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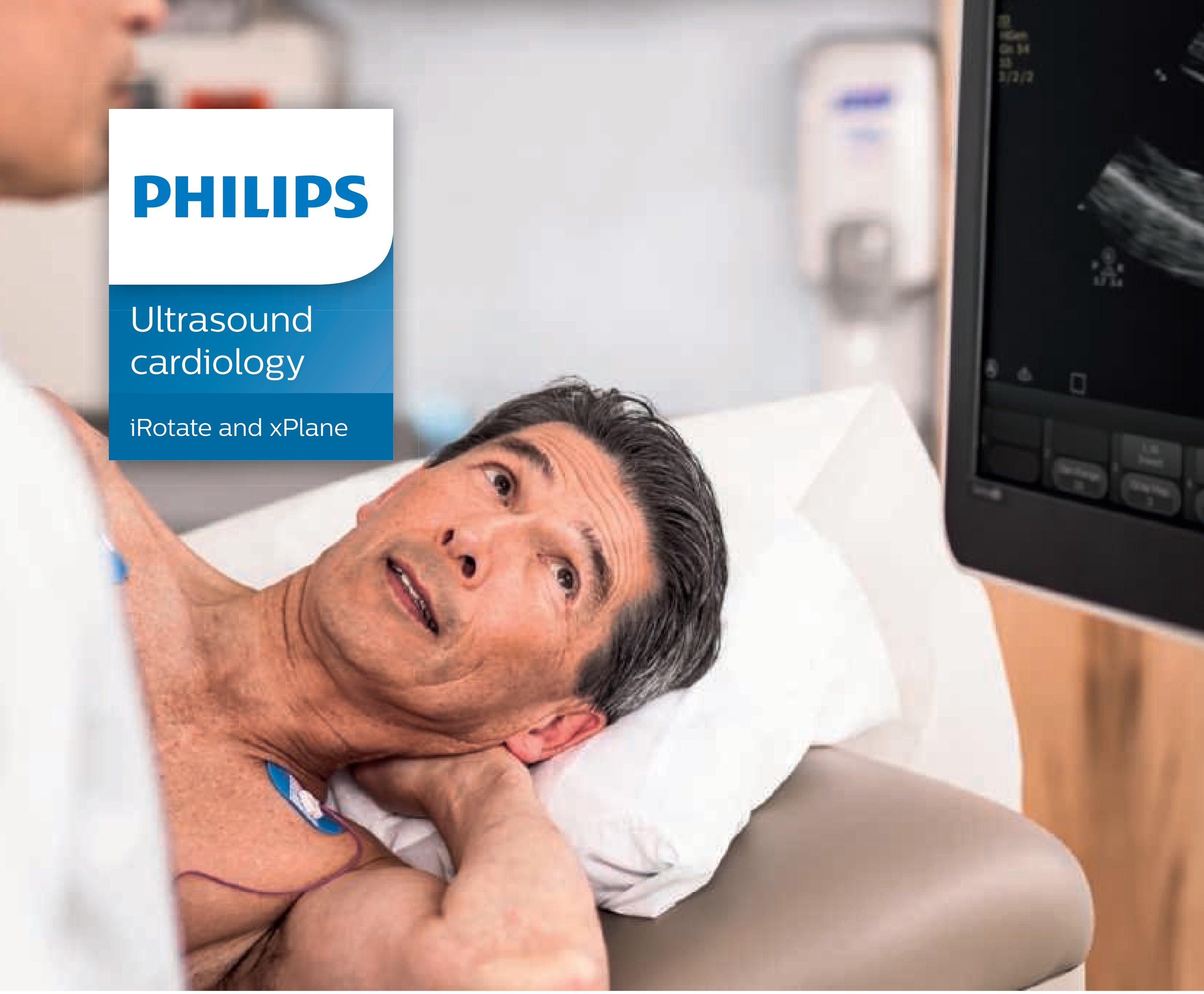
Ultrasound cardiology

