of the left ventricle will be obtained [Figure 9]. This view is characterised by the centre of the mitral valve in the commissural view, the tip of the left ventricular cavity with tapered configuration directly below the transducer, the transversely intersected coronary sinus in the inferior region of the mitral annulus, the left atrium with the left atrial auricle cranial to the anterior mitral annulus and the inflow tract of the upper left pulmonary vein cranial to the left atrial auricle. The apical 2-chamber view completely visualises the inferior (left side) and anterior (right side) wall of the left ventricle. Near to the anterior region the P1-scallop of the mitral valve and in the centre of the commissural view of the mitral valve the A2-scallop is seen. Near to the inferior mitral annulus the P3-scallop of the mitral valve is shown. The apical 2-chamber view should also be documented by two-dimensional colour-coded Doppler echocardiography in the presence of turbulences at the mitral valve.

Figure 9 The standardised apical 2-chamber view is characterised by the following cardiac structures: the tip of the left ventricular cavity at the top of the sector with tapered configuration in healthy subjects and the complete inferior and anterior region of the left ventricle (LV), the mitral valve (MV) sliced in the commissural intersection, the left atrium (LA), the cross section of the proximal coronary sinus (CS) in the inferior region of the mitral annulus and the left atrial auricle (LAA) cranial to the anterior mitral annulus as well as the mouth of the upper left pulmonary vein cranial to the LAA. In (A) the apical 2-chamber view is shown during early diastole, in (B) during mid systole.



By a further clockwise 60° rotation of the transducer the apical 4-chamber view will be obtained [Figure 10]. This view is characterised by the tip of the left ventricular cavity below the transducer, the centre of the mitral valve, the interventricular septum, the cardiac crux, the interatrial septum, the left atrium, the inflow tract of the right ventricle with the medial wall of the right ventricle, the tricuspid valve and the right atrium. The apical 4-chamber view completely visualises the inferoseptal (left side) and lateral (right side) wall of the left ventricle. Near to the inferoseptal region of the left ventricle the A2-scallop of the mitral

valve is shown, near to the lateral region of the left ventricle the P2- or P1-scallop is displayed. The documentation of the apical 4-chamber view by two-dimensional colour-coded Doppler echocardiography is very suitable to understand the location of mitral valve regurgitation. Normally the A2-scallop and the P2-scallop of the mitral valve is displayed in the standardised apical 4-chamber view. If the commissure of the mitral valve is oriented from strictly medial to strictly lateral, the A2-scallop and the P1-scallop is displayed. To visualise the anterolateral commissure foreshortening of the 4-chamber view in direction to the left ventricular outflow tract has to be performed. By tilting the scan plane into a more ventral direction the A1- and P1-scallop is visualised. Thus, leakages in this region can be detected by two-dimensional colour-coded Doppler echocardiography. To visualise the posteromedial commissure tilting of the sectional plane of the standardised 4-chamber view into direction of the posterior mitral annulus has to be performed. This region is characterised by the longitudinally intersected coronary sinus at the posterior annulus of the mitral valve. By two-dimensional colour-coded Doppler echocardiography leakages in the region of the A3- and P3-scallop can be detected [Figure 11].
For determination of diastolic function the E/E´- ratio is used as a surrogate parameter for estimation of the left ventricular end-diastolic pressure. E is characterised by the maximum velocity of the E-wave determined in the pulsed wave Doppler spectrum of the mitral inflow. E` is characterised by the mean value of the maximum myocardial velocities at the time of the E-wave determined in the pulsed wave tissue Doppler spectrum of the basal myocardial regions of the inferoseptal and lateral left ventricular wall [Figure 12]. A normal left ventricular end-diastolic pressure is indicated by an E/E`- ratio < 8: An increase of ventricular filling pressure can be assumed if the E/E`- ratio is > 15. This calculation can only be performed if regional wall motion abnormalities are excluded.

Figure 10 The standardised apical 4-chamber view is characterised by the following cardiac structures: the tip of the left ventricular cavity at the top of the sector with tapered configuration in healthy subjects and the complete inferoseptal and lateral region of the left ventricle (LV), the centre of the mitral valve (MV), the interventricular septum, the cardiac crux, the interatrial septum (IAS), the left atrium (LA), the medial right ventricular wall, the inflow tract of the right

ventricle (RV), the centre of the tricuspid valve (TV) and the right atrium (RA). The left ventricular apex and the cardiac crux are the essential cardiac structures for the correct documentation of the apical 4-chamber view. In (A) the apical 4-chamber view is shown during late diastole, in (B) during mid systole.

