Original Article

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Real Time Three-dimensional Transesophageal Echocardiography: Evaluation of Prosthetic Valves

Ecocardiograma Transesofágico Tridimensional en Tiempo Real: Evaluación de Prótesis Valvulares

Eugenio S. de Albuquerque[1], Jose Maria Del Castillo[1], Carlos Antônio da Mota Silveira[1], Diana Lamprea Sepulveda[2], Ricardo Lima[3], Pedro Salerno[3], Paulo Ferraz[3], Alexandre Magno Macário[3]

[1] Echocardiographers of PROCAPE / UPE, [2]Service Manager of Valve Diseases of PROCAPE / UPE, [3]Cardiovascular Surgeons of PROCAPE / UPE

SUMMARY

Introduction: Echocardiography is the technique of choice for the anatomical and functional assessment of cardiac structures. From 2007 onwards was commercially available a probe for the performance of three-dimensional transesophageal examinations in real time. **Objective:** We describe the experience of the echocardiography laboratory from PROCAPE/University of Pernambuco/Brazil with the real time 3D TEE in the evaluation of prosthetic valves. **Material and methods:** From March/2009 to July/2012 had been evaluated 273 valve prostheses in 208 patients. The equipment used was a Philips iE33 (Philips Medical Systems®, Bothell, WA, USA) equipped with transesophageal probe X7-2t. Three-dimensional images, acquired by modes 3D zoom and full volume, were processed and reviewed, when necessary, in a work station equipped with the program QLab 6.0®. The patients were male (105 – 50.5 %) and female (103 – 49.5 %). The age ranged from 14 to 81 years (51±2.2 years). Total of prostheses evaluated, 221 (81 %) were biological (150 in the mitral position, 68 in the aortic position and 3 in the tricuspid position) and 52 (19 %) were mechanical (35 in the mitral position and 17 in the aortic position). Three-dimensional images have provided additional information, allowing the identification of several mechanisms of prostheses dysfunction when compared to images in 2D. **Conclusion:** Real time 3D TEE demonstrates easily the spatial relationship between the various cardiac structures. Its perspective of vision, superior in relation to the examination in 2D, allows a more accurate interpretation of the different mechanisms of valve prostheses dysfunction (objective of this study) and facilitates the interpretation of the physiopathology of the lesions by non-echocardiographers (clinicians and surgeons) and may help in more appropriate choice of therapeutic procedure to be adopted.

Descriptors: Echocardiography, Transesophageal; Heart Valve Prosthesis; Echocardiography, Three-Dimensional

RESUMEN

Introducción: El ecocardiograma se ha tornado uno de los más importantes instrumentos de imagen en la cardiología actual, favorecido por significativa evolución tecnológica permitiendo su avance en corto espacio de tiempo, desde una representación unidimensional seguida por el estudio bidimensional, por la inclusión de las diversas técnicas de Doppler y más recientemente, de la tecnología tridimensional. El ecocardiograma tridimensional en tiempo real fue introducido en los años noventa, limitado inicialmente al estudio transtorácico. Solamente a partir del 2007, se tornó disponible comercialmente una sonda transesofágica capaz de obtener imágenes tridimensionales en tiempo real. **Objetivo:** Describir la experiencia del laboratorio de ecocardiografía del Pronto Socorro Cardiológico de la Universidad de Pernambuco (PROCAPE/UPE) en el estudio de prótesis valvulares, evaluando la calidad de las imágenes obtenidas por el ecocardiograma transesofágico tridimensional (ETE3D), comparándolas con los hallados del examen bidimensional y correlacionándolas con los datos obtenidos en los casos de procedimientos quirúrgicos asociados. **Material y Métodos:** Durante el período de marzo/2009 a julio/2012 fueron evaluadas 273 prótesis en 208 pacientes con el ecocardiógrafo ➔