iRotate and xPlane



Revealing **new insights**

iRotate electronic rotation and xPlane adjustable biplane imaging

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Introduction

Echocardiography is one of the most frequently used techniques for diagnosis, management and follow-up of patients with any suspected or known cardiovascular disease. It is based on multiple, sequential, single cardiac planes, taken from standard positions on the chest wall. With the development of the new generation of 2D/3D matrix transducers, a new image modality called simultaneous multiplane imaging (SMPI) has become available. This new modality permits the use of a full electronic rotation of 360° of the 2D image (iRotate), and a simultaneously adjustable biplane 2D image (xPlane).

Although biplane and triplane echocardiography have been available since 1988, literature is currently scarce, suggesting the potential of this technique has not been fully appreciated, or the technology has not been adequate. In 2003, transthoracic biplane echocardiography was introduced by Sugeng et al. showing the value of a simultaneous display of two imaging planes during stress echocardiography.1 This reduced examination time and had the potential for a single beat assessment of left ventricular (LV) function in patients with atrial fibrillation. The iRotate and xPlane, modalities have the potential to overcome the limitations of biplane and triplane imaging and have important clinical value.

Image acquisition

For the purposes of this paper, simultaneous multiplane imaging was performed using the Philips iE33 or EPIQ 7 ultrasound system, equipped with an X5-1 transthoracic echocardiography (TTE) or X7-2t transesophageal echocardiography (TEE) xMATRIX transducer. Rather than manually rotating the transducer to search for a non-obscured echo window, SMPI makes it possible to find the necessary view within the acoustical window without further manipulating the transducer.

Imaging: How to start?

The reference image is defined by the transducer position, chosen by the operator and optimized in the same manner as for a conventional 2D image. From this reference image, the spatial relation of the secondary image plane can be modified by applying rotation around a central longitudinal axis (iRotate), or one of the four simultaneous multiplane imaging modes xPlane with lateral tilt, xPlane with elevation tilt, xPlane with iRotate, and xPlane with iRotate color flow.

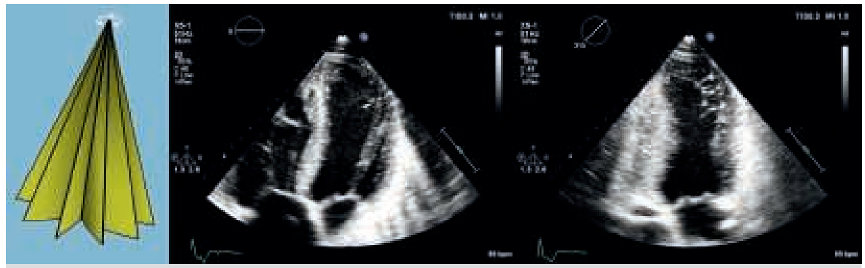

Figure 1 From the reference image, apical four-chamber view (defined as 0° or 360°), a two-chamber view is obtained by rotation of ±60° (to 300°).

iRotate

During TTE, iRotate lets you rotate the image plane through 360° from the reference image, in 5° steps; during TEE 180° is possible, in 1° steps (*Figure 1*).

Note that the frame rate is not compromised in iRotate mode; in xPlane mode it drops by half.

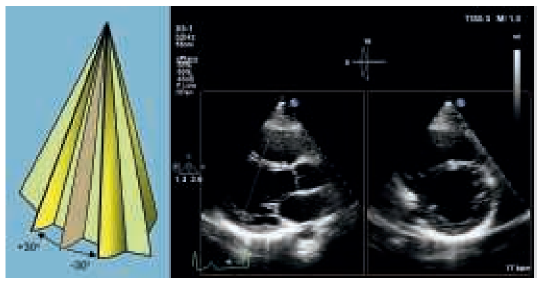

Figure 2 xPlane with lateral tilt: from a standard parasternal long-axis view (reference image) an orthogonal view at the papillary muscle level can be obtained with a lateral tilt of +18°.

xPlane with lateral tilt or elevation tilt

From a reference image, xPlane lets you acquire an orthogonal view through the midline, and display it as a secondary image. You can select an alternative secondary image with a lateral tilt of up to +30° to -30° from the midline (*Figure 2*), or a secondary image with an elevation tilt from the reference image of up to +30° to -30° (*Figure 3*).