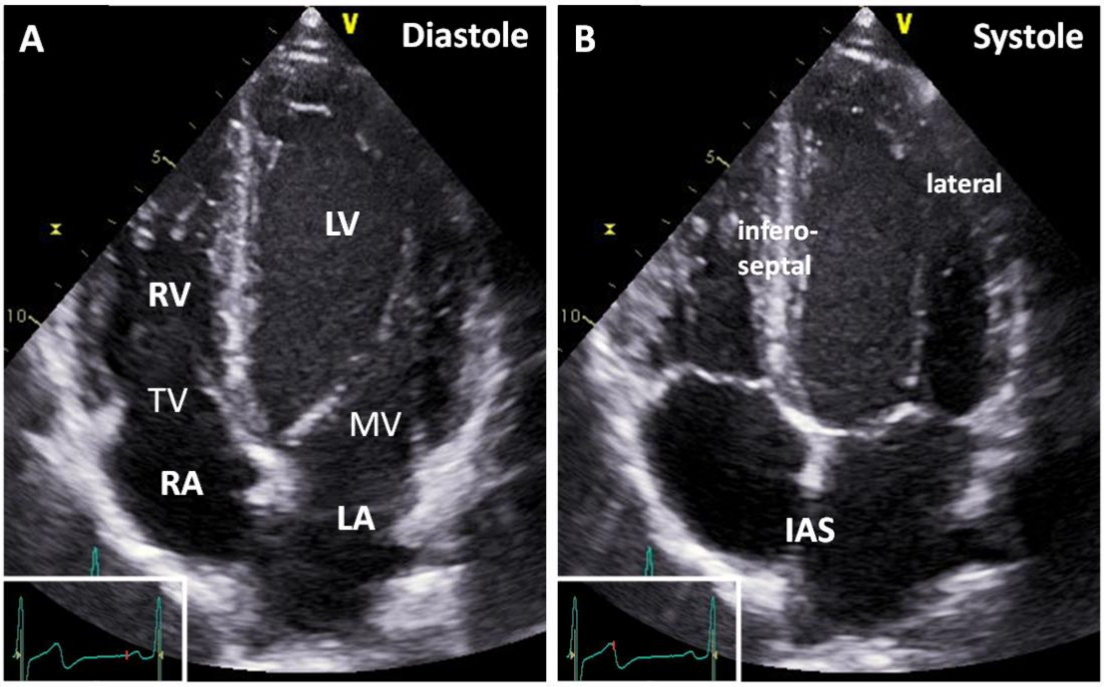


Figure 11 The standardised apical colour-coded 4-chamber view should be added to the documentation for qualitative assessment of mitral regurgitation. The A2- and P2- Scallop is intersected in the standardised apical 4-chamber view during diastole (A) as well as during systole (B). In the illustration a defect of the P2-scallop with a consecutive proximal regurgitant jet formation into the anterior direction is shown (B). Tilting the sectional plane into ventral or dorsal direction enables the assessment of regurgitant phenomena in the commissural regions. The ventral tilting of the standardised sectional plane of the apical 4-chamber view into the direction of the left ventricular outflow tract displays the anterolateral commissure of the mitral valve with the A1- and P1-scallop during diastole (C) and systole (D). In (D) a leakage of the mitral

valve is also documented in the P1-region. The dorsal tilting of the standardised sectional plane of the apical 4-chamber view into the direction of the dorsal mitral annulus near to the longitudinally intersected coronary sinus displays the posteromedial commissure of the mitral valve with the A3- and P3-scallop during diastole (E) and systole (F). In (F) the mitral valve does not show any regurgitation in the P3-region. In summary in this example a defect in the P1- and P2-scallop is documented. In addition, tricuspid valve function is documented in the apical colour-coded 4-chamber view during diastole (G) and systole (H). Tricuspid regurgitation is displayed by the systolic turbulences into the right atrium (H).