Institute: Emergency Heart Hospital, University of Pernambuco (PROCAPE / UPE). Recife-PE. Brazil-BR
Mailing address: Eugenio S. Albuquerque
Rua [Street] Carlos Pereira Falcão, 231-A - Boa Viagem ZIPCODE 51021-350 - Recife-PE. Brazil-BR
Phone: (81) 3465-1562
eugenio_albuquer@uol.com.br or eugenios@cardiol.br
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Philips iE33 equipado con sonda transesofágica X7-2t (*Philips Medical Systems®, Bothell, WA, USA*). Las imágenes tridimensionales adquiridas en los exámenes fueron enviadas a la estación de trabajo equipada con el *software* QLab 6.0 (*Philips Medical Systems)* para posterior revisión *off-line*. Fueron evaluados 105 (50,5%) pacientes del sexo masculino y 103 (49,5%) del sexo femenino. La edad varió de 14 a 81 años (51±2,2 años). Del total de las prótesis evaluadas, 221 (81 %) eran biológicas (150 en la posición mitral, 68 en la posición aórtica y 3 en la posición tricúspide) y 52 (19 %) eran mecánicas (35 en la posición mitral y 17 en la posición aórtica). Las imágenes fueron adquiridas preferentemente en el modo *3D zoom* y suministraron información adicional considerada útil en la mayoría de los casos, sobre todo en el estudio de las prótesis en la posición mitral, permitiendo fácil y rápida evaluación y mejor comprensión de los diversos mecanismos de disfunción. Las imágenes de las prótesis en las posiciones aórtica y tricúspide obtenidas por el ETE3D, aunque hayan acrecentado informaciones útiles, no demostraron la misma calidad cuando son comparadas a las imágenes obtenidas de las prótesis en la posición mitral. **Conclusión:** Después del período de formación y curva de aprendizaje relativamente cortos y sin prolongamiento excesivo del tiempo de examen, concluimos que el ETE3D en tiempo real suministra informaciones adicionales útiles con relación a los diversos mecanismos de disfunción de prótesis, principalmente en la posición mitral. El método también propicia mejor entendimiento de las relaciones anatómicas entre las diversas estructuras del corazón.

Descriptores: Ecocardiografía Transesofágica, Prótesis Valvulares Cardíacas, Ecocardiografía Tridimensional

INTRODUCTION

Echocardiography is considered the most important imaging method for diagnosing cardiovascular diseases and it is due to both the ability to anatomical and functional assessment of the various cardiac structures and its availability, ease of implementation and relatively low cost. Since its emergence, about 50 years ago, the method has been acquiring progressive technological sophistication. Initially, the test was only one-dimensional, evolving subsequently to bi-dimensional mode. Soon after, there was the inclusion of several Doppler techniques, and finally the emergence of the three-dimensional echocardiography. The first reports on three--dimensional ultrasound dates from the 60s[1]. However, only after the development of computer technology, particularly from the 90s[2], three-dimensional examination began to evolve indeed. However, the technique was still quite limited, depending on protracted processes of offline reconstruction and limited to the study of ventricular volumes and ejection fraction [3-6], ventricular mass[7] and valve disease, particularly of mitral valve [8-10].

Only after 2007 it became commercially available the transesophageal probe, capable of real-time acquisition and online viewing of three-dimensional images. This is a probe with high technological sophistication, consisting of approximately 2,500 elements capable of acquiring much information with respect to the cardiac anatomy during the same cardiac cycle.

PURPOSE

To describe the experience of the Echocardiography Laboratory of the Emergency Heart Hospital, University of Pernambuco (PROCAPE / UPE), with real-time three-dimensional transesophageal echocardiography (3DTEE), comparing the diagnostic gains of this new technique with the conventional two-dimensional TEE in evaluating prosthetic valves.