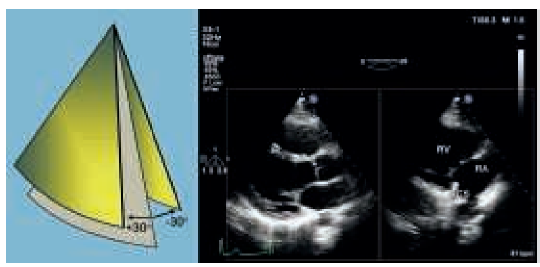

Figure 3 xPlane with elevation tilt: from a parasternal long-axis view (reference image) a right ventricular inflow view can be obtained by an elevation tilt of -26°. RV, right ventricle; RA, right atrium; CS, coronary sinus.

xPlane with iRotate:

This mode combines xPlane and iRotate. You can select a secondary image by adjusting the rotation around the central longitudinal axis of the reference image.[2] (*Figure 4*)

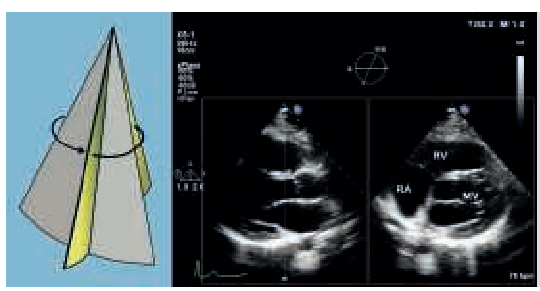

Figure 4 xPlane with rotation: from a parasternal long-axis view (reference image) an unorthodox short axis-long-axis view can be obtained, in this example with a rotation of + 150°. RV, right ventricle; RA, right atrium; MV, mitral valve.

xPlane and iRotate color flow

This mode can help in the identification of the exact etiology and underlying of the valve dysfunction and allows a comprehensive evaluation of the regurgitant jet. It is easier to detect multiple regurgitation jets, the exact vena contracta and extent of the jet(s). (*Figure 5* and *Figure 6*)

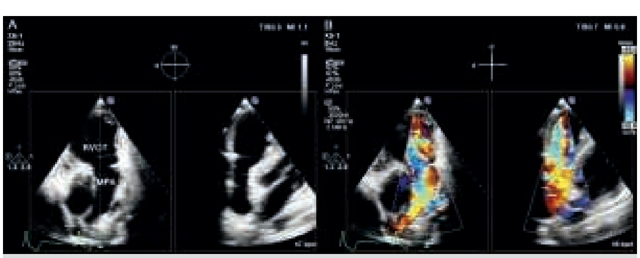

Figure 5 Severe pulmonary regurgitation seen simultaneously in the parasternal short (reference image) and long-axis view in xPlane mode. RVOT, right ventricle outflow tract; MPA, main pulmonary artery.

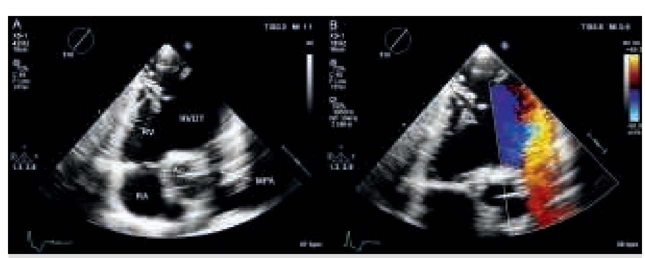

Figure 6 Severe pulmonary regurgitation seen in the RV coronal view in iRotate mode. RV, right ventricle; RA, right atrium; RVOT, right ventricle outflow tract; MPA, main pulmonary artery; Ao, aorta

