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IMAGING VIGNETTE

3D TEE With Stereovision for Guidance of the Transcatheter Mitral Valve Repair

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THREE-DIMENSIONAL (3D) TRANSESOPHAGEAL ECHOCARDIOGRAPHY (TEE) has rapidly moved into clinical routine, and is increasingly useful in different percutaneous catheter based interventions, especially the transcatheter mitral valve repair (TMVR) procedure (MitraClip) (1,2). However, in commercially available systems today, the online image presentation is lacking the true depth sense. Depth vision can be obtained in different ways, where the red-green coding and use of red-green glasses is an accessible way to enable depth vision in online 3D TEE images. We illustrate the incremental value of 3D TEE with stereovision in a 75-year-old woman with heart failure and functional mitral regurgitation grade 3/3 who was denied conventional surgery due to comorbidities and therefore underwent TMVR.

The additional value of 3D TEE lies mainly in the possibility of seeing the valve and the device in an anatomical context. The most valuable additional information provided by 3D TEE is the guidance for adjusting the clip perpendicular to the line of coaptation in an "en face" view as illustrated in Figure 1. However, for guiding the clip from the septum towards the mitral valve there is a "blind spot" in echo guidance from the transseptal puncture and moving the device down toward the valve where both 2-dimensional (2D) TEE and "conventional" 3D TEE has shortcomings. Using 2D, it is difficult to keep the tip of the device in the image plane when moving from the septum towards the valve plane. Although 3D permits keeping the device within the image plane throughout this movement, the lack of stereo vision in the conventional image presentation prevents a correct assessment of the distance between structures, due to lack depth coding. Both 2D and 3D thus carry some uncertainty during maneuvering towards the valve and, consequently, some potential risk for complications when not seeing the exact location of the repair device. The novel stereo vision modality with red-blue/cyan color coding (GE Vivid E9, Horten, Norway) makes it possible for the operator using red-blue/cyan glasses to actually see the distance in stereo depth coding between the device and intracardiac structures, i.e., the coumadin ridge, the atrial wall, and the mitral valve. Figures 2 to 5 and the associated Online Videos (Online Videos 1, 2, 3, 4, 5, 6, 7, and 8) illustrate the different phases of maneuvering during the movement in the left atrium from the transseptal puncture towards the mitral valve.

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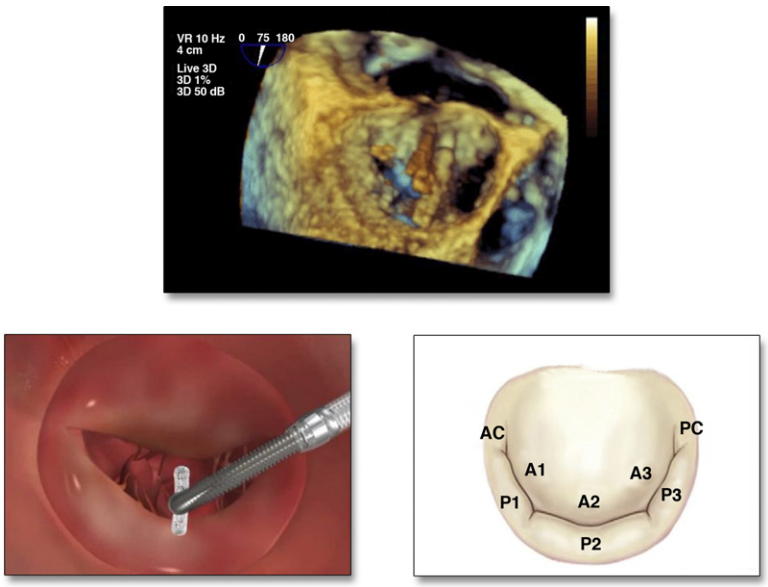

Figure 1. 3D-TEE and the Surgeon's View of the Mitral Valve

A 3-dimensional transesophageal echocardiographic (3D-TEE) view of the mitral valve, called the "en face" or "surgical view," presents the view of the mitral valve similar to that seen by the surgeon from a left atrial perspective. This view is useful for orienting the device perpendicular while approaching the mitral valve line of coaptation with the aim of grasping the free edges of the middle portion of the mitral valve for reducing the degree of mitral regurgitation. Anterior is to the top, where the aortic valve is, and the left atrial appendage is to the left of the figure. A1, A2, and A3 represent the segments 1, 2, and 3 of the anterior mitral valve leaflet; P1, P2, and P3 represent the segments 1, 2, and 3 of the posterior mitral valve leaflet. AC = anterolateral or lateral commissure; PC = posteromedial or medial commissure.