MATERIALS AND METHODS

During the period from March 2009 to July 2012, we assessed 273 prosthetic valves in 208 patients. We used the echocardiographer iE33 *(Philips Medical Systems®, Bothell, WA, USA)* equipped with three-dimensional transesophageal probe X7-2t. All patients underwent two-dimensional transthoracic echocardiography and two--dimensional transesophageal examinations with conventional plans. Then, three-dimensional images were acquired in live 3D, 3D zoom and full volume modes. Special emphasis was given to the 3D zoom mode because the quality of the images obtained was higher with fewer artifacts when compared to those obtained in full volume mode.

After a brief study of the structures of interest in real time, we selected the top images and performed their analysis in more detail in offline mode by using the settings of gain and compression and performing the required cuts. Subsequently, when necessary, images were sent to a workstation equipped with *QLab* 6.0 software *(Philips Medical Systems)*. The images were reviewed by two more operators in the laboratory.

RESULTS

The male patients corresponded to the total of 105 (50.5%). Female patients totaled 103 (49.5%). Their ages ranged from 14 to 81 years (51 ± 2.2 years). Of the total prostheses evaluated, 221 (81%) were biological (150 at mitral position, 68 at aortic position and 3 at tricuspid position) and 52 (19%) were mechanical (35 at mitral position and 17 at aortic position). The main findings of examinations of the prostheses are summarized in the plot below.

The identification of mechanisms of prosthesis dysfunction was quite easier by the three-dimensional study, and the image quality of the study of prostheses at mitral position was higher when compared to the study of prosthesis at aortic position, while the image quality of the prosthesis at tricuspid position was considered limited (although only 3 biological prosthesis at tricuspid position have been evaluated).

DISCUSSION

Transesophageal echocardiography[11] (TEE) is considered a very useful tool in cardiology, providing images of better quality and resolution than transthoracic echocardiography. For the study of prostheses, TEE is an essential examination, especially in reference services where there is a large volume of valve pathologies, particularly in our country, where there is still significant prevalence of rheumatic valve disease.

In this work, the main purpose was to demonstrate the experience of the Echocardiography Laboratory of PROCAPE / UPE with 3DTEE in evaluating prosthetic valves.

Key Findings of 3DTEE

After a relatively short period of learning with the handling of this new technique, we were able to take excellent quality pictures in most cases, particularly in mitral prosthesis.

Three-dimensional images allowed a more precise identification of the anatomical relationships between the various structures of the heart [12] (Figure 1).

Periprosthetic failures are best identified with 3DTEE, especially when using the color flow mapping (Figure 2).

During the three-dimensional study no further calculations than the usually ones were performed during the two-dimensional examination (transthoracic and transesophageal). However, in some cases we can relatively easily measure the flow area of the prosthesis by 3D planimetry, as well as measuring the hole area of periprosthetic failure (Figures 3 and 4).

In our casuistry, the stenoses were more common in biological prostheses and thrombosis in mechanical prosthesis (Figure 5).

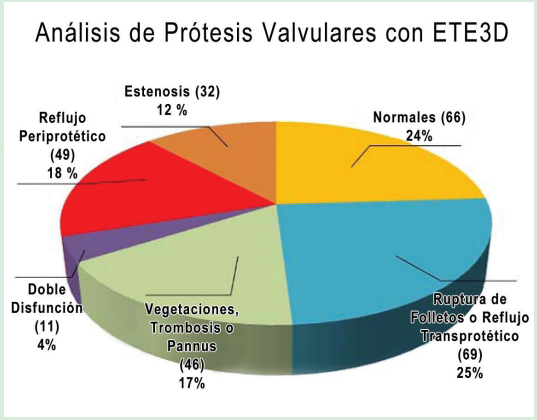
In the evaluation of patients with infectious endocarditis, the 3DTEE was more effective than the two-dimensional examination to identify the volume of vegetation, the area affected by the infectious process, the area preserved, as well as complications of the disease [13] (Figure 6).

The 3DTEE images have had good correspondence with the intraoperative findings (Figures 7 and 8).