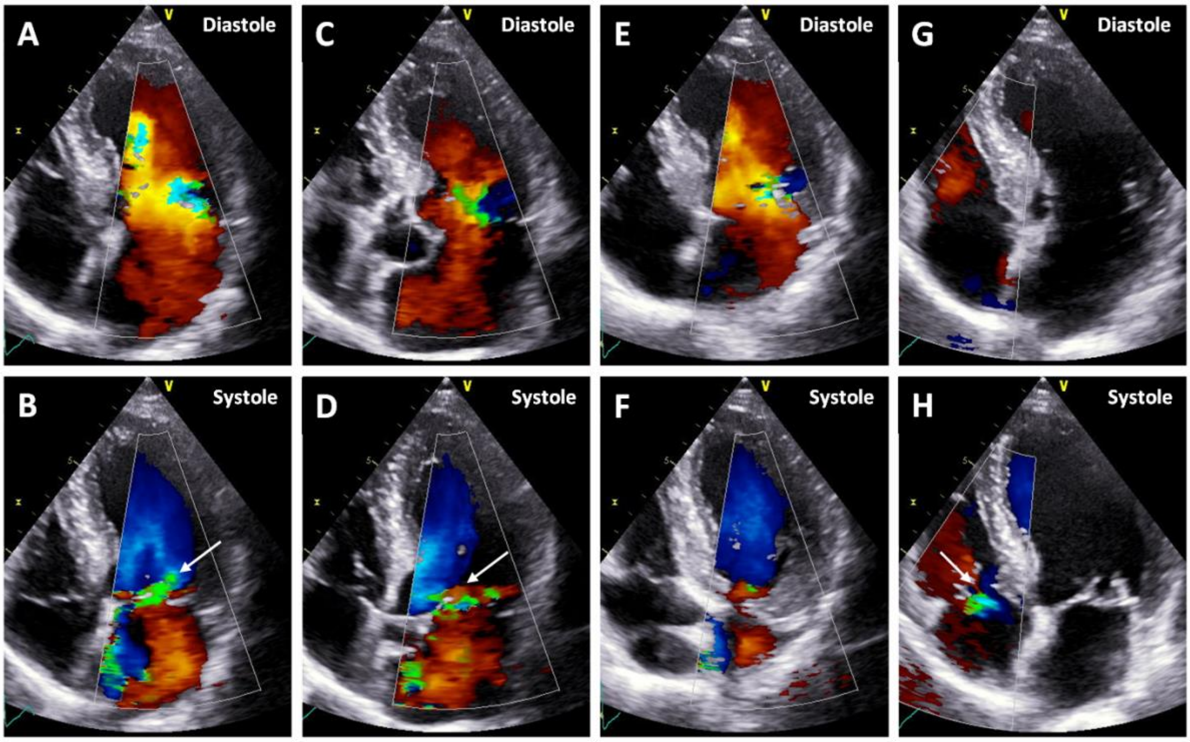
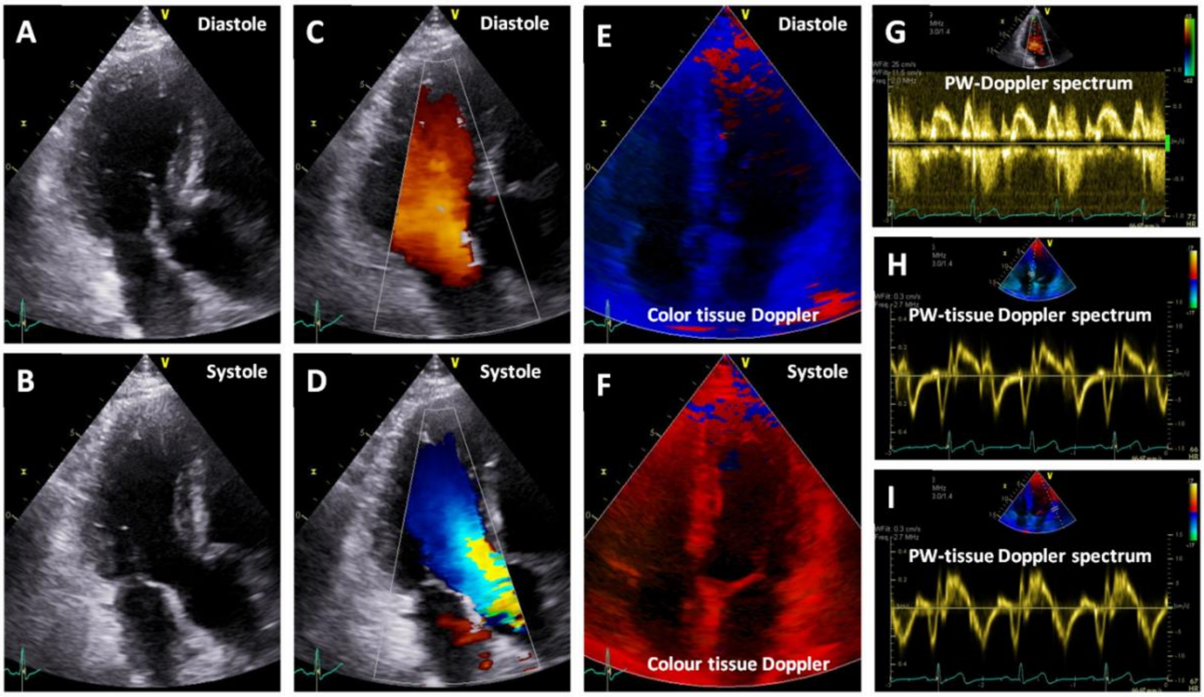