Unique applications of SMPI

Left-ventricular and atrial assessment

Two-dimensional echocardiography has, apart from image quality issues, limited value in the calculation of LV volumes and ejection fraction. This is because LV images (in particular the 2-chamber view) are often foreshortened, the four-chamber and two-chamber views are not truly perpendicular to each other, and the geometrical assumptions applied in the biplane Simpson calculation will not be met.

These limitations can be overcome with the use of xPlane: two perpendicular image planes can now be acquired from the same heartbeat, a big advantage in particular in patients with atrial fibrillation. An analysis based on biplane or triplane imaging may be a simple and reasonable alternative for those patients were 3D echocardiographic technique is not applicable. You can now ensure that the two planes are perpendicular, if the apical four-chamber view is foreshortened xPlane or iRotate directly reveals an incorrect 2-chamber view. Likewise, xPlane may also be a simple and a reasonable alternative to the 3D echocardiographic technique to quantify left atrial (LA) volumes.

Automatic rotation during stress echocardiography

During stress echocardiography, iRotate allows you to complete an entire stress echo protocol, including standard apical two- and three-chamber views, from a standard non-foreshortened four-chamber view, without changing the transducer position. The rotation for the two- and three-chamber views, obtained at baseline, can be used as a default setting during the rest of the study. This default setting reduces the variability of the standard imaging planes throughout the stress test, and provides more accurate acquisition for analysis of LV wall-motion abnormalities. (*Figure 7*)

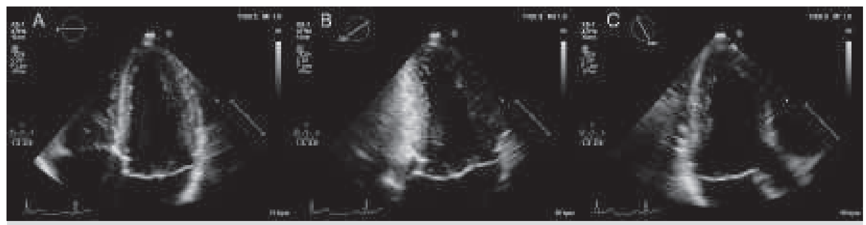

Figure 7 (A) Standard, non-foreshortened apical four-chamber view (reference image). Without moving the transducer, iRotate makes it possible to acquire the (B) two and (C) three-chamber view.

A new approach to right ventricular assessment with iRotate

iRotate has made it possible to visualize the right ventricle (RV) from a single acoustic window, with the transducer in a fixed position, using defined anatomic landmarks.[3] The views that can be acquired are: a focused, non-foreshortened RV view with the interventricular septum (IVS)-RV centred along or near to the midline of the sector (4C, 0º) showing the lateral RV wall; coronary sinus view (CS ±40º) showing the anterior RV wall; aortic view (Ao ±40º) showing the RV inferior wall; and coronal view (CV±90º) showing the RV outflow tract (RVOT) anterior wall and inferior wall of the RV. The feasibility is good and normal values of RV dimension and function have been established. Further studies are needed to discover the full potential of this new technique for evaluation of the RV in various diseased states. (*Figure 8*)