CONCLUSIONS

The three-dimensional transesophageal echocardiography is a promising new technique with the ability to more easily show the spatial relationship between the various structures of the heart. Its viewing perspective, higher than the two-dimensional examination, allows faster and more accurate identification of the various mechanisms of dysfunction of valve prostheses (purpose of this article) and makes possible a better interpretation of the pathophysiology of injuries by non-echocardiographers (general practitioners, cardiologists, and surgeons) helping to choose the most appropriate therapeutic procedure to be adopted.

In our experience, corroborated by several authors, the method has proven to be excellent for evaluating mitral prostheses, while the image quality of the aortic prostheses, although better than the two-dimensional examination, is lower compared to the study of mitral prostheses. The probable explanation for this is that the structures



Graphic: *Resultados da análise das próteses valvares com ETE3D.*

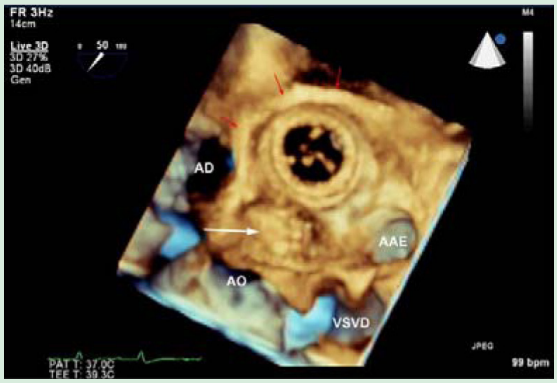


Figure 1: *3DTEE, view of the left atrium demonstrating bioprosthetic valve at normal mitral position and its relationship with the left atrial appendage (LAA), interatrial septum (red arrows), right ventricular outflow tract (RVOT) and right atrium (RA) In the region of the mitral--aortic fibrosa, separating the prosthetic aortic valve ring, there is a characteristic lump of abscess (white arrow)*

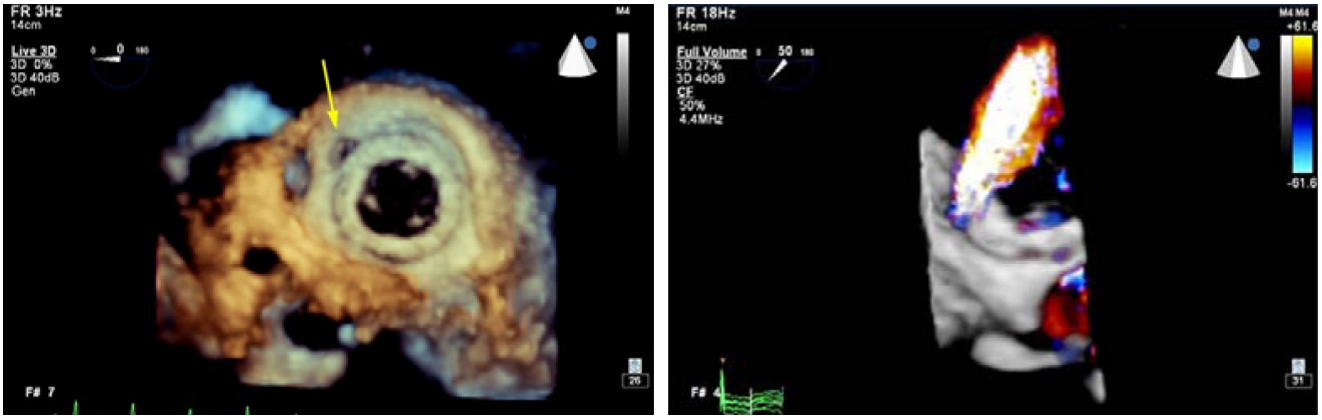


Figure 2: *Left picture, mitral biological prosthesis viewed from the left atrium. The arrow shows the hole through which there is periprosthetic failure. Right picture, demonstration of periprosthetic failure by three-dimensional color Doppler.*