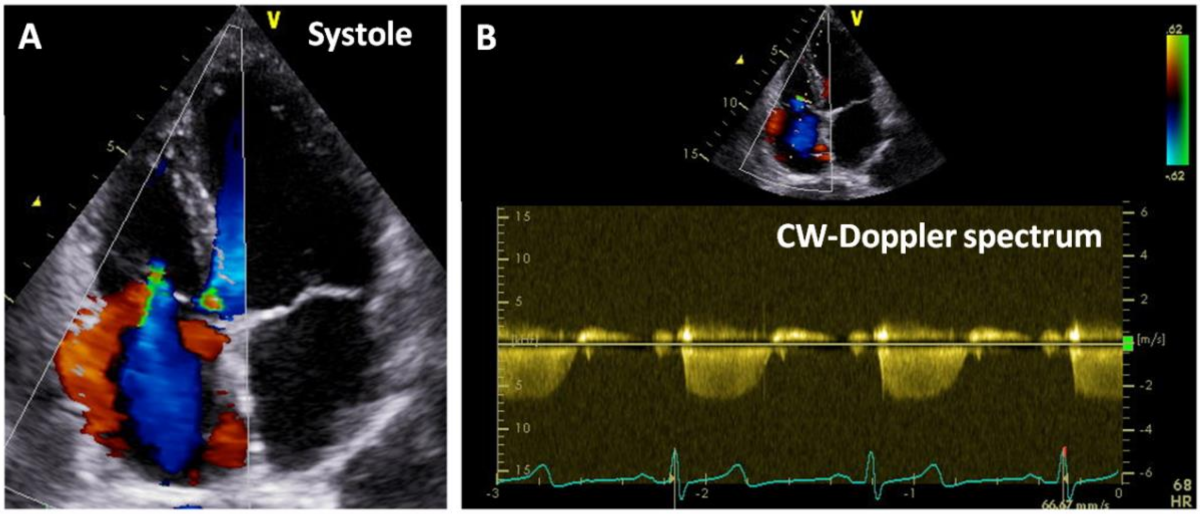
Figure 12 Standardised documentation in transthoracic echocardiography for assessment of the E/E`-ratio: the standardised apical long axis is displayed during diastole (A) and systole (B). The colour-coded apical long axis view is displayed during diastole (C) and systole (D) to document the central inflow into the left ventricle for correct positioning of the pulsed wave Doppler sample volume of the mitral inflow. The colour-coded tissue Doppler of the apical 4-chamber view is displayed during diastole (E) and systole (F) for correct positioning of the sample volume in the basal septal and lateral myocardium for

pulsed wave tissue Doppler of the myocardial velocities. The pulsed wave Doppler spectrum of the mitral inflow for assessment of the maximum velocity of the E-wave is shown in (G). The pulsed wave tissue Doppler spectrum of the basal septal wall is shown in (H), the basal lateral wall is shown in (I). The mean value of the velocities of the E`-waves of the septal and lateral region is used for calculation of the E/E`-ratio.



The apical 4-chamber view should also be documented by two-dimensional colour-coded Doppler echocardiography for the detection of tricuspid regurgitation. The width of the proximal jet formation of tricuspid regurgitation can be used for semi-quantitative estimation of the severity of tricuspid regurgitation. Furthermore, the general documentation from the apical window includes a continuous wave Doppler spectrum of the blood flow through the tricuspid valve [Figure 13]. The systolic pulmonary arterial pressure values can be calculated by the simplified Bernoulli equation determining the maximum velocity of the tricuspid valve regurgitation. Prerequisite for this calculation is a normal function of the pulmonary valve.