The most important potential gain of using stereovision is: 1) increased safety, due to the continuous visualization of the device which enables a safer translation of the device from the atrial septum to the correct positioning above the mitral valve due to the visualization of the distance to intracardiac structures, making it easier for the operator to avoid unnecessary contact with the LA wall; and 2) a shorter procedural time due to the possibility of continuous visualization for the operator without waiting for the repositioning of image planes and/or changing imaging modalities between 2D and 3D images. However, the limitation of the present approach is the necessity for the operator and TEE examiner to use red-blue/cyan glasses. An improvement to the existing system could be a 3D screen to overcome this inconvenience for the operator.

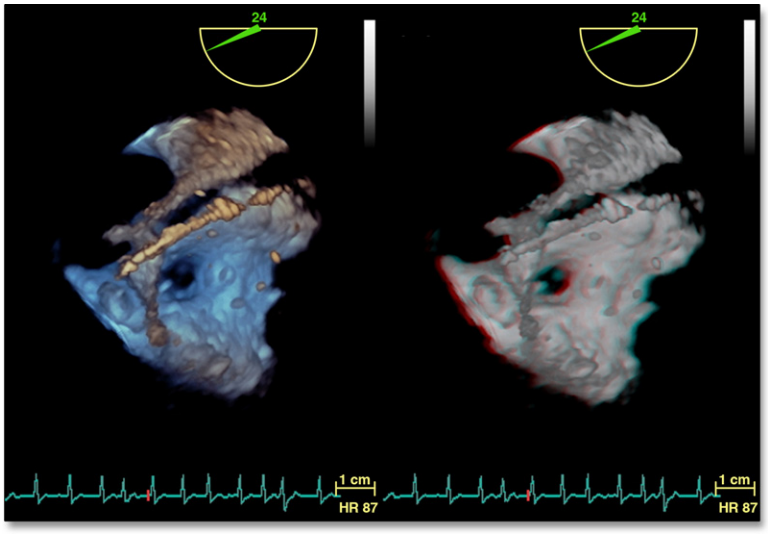

Figure 2. Maneuvering of Guide Catheter Under Stereovision

The guide is maneuvered into the left upper pulmonary vein (the **left** and **right panels** refer to the same image presented side by side for comparison with conventional display and stereovision, respectively). The guide is seen crossing obliquely along the left atrium with the tip of the guide wire seen on the left side. The true distance between the guide wire and left atrial wall, the coumadin ridge (under the guide tip in the image and Online Video), the left atrium appendix (seen as a drop-out beneath the ridge) and the device can be appreciated using red-blue/cyan glasses. Also refer to Online Videos 1 and 2, which correspond to the **left** and **right panels**, respectively.

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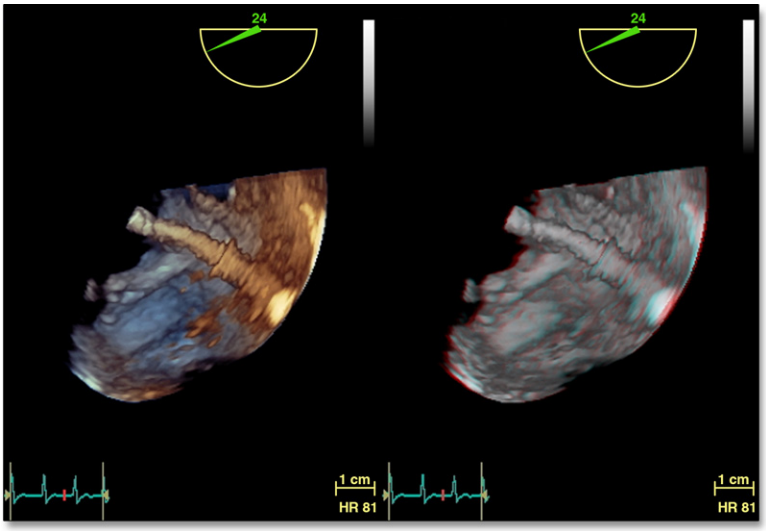

Figure 3. Maneuvering of Clip Into Pulmonary Vein

The Clip is maneuvered into the left upper pulmonary vein using stereovision (the **left** and **right panels** refer to the same image presented side by side for comparison with conventional display and stereovision, respectively). The device is seen crossing obliquely along the left atrium with the tip of the device seen on the left side. The true distance between the coumadin ridge below and the device can be better appreciated using red-blue/cyan glasses. Also refer to Online Videos 3 and 4, which correspond to the **left** and **right panels**, respectively.