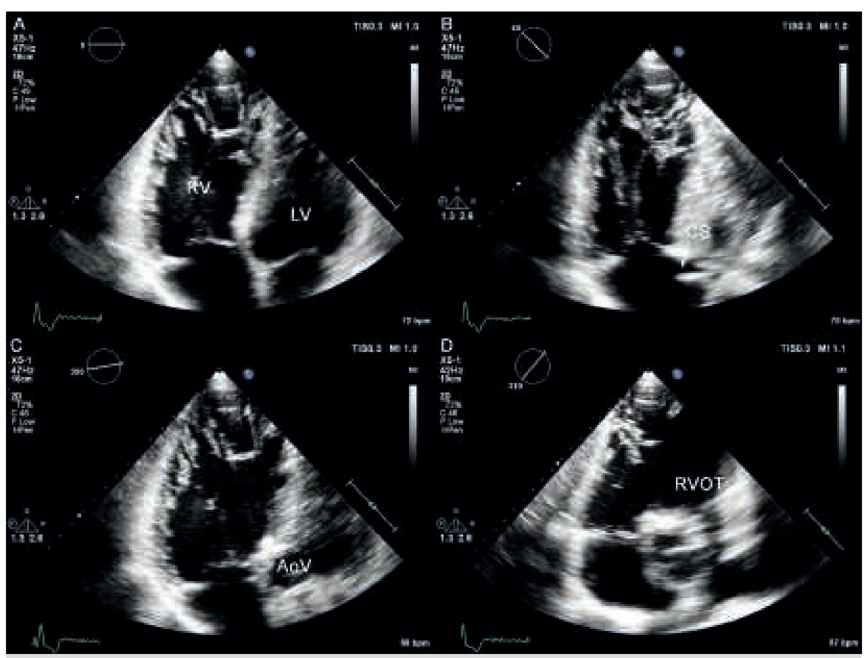

Figure 8 Standardized approach for RV assessment: A) Focused four-chamber view (0°), lateral wall; B)coronary sinus view (+40°), anterior wall; C) aortic view (-40°), inferior wall; D) coronal view (-90°) inferior wall and RVOT anterior wall. RV, right ventricle

Clinical value of SMPI in the assessment of valve pathology:

Valve regurgitation

It is important in the management of patients with mitral valve regurgitation to identify the exact etiology and underlying lesions that result in mitral valve dysfunction. In Europe, degenerative mitral valve disease is the most common etiology. In such patients, a precise morphologic assessment is necessary to predict the likelihood of successful reconstructive valve surgery. Although in most patients the localization of the pathology (assessment of the involved mitral leaflet segments) can be identified with standard 2D echocardiography, this requires extensive expertise. Mitral regurgitation is not always present or maximally visualized in the standard 2D cross-sections as it depends on mechanism and jet morphology.

iRotate applied with the transducer in the apical position and the mitral valve centered along, or as near as possible, to the midline gives a comprehensive evaluation of the mitral regurgitant jet. (*Figure 9*)

xPlane with lateral tilt is also useful in evaluating the mitral valve (*Figure 10*), segmental analysis of the scallops involved in mitral valve prolapse may become easier to identify

Guided by the mitral valve short axis view, multiple mitral valve parasternal long axis views allow segmental analyses of the mitral valve scallops. (A) P3 and A3 scallops, (B) P2 and A2 scallops, (C) P1 and A1 scallops.

Valve stenosis

It is possible to measure the direct area of the left ventricular outflow tract, aortic and mitral valve on short-axis 2D images in patients with excellent transthoracic image quality. However, planimetry of the valve area should always be interpreted with caution due to the complex 3D anatomy of the orifice. It can also be difficult to align the image plane with the narrowest point at the leaflet tips. In particular, in the "dome-like" opening of the mitral and the bicuspid aortic valve, where the closure line can sometimes be eccentric. This is an important source of error in estimating stenosis severity.

By use of xPlane with lateral tilt, a cross-sectional image from the LV outflow tract (LVOT) or valve at the correct level can be acquired, guided by the parasternal long-axis view. However, care must still be taken when performing this measurement, as the motion of the heart through the cardiac cycle may result in the reference line not transecting the same region of interest at certain time points in the heart cycle.