Figure 13 Documentation of a mild tricuspid regurgitation in the apical colour-coded 4-chamber view during systole (A). Tricuspid regurgitation is displayed by the systolic turbulences into the right atrium. The continuous wave Doppler spectrum of the tricuspid regurgitation is shown in (B). The systolic pulmonary arterial pressure can be estimated under the assumption of a normal right ventricular outflow tract and a normal pulmonary valve with the right ventricular pressure using the simplified Bernoulli equation (dP = 4 $Vmax^2$).

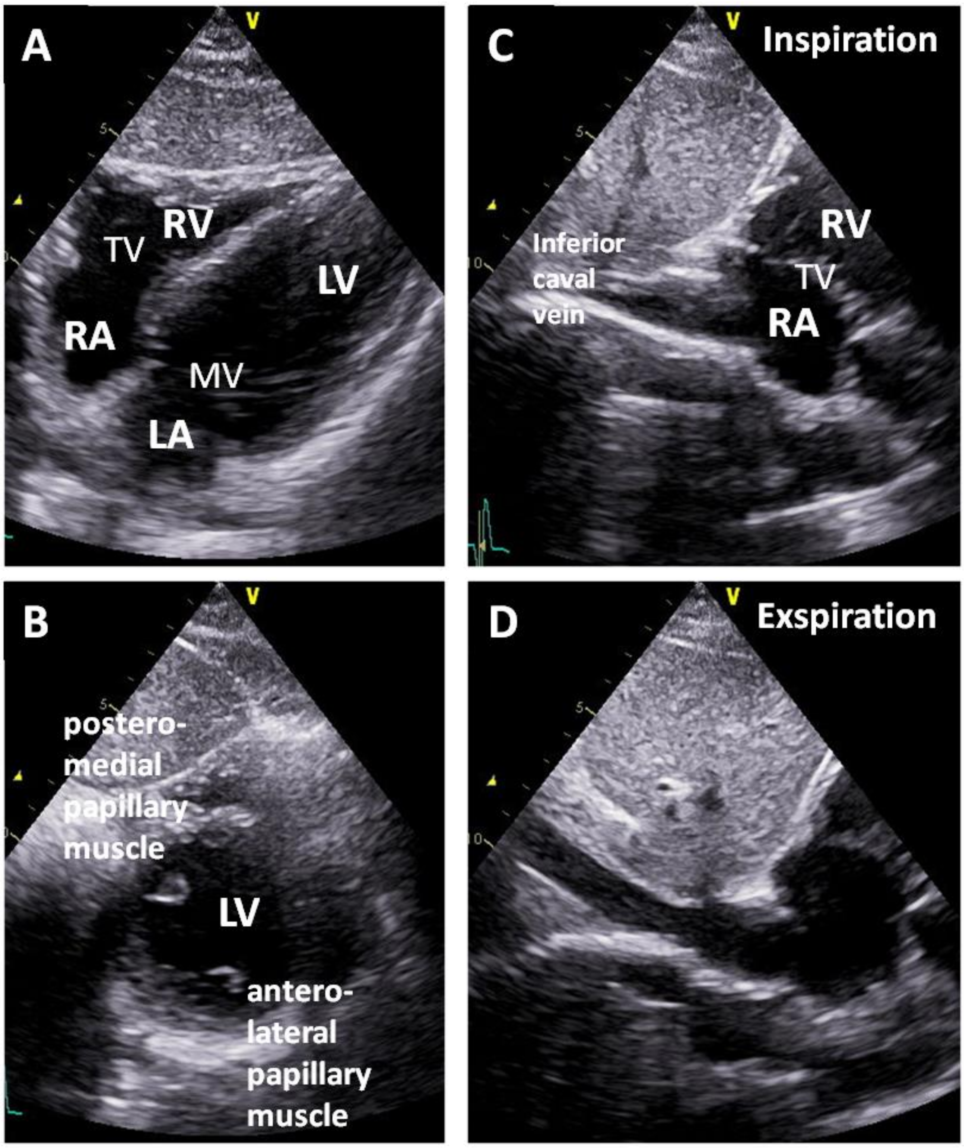


The documentation taking the subcostal acoustic window as a starting point

Normally the subcostal transthoracic echocardiography should start with the subcostal 4-chamber view which is sometimes easier to visualise during moderate inspiration of the patient. Then, by a counter clockwise 60-90° rotation the short axis views of the left ventricle can be obtained [Figure 14]. The subcostal documentation can often visualise the complete cardiac morphology and can be used for the assessment of left ventricular function by two-dimensional echocardiography as well as for the assessment of valve function by two-dimensional colour-coded Doppler echocardiography if the parasternal approach is not possible. However, the pulsed wave and continuous wave Doppler echocardiography is only possible for the pulmonary valve because the Doppler angle for scanning all the other cardiac valves is not well suitable for reliable Doppler spectra.