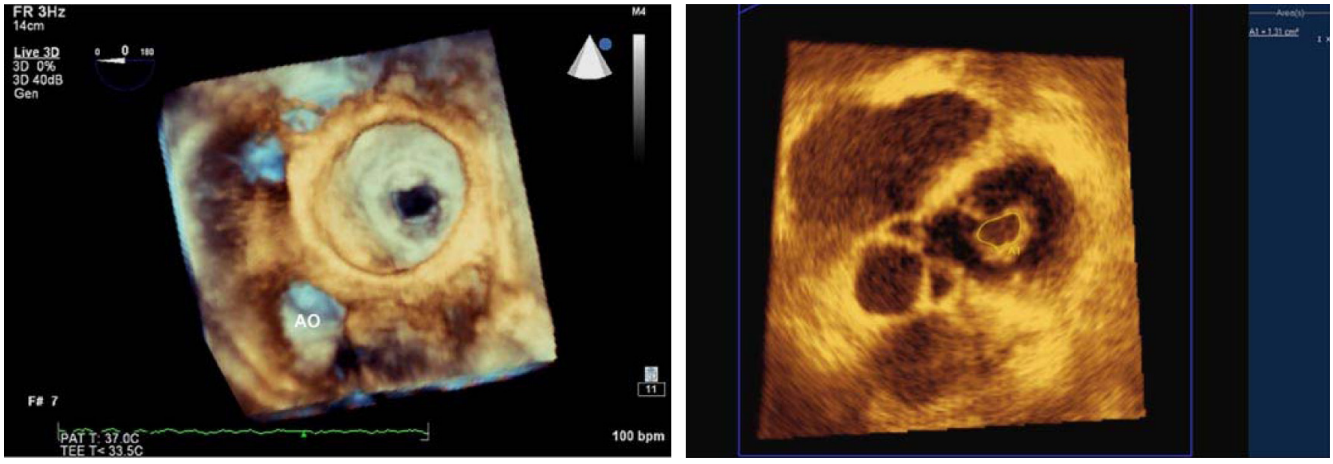


Figure 3: *Left picture, normal biological mitral prosthesis. View of LA in diastole. Right picture, planimetry obtained in QLab® workstation with value obtained for flow area = 1.31 cm².*