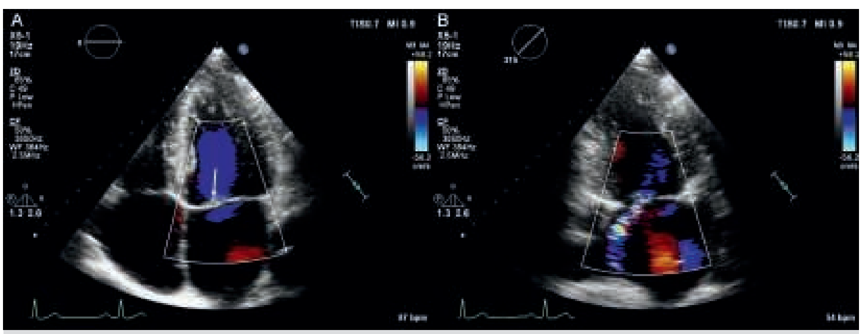

Figure 9 A mitral regurgitation jet is sometimes not visible in a standard apical view (A). A complete rotation around the centered mitral valve allows easy location of eccentric jets (B).

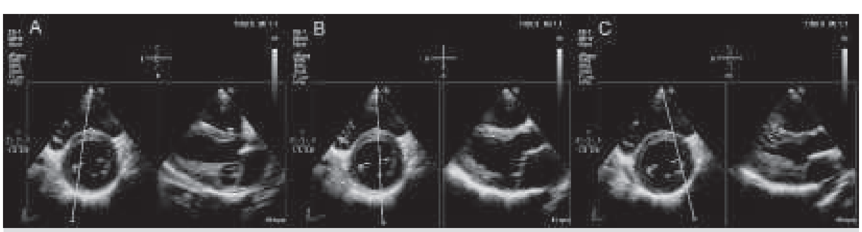

Figure 10 Mitral valve morphology and function benefits by xPlane with lateral tilt

Measurement of valve annulus and area

The mitral annulus (MA) is a vital component of the mitral valve apparatus. Dilatation of the MA is one of the main mechanisms of mitral regurgitation. However, rather than being circular, the MA is oval or D-shaped, and different cross-sections result in different dimensions.

An xPlane from a correctly orientated apical 2-chamber view – in which the mitral valve scallops P3, A2, P1 and both papillary muscles are intersected symmetrically – allows a measurement of the major (primary image) and minor (secondary image) axis diameters of the mitral valve annulus. Likewise, in normal and dilated right ventricles, an xPlane from a parasternal short-axis or focused apical four-chamber view allows a measurement of two axes diameters of the tricuspid valve annulus. However, due to the complex non-planar morphology of the mitral and tricuspid annulus these measurements may be limited.

Clinical value for surgical and interventional cardiology

The iRotate images acquired during TEE are identical to the images acquired with a traditional TEE transducer, except the steering mechanism is electronic, not mechanical. xPlane with lateral and elevation tilt work the same way as for TTE.

Left atrial appendage

The left atrial appendage (LAA) may harbor thrombi that can result in transient ischemic attack or cerebral vascular accident. Unfortunately, it may sometimes be difficult to differentiate thrombi from pectinate muscles.

A lateral sweep across the LAA in xPlane mode may more easily differentiate an organized thrombus from these small pectinate muscles.

MitraClip mitral valve repair

During the MitraClip procedure for treatment of mitral regurgitation, the mitral valve leaflets are clipped together. This procedure critically depends on echocardiographic imaging to position the MitraClip and perform a safe atrial septal puncture.