Between the scan planes of the subcostal 4-chamber view and the subcostal views of the left ventricle the mouth of the inferior caval vein into the right atrium can be longitudinally visualised. Furthermore, using this view the great hepatic veins can be displayed. The documentation of the opening of the inferior caval vein during in- and expiration is used to estimate the central vein pressure and the right atrial pressure. If the right ventricular preload is normal the inferior caval vein collapses completely during deep inspiration [Figure 14]. A partial or missing collapse is documented in the presence of elevated central vein pressure.

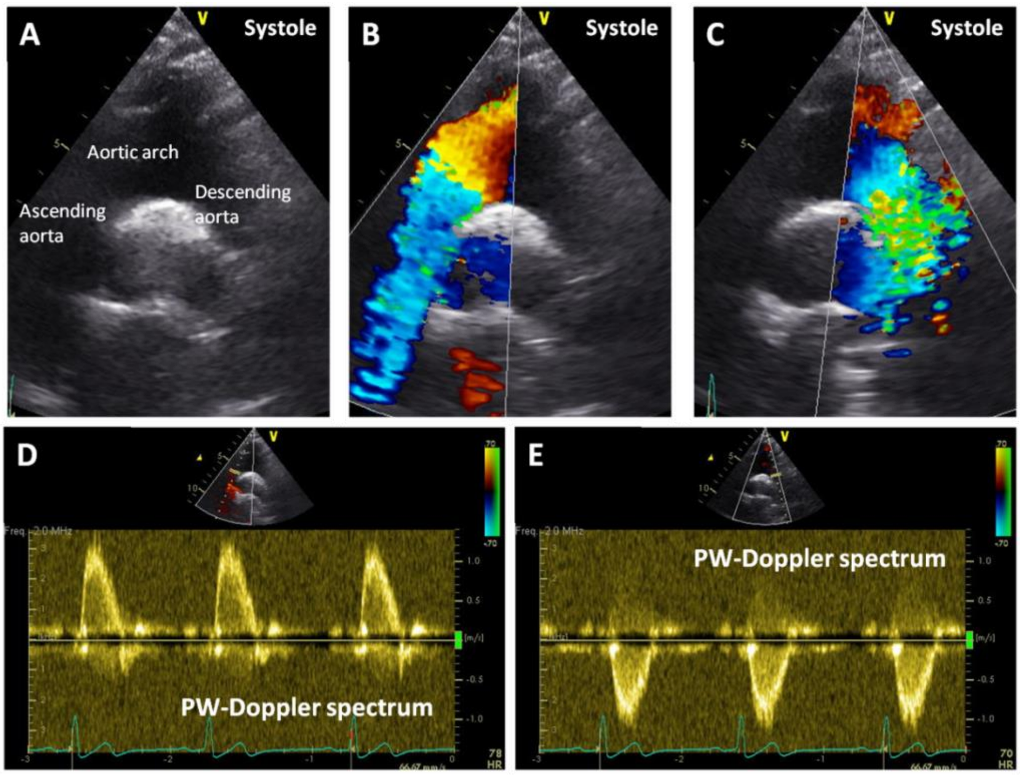
Figure 14 **The subcostal 4-chamber view is characterised by the following cardiac structures: (A): the tip of the left ventricular (LV) cavity at the right of the sector, the centre of the mitral valve (MV), the interventricular septum, the interatrial septum, the left atrium (LA), the medial right ventricular wall, the inflow tract of the right ventricle (RV), the centre of the tricuspid valve (TV) and the right atrium (RA). The perpendicular sectional plane is a left ventricular short axis view (B). The two-dimensional documentation of the mouth of the inferior caval vein is shown during inspiration (C) and during expiration (D) for estimation of the right ventricular filling pressure.**



The documentation taking the suprasternal acoustic window as a starting point

Normally the suprasternal transthoracic echocardiography should be part of the transthoracic documentation [Figure 15]. The longitudinal intersection of the aortic arch has to be documented in all patients with aortic valve diseases as well as suspected diseases of the thoracic aorta. Especially in emergency situations this view is important for the diagnosis and documentation of the dissection membrane of a dissection of the ascending aorta. If the acoustic window is sufficient the complete ascending aorta, the supraaortic branches and the proximal part of the descending aorta can be visualised.