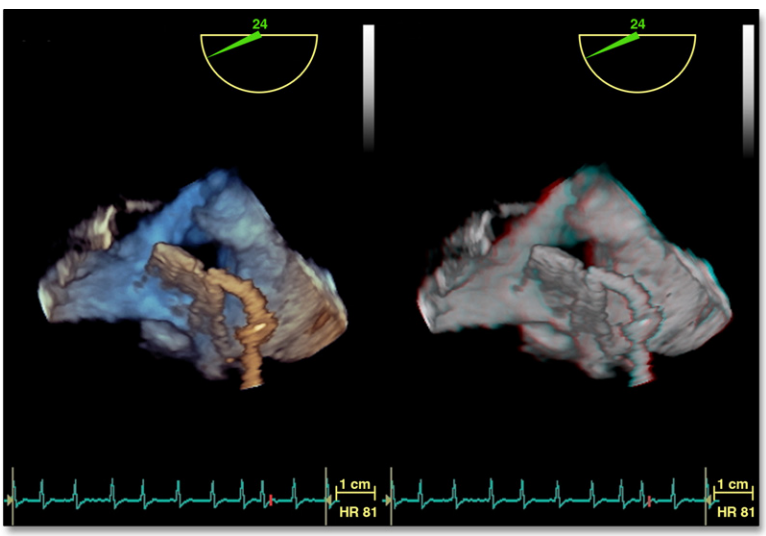

Figure 4. Maneuvering of Clip Towards Mitral Valve

The clip is maneuvered from the ridge down towards the mitral valve. The LA appendage is seen as a circular black hole in the background (the **left** and **right panels** refer to the same image presented side by side for comparison with conventional display and stereovision, respectively). The distance to the coumadin ridge and other intra-atrial structures **(right)** is better appreciated under stereovision, and helps avoid unnecessary contact between the clip and intra-atrial structures. Also refer to Online Videos 5 and 6, which correspond to the **left** and **right panels**, respectively. Abbreviation as in Figure 2.

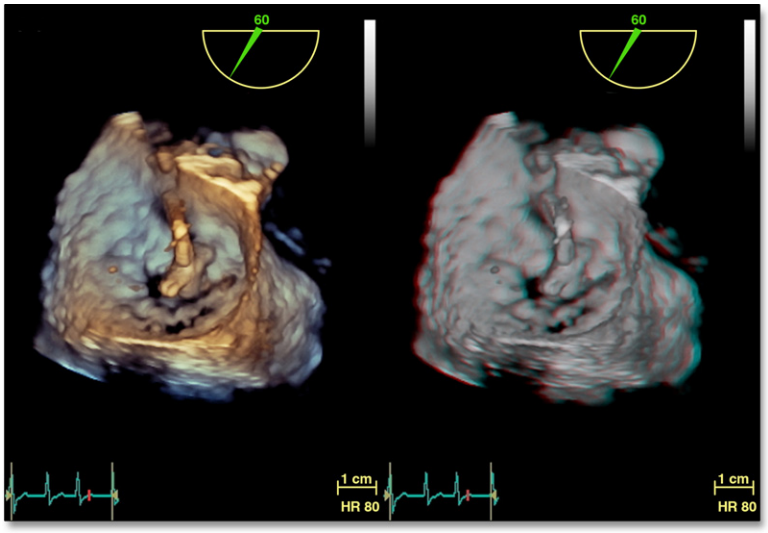

Figure 5. Positioning of the Clip Across the Mitral Valve

The clip is positioned above the valve perpendicular to the line of coaptation and opened using 3D TEE. Using stereovision, the angulation error in the anterior-posterior aspect is revealed: using red-blue/cyan glasses the posterior clip arm clearly can be demonstrated to be much higher above the posterior leaflet in comparison to the anterior arm, which actually is in contact with the anterior leaflet. Using stereovision, this angulation error is then corrected accordingly. Also refer to Online Videos 7 and 8, which correspond to the **left** and **right panels**, respectively. Abbreviation as in Figure 1.

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