An xPlane image simultaneously showing the bicaval view in combination with an aortic valve short-axis view provides essential information for the correct placement of the septal puncture. (*Figure 11*)

For the positioning of the delivery catheter toward the mitral valve regurgitant jet, and the grasping of the mitral valve leaflets from their underside, xPlane may facilitate with an inter-commissural view in combination with a long-axis view. The use of lateral and elevation tilt easily allows continuous monitoring of the clip in the primary image, and thus the exact position of the clip during deployment in the two orthogonal planes. (*Figure 12*)

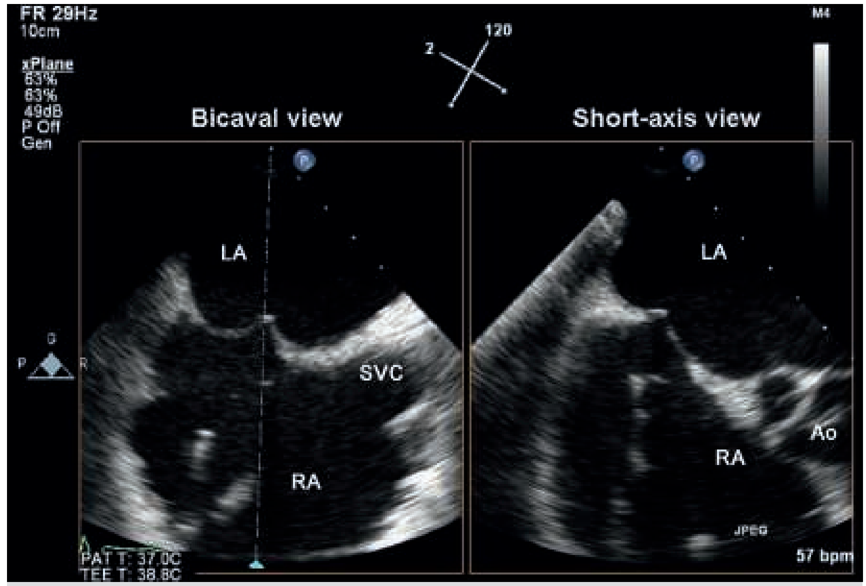

Figure 11 xPlane image during transesophageal echocardiography showing simultaneously the bicaval and short-axis view of the atrial septum for correct placement of the septal puncture (iRotate 120° with lateral tilt 2°). LA, left atrium: RA, right atrium; SVC, superior vena cava

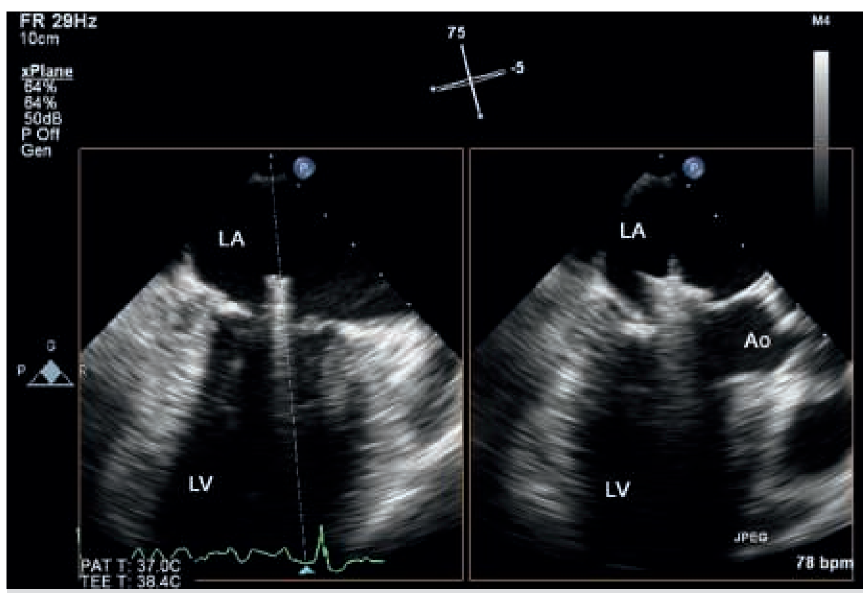

Figure 12 iRotate (75°) and xPlane lateral tilt (-5°) allows continuous monitoring of the deployment of the mitral clip during a MitraClip procedure. LA, left atrium; LV, leftventricle; Ao, aorta.