Figure 15 The standardised transthoracic documentation of the suprasternal view displays the ascending aorta, the aortic arch and the proximal descending aorta in (A). In (B) the colour-coded suprasternal view of the ascending aorta , in (C) the colour-coded suprasternal view of the descending aorta is shown. The pulsed wave Doppler spectrum of the aortic flow in the ascending aorta is shown in (D), in the descending aorta in (E).



Standardised documentation of transthoracic echocardiography

Transthoracic echocardiography is not possible to learn within a few hours or days. A learning interval with theoretical and practical teaching and supervision is necessary to become familiar with the standards of echocardiographic documentation. Performing echocardiography not correctly is potentially dangerous for the patients. It is essential to document the correct sectional planes to analyse the complete heart and to have the chance of making the correct diagnosis.

In order to perform echocardiography well this requires technical skill, methodological knowledge as well as sufficient clinical expertise of cardiovascular disorders. There are several issues which have to be considered in order to be sure to diagnose pathological findings correctly by echocardiography.

The following issues will be examples for wrong decision making by non-standardised echocardiography:

In normal hearts the left ventricular cavity is forming the apex of the heart. Thus, if the right ventricle is seen at the apex of the heart, the heart is diseased due to right ventricular enlargement or the scan plane is wrong which implies wrong scan planes for the analysis of the left ventricle. The consequence will be overlooking of ischemia or misinterpretation of right ventricular diseases.

In normal hearts with a small QRS complex in the electrocardiogram the cavity tip of the left ventricle has a tapered shape. If in all apical views the cavity tip of the left ventricle is rounded, the heart is diseased mostly due to ischemia or all apical scan planes are wrong. The consequence will be misinterpretation of regional wall motion abnormalities.

If the apical 2-chamber and 4-chamber view is not documented correctly due to foreshortening the basal inferior and inferoseptal region of the left ventricle will not be analysed. Thus, if these wrong views will be acquired, the consequence will be missing the diagnosis of inferior myocardial ischemia.

The problem of cardiovascular diseases is the fact that - especially due to ischemia - acute complications can occur. But most of the complications can be prevented by performing echocardiography more carefully. Thus, correct diagnoses can be made..

In cardiac diseases the documentation of the standardised transthoracic echocardiographic approach obviously should be complemented by specific additional views, e.g. as shown in figure 11 for the documentation of the localisation of mitral regurgitation [(3)]. Thus, detailed information for the necessary echocardiographic documentation in patients with aortic valve diseases [(4-7)], mitral valve diseases [(4;8;9)], right heart diseases [(10;11)] or diastolic left ventricular dysfunction [(12)] has to be considered. Normal reference values and ranges of echocardiographic parameters have to be well known to detect cardiovascular pathologies [(13;14)]. Furthermore, in case of emergency specific technical skills and clinical expertise are necessary to perform echocardiography with sufficient quality [(15;16)].

Summary

Echocardiography is a specialised method of ultrasound requiring specific equipment and expertise. The difficulties of scanning the heart between the lung and the ribs, the individual orientation of the heart in the thorax as well as the complexity of detectable cardiovascular disorders are challenging. The base of echocardiographic documentation is the acquisition of standardised views which enable the diagnosis of the majority of cardiac diseases. This chapter has described the correct documentation of scan planes in the transthoracic echocardiographic investigation with respect to the different acoustic windows.

The learning of transthoracic echocardiography includes the understanding of the handling of the transducer and the knowledge about the optimisation of the ultrasound settings using special ultrasound machines. Furthermore the transthoracic examination procedure should be taught to be standardised and complete to be able to make the correct diagnosis and to compare follow-up examinations. Transthoracic echocardiography is performed using different acoustic windows. In each acoustic window several cineloops and Doppler spectra have to be acquired. The standardised views are characterised by specific cardiac structures and their positioning in the scanning sector. Thus, every standardised view is highly reproducible and verifiable. In this chapter the reader was intended to be familiarised with

the correct standardised echocardiographic documentation so that cardiac structures can be visualised in a targeted manner by transthoracic echocardiography.