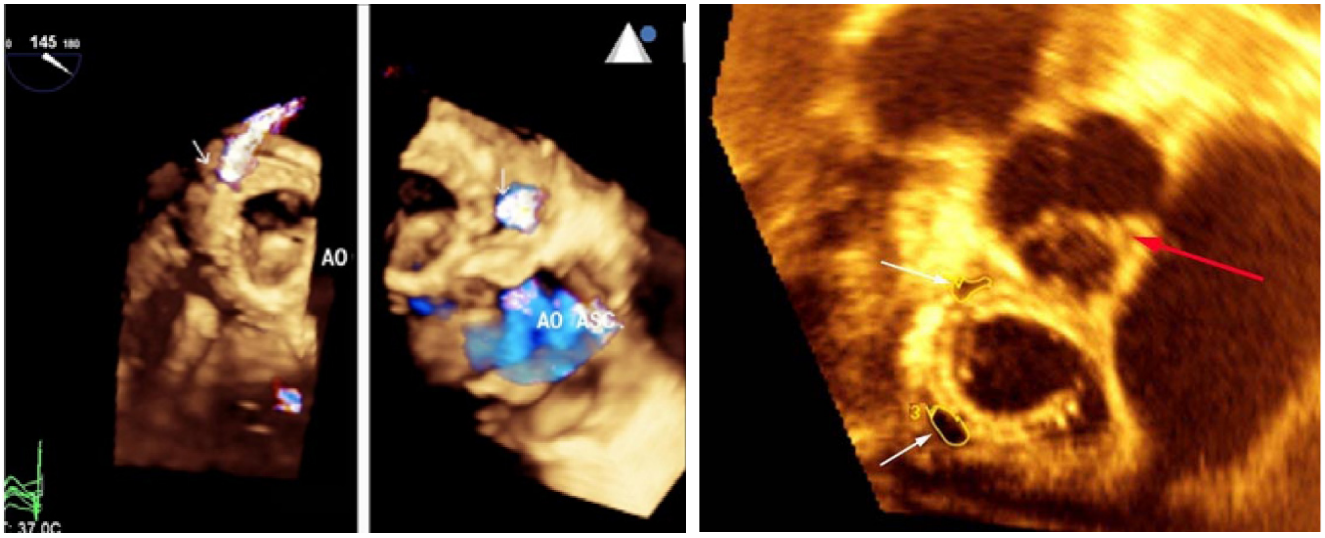


Figure 4: *Left and center pictures, three-dimensional color Doppler of biological mitral prosthesis with two holes of periprosthetic failure (white arrows). Right picture, planimetry of the failure holes (white arrows), estimated areas of 0.45 cm² (hole located at 7 o'clock) and 0.26 cm² (hole located at 11 o'clock). The red arrow points to the aortic valve (equivalent to 12 o'clock position).*

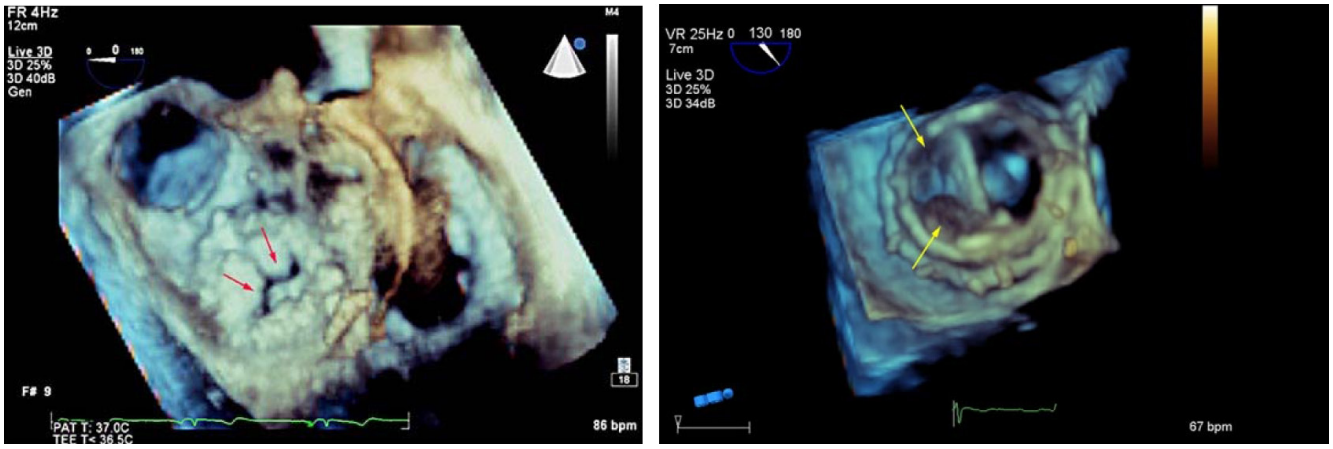


Figure 5: *Left picture, biological prosthesis at mitral position showing stenosis. View of the left atrium in diastole. Note the clear thickening and calcification on the ring and prosthetic leaflets and the small slit-like opening (red arrows). Right picture, metallic double disc prosthesis at mitral position in diastole, with one of the discs immobilized by the interposition of two thrombi (yellow arrows).*