Congenital heart disease

Atrial septal defect

The size of the atrial septal defect (ASD) and surrounding rims are crucial determinants in the selection of percutaneous or surgical closure. When an ASD is larger than 30mm or has an insufficient rim of tissue around the defect, it is not suited for percutaneous closure. Also, it is well known that, in particular, in non-circular defects the maximal diameter may be underestimated with monoplane 2D-echocardiography.

The many images available in iRotate mode and the orthogonal images obtained with xPlane can give comprehensive visualization of the defect and its surrounding rims (*Figure 13*). In various cases of congenital heart disease, the use of these two modes is of great value, as the region of interest often does not lie in the standardized 2D-echocardiographic views.

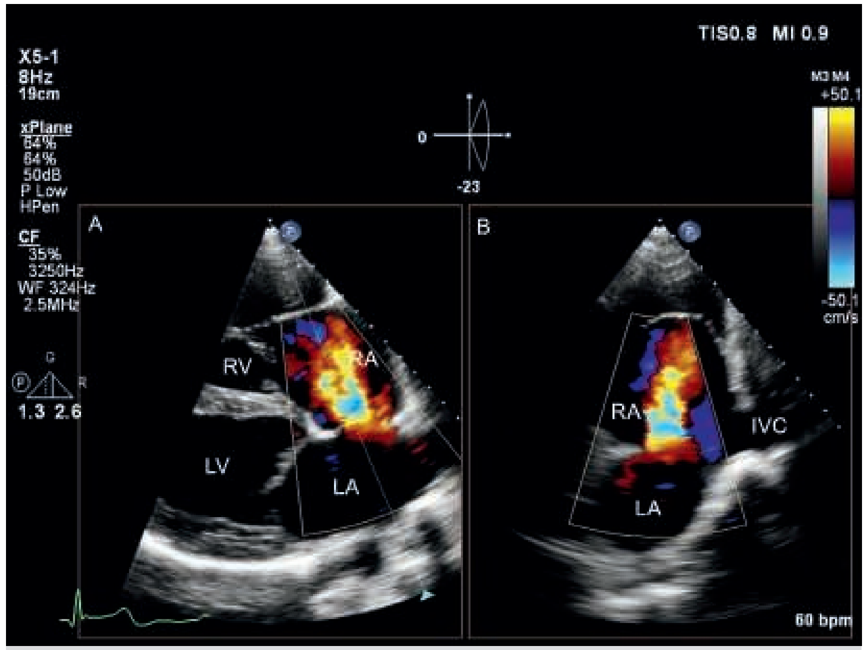

Figure 13 Color Doppler image of an atrial septal defect as seen from a low right parasternal window. xPlane allows simultaneous visualization of the ASD in two planes (A, B).

Conclusions

Simultaneous multiplane imaging is a quick, simple to use, and easy to understand echo modality, that can reduce scanning time in a high-volume echocardiography laboratory, and provide unique clinical information on cardiac function and morphology. It also has the potential to ultimately bridge the gap between 2D and 3D thinking, making the integration of 3D echocardiography easier in the clinical echo lab.

[1] Sugeng L, Kirkpatrick J, Lang RM, et al: Biplane stress echocardiography using a prototype matrix-array transducer. J Am Soc Echocardiogr 2003;16:937–941.
[2] McGhie JS, Vletter WB, de Groot-de Laat LE, Ren B, Frowijn R, van den Bosch AE, Soliman OI, Geleijnse ML. Echocardiography. Contributions of simultaneous multiplane echocardiographic imaging in daily clinical practice. 2014 Feb;31(2):245-54.
[3] McGhie JS, Menting ME, Vletter WB, Frowijn R, Roos-Hesselink JW, van der Zwaan HB, Soliman OI, Geleijnse ML, van den Bosch AE. Quantitative assessment of the entire right ventricle from one acoustic window: an attractive approach.Eur Heart J cardiovasc. Imaging. 2016 Aug 7.

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