References

1. Evangelista A, Flachskampf F, Lancellotti P, Badano L, Aguilar R, Monaghan M et al. European Association of Echocardiography recommendations for standardization of performance, digital storage and reporting of echocardiographic studies. Eur J Echocardiogr 2008; 9(4):438-448.

2. Hagendorff A. Transthoracic echocardiography in adult patients--a proposal for documenting a standardized investigation. Ultraschall Med 2008; 29(4):344-365.

3. Buck T, Breithardt O, Faber L, Fehske W, Flachskampf F, Franke A et al. Manual zur Indikation und Durchführung der Echokardiographie. Clin Res Cardiol 2009; S4:3-51.

4. Baumgartner H, Hung J, Bermejo J, Chambers JB, Evangelista A, Griffin BP et al. Echocardiographic assessment of valve stenosis: EAE/ASE recommendations for clinical practice. Eur J Echocardiogr 2009; 10(1):1-25.

5. Lancellotti P, Tribouilloy C, Hagendorff A, Moura L, Popescu BA, Agricola E et al. European Association of Echocardiography recommendations for the assessment of valvular regurgitation. Part 1: aortic and pulmonary regurgitation (native valve disease). Eur J Echocardiogr 2010; 11(3):223-244.

6. Hagendorff A, Stoebe S, Tarr A, Pfeiffer D. [Standard transthoracic echocardiography examination in patients with degenerative stenosis of the aortic valve]. Ultraschall Med 2012; 33(6):520-538.

7. Hagendorff A, Stobe S, Tarr A, Pfeiffer D. [Special echocardiographic diagnosis and specific problem constellations in patients with degenerative stenosis of the aortic valve]. Ultraschall Med 2013; 34(3):214-232.

8. Lancellotti P, Moura L, Pierard LA, Agricola E, Popescu BA, Tribouilloy C et al. European Association of Echocardiography recommendations for the assessment of

valvular regurgitation. Part 2: mitral and tricuspid regurgitation (native valve disease). Eur J Echocardiogr 2010; 11(4):307-332.

9. Lancellotti P, Tribouilloy C, Hagendorff A, Popescu BA, Edvardsen T, Pierard LA et al. Recommendations for the echocardiographic assessment of native valvular regurgitation: an executive summary from the European Association of Cardiovascular Imaging. Eur Heart J Cardiovasc Imaging 2013; 14(7):611-644.

10. Milan A, Magnino C, Veglio F. Echocardiographic indexes for the non-invasive evaluation of pulmonary hemodynamics. J Am Soc Echocardiogr 2010; 23(3):225-239.

11. Rudski LG, Lai WW, Afilalo J, Hua L, Handschumacher MD, Chandrasekaran K et al. Guidelines for the echocardiographic assessment of the right heart in adults: a report from the American Society of Echocardiography endorsed by the European Association of Echocardiography, a registered branch of the European Society of Cardiology, and the Canadian Society of Echocardiography. J Am Soc Echocardiogr 2010; 23(7):685-713.

12. Nagueh SF, Appleton CP, Gillebert TC, Marino PN, Oh JK, Smiseth OA et al. Recommendations for the evaluation of left ventricular diastolic function by echocardiography. Eur J Echocardiogr 2009; 10(2):165-193.

13. Lang RM, Bierig M, Devereux RB, Flachskampf FA, Foster E, Pellikka PA et al. Recommendations for chamber quantification: a report from the American Society of Echocardiography's Guidelines and Standards Committee and the Chamber Quantification Writing Group, developed in conjunction with the European Association of Echocardiography, a branch of the European Society of Cardiology. J Am Soc Echocardiogr 2005; 18(12):1440-1463.

14. Lancellotti P, Badano LP, Lang RM, Akhaladze N, Athanassopoulos GD, Barone D et al. Normal Reference Ranges for Echocardiography: rationale, study design, and methodology (NORRE Study). Eur Heart J Cardiovasc Imaging 2013; 14(4):303-308.

15. Neskovic AN, Hagendorff A, Lancellotti P, Guarracino F, Varga A, Cosyns B et al. Emergency echocardiography: the European Association of Cardiovascular Imaging recommendations. Eur Heart J Cardiovasc Imaging 2013; 14(1):1-11.

16. Hagendorff A, Tiemann K, Simonis G, Campo dell' Orto M, von Bardeleben S. Empfehlungen zur Notfallechokardiographie. Der Kardiologe 2014.