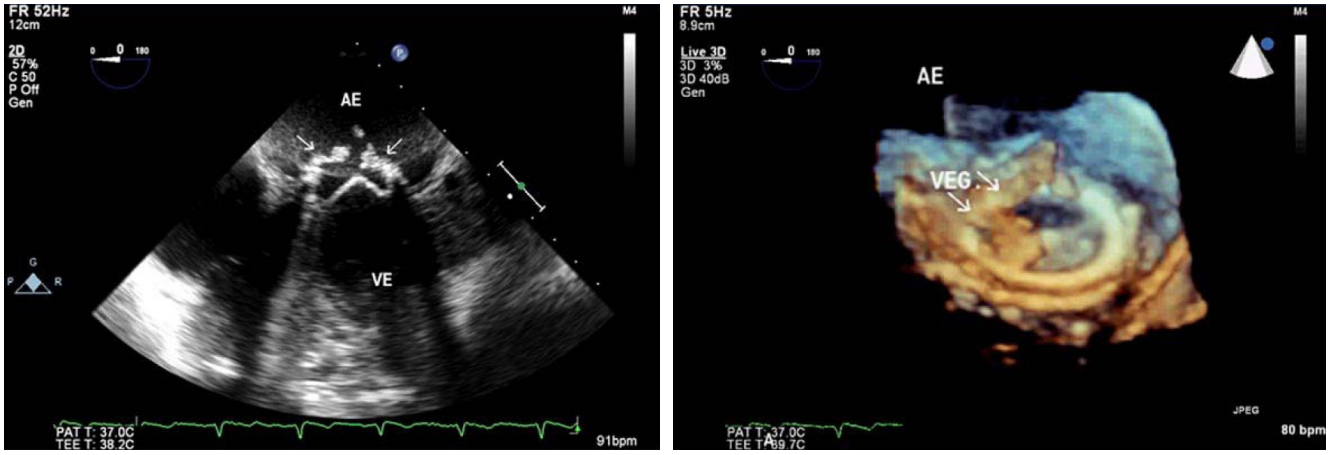


Figure 6: *Left picture, two-dimensional TEE with image obtained at 4-chamber position (0º) from a patient with mechanical prosthesis at mitral position of 2 discs, showing two periannular vegetations, medial and lateral (arrows). Right picture, 3DTEE, view of LA demonstrating single vegetation around great part of the mitral prosthesis ring.*

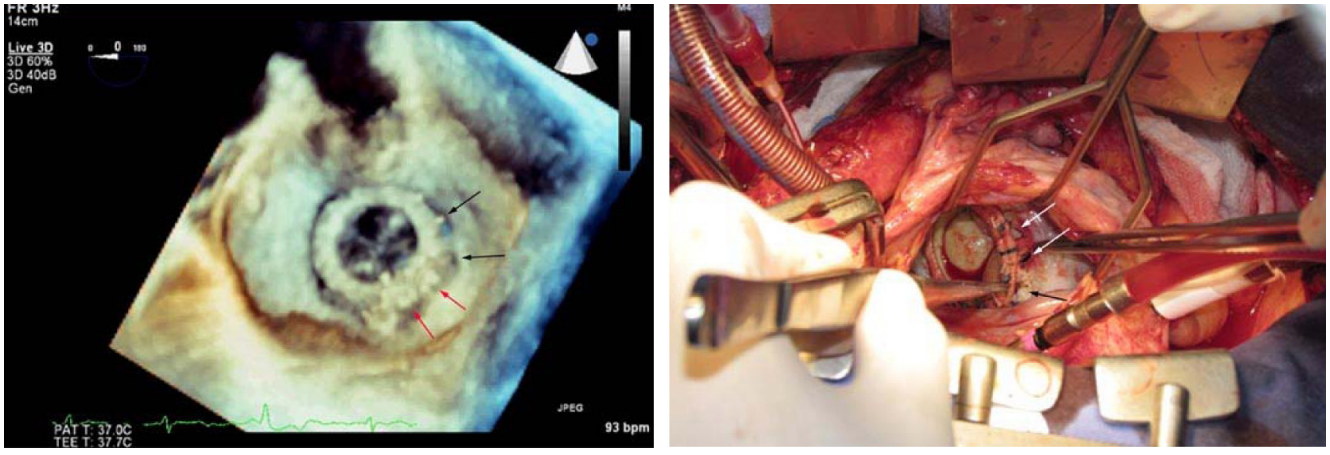


Figure 7: *Left picture, view of LA with biological mitral prosthesis demonstrating suture dehiscence where there is periprosthetic leak (2 holes at 2 o'clock and 3 o'clock - black arrows). A little further down (4 o'clock and 5 o'clock) there is a region with reinforced suture (red arrows) from previous surgery. Right picture, detail of the surgery confirming the 2 holes of periprosthetic leak (2 o'clock and 3 o'clock - white arrows) and the reinforcement of the suture (4 o'clock and 5 o'clock - black arrow).*

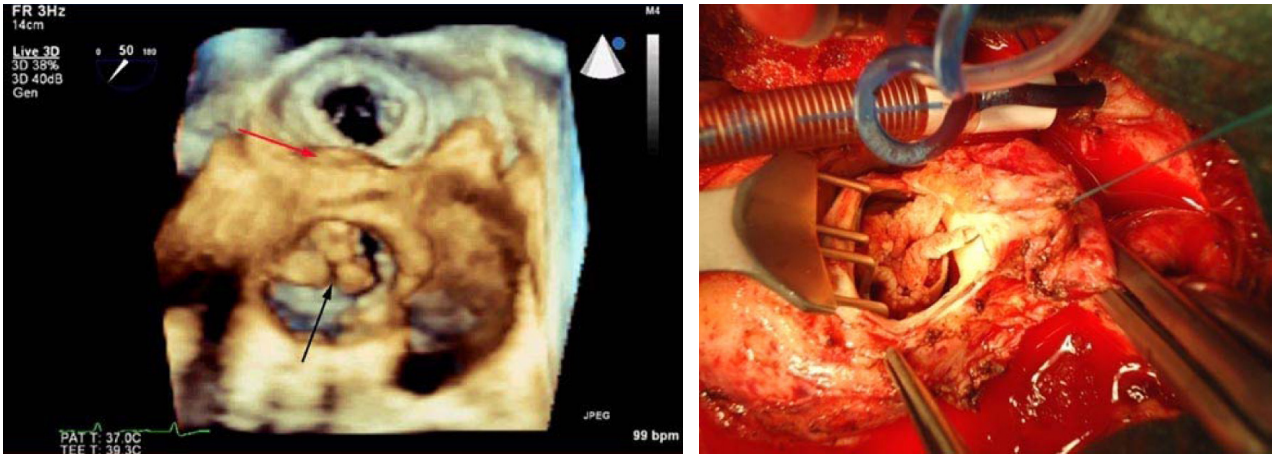


Figura 8: *Esquerda, ETE3D, demonstrando grandes vegetações (seta preta) na prótese biológica aórtica (visão da aorta ascendente). No plano superior, vista do A.E., revelando prótese biológica mitral normal. A seta vermelha mostra abaulamento da fibrosa mitroaórtica por abscesso. Direita, exposição cirúrgica da vegetação demonstrando sua semelhança com a imagem obtida pelo ETE3D.*

of prosthesis at aortic position are parallel to the ultrasonic beam and not perpendicular as in the case of prostheses at mitral position. The images of tricuspid prostheses were considered lower in quality and this is because of its more anterior position and therefore farther from the transducer [14-15].

It is important to mention that the three-dimensional technique will not exclude the two-dimensional study. One of the facilities of using the 3D probe is the capability to switch almost instantaneously between two- and three-dimensional methods which allow rapid comparison of the images. Moreover, it is the two-dimensional study that guides the exam to obtaining three-dimensional images.

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