Three-dimensional echocardiography-guided repair of severe paravalvular regurgitation in a bioprosthetic and mechanical mitral valve

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Severe paravalvular mitral regurgitation is a rare but important complication of mitral valve replacement, often producing symptoms associated with refractory heart failure or haemolysis. Explantation and replacement of the prosthesis are required in some patients but may not be possible in patients with high risk of morbidity or mortality with re-operation. We present two patients with symptomatic paravalvular mitral regurgitation who were deemed too high risk for re-operation because of multiple previous sternotomies and comorbidities. Percutaneous three-dimensional (3D) echocardiography-guided repair with septal occluder devices was undertaken in the first case of a paravalvular defect adjacent to a mitral bioprosthesis and in the second case adjacent to a mechanical mitral prosthesis. Both cases illustrate the advantage 3D echocardiography provides by allowing en-face views of the paravalvular leak and unique views of the catheter and device placement. The second case further demonstrates the novel use of full volume colour to define the extent of the regurgitant jet and provides information critical to device sizing and placement.

KEYWORDS
Paravalvular regurgitation; Three-dimensional echocardiography

We present two cases of severe paravalvular mitral regurgitation referred for percutaneous closure of the defect. In both cases, repeat sternotomy was considered significantly high risk. Two-dimensional and three-dimensional (3D) transesophageal echocardiography (TEE) was used to help guide the defect closures. The first case demonstrates the use of real-time 3D (RT3D) TEE imaging of a mitral bioprosthesis, and the second case highlights the use of full volume colour 3D TEE in a mechanical mitral valve.

An 80-year-old male underwent coronary artery bypass graft operation for three-vessel coronary artery disease. Immediately following the operation, he developed severe mitral regurgitation and required a repeat sternotomy for bovine mitral valve replacement (MVR). Five years later, the patient presented with recurrent symptoms of congestive heart failure (CHF). Both two-dimensional transthoracic echocardiography (TTE) and TEE showed a normally seated bioprosthetic valve with preserved function, mild central mitral regurgitation, and severe anterolateral paravalvular regurgitation. Normal right and left ventricular size and function were noted. The severe mitral paravalvular regurgitation was the sole explanation for his repeated bouts of pulmonary oedema. Owing to the high-risk nature of a repeat sternotomy in this patient, he was referred for percutaneous closure of the mitral paravalvular regurgitation.

Percutaneous closure was performed under fluoroscopic and TEE guidance. Two-dimensional TEE imaging with colour (Figure 1A) demonstrated a normally seated mitral bioprosthetic valve with a severe anterolaterally directed jet of paravalvular regurgitation. A matrix array 3D TEE probe (IE33, Philips Ultrasound, Andover, MA, USA) was used to acquire RT3D imaging. These images allowed visualization of the mitral annulus en-face from the left atrium and demonstrated a crescent-shaped defect through which the guidewire was passed (Figure 1B). An Amplatzer Duct Occluder (12/10 mm, AGA Medical Corporation) was deployed across the defect. Adequate positioning without impingement of the adjacent mitral bioprosthesis was ensured by 3D echocardiographic guidance (Figure 2). Following deployment of the device, however, significant

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paravalvular regurgitation remained. 3D imaging enabled further localization of the regurgitation and guided the placement of a second Amplatzer Duct Occluder (10/8 mm) just posterior to the first device (Figure 3A). Following release of the two devices, a significant reduction of the mitral paravalvular regurgitation was noted by 2D TEE (Figure 3B). Full volume colour 3D TEE demonstrated a moderate amount of residual paravalvular regurgitation despite device placement (Figure 5B). During this time, consideration was given to exchanging the device with a larger duct occluder however given the extent of the defect visualized by 3D TEE, placement of a second device appeared to be the best option. A second Amplatzer Duct Occluder device (10/8 mm) was delivered and placed adjacent to the first under TEE guidance (Figure 6A). Following release of both devices, colour 3D TEE demonstrated significant reduction of paravalvular mitral regurgitation (Figure 6B). The patient tolerated the procedure well and a TTE conducted 2 days later confirmed reduction of her paravalvular regurgitation from severe to mild.

The second case is a 68-year-old woman with a history of rheumatic mitral stenosis who initially underwent valve replacement with a bovine pericardial prosthesis. The procedure was complicated by malaposition of leaflets requiring repeat sternotomy and replacement of her bioprosthesis with a tilting disc bileaflet mechanical mitral valve (St Jude Medical, Inc., St Paul, MN, USA). The patient developed further multiple complications including acute renal failure and ischaemic bowel. One week later, she developed symptoms of CHF attributed to severe paravalvular mitral regurgitation diagnosed by TTE and TEE. She was reviewed by the Cardiac Surgery Service who felt she was too high risk for a third cardiac operation. The patient was referred for percutaneous repair of her paravalvular mitral regurgitation because of her ongoing symptoms of heart failure.

The patient proceeded to the cardiac catheterization laboratory for closure of paravalvular regurgitation under TEE and fluoroscopic guidance. By 2D TEE, it appeared that the paravalvular regurgitation was originating from a defect which was posteromedially located along the prosthetic annulus. Live 3D TEE and simultaneous full volume 3D TEE with colour clearly showed the position of the defect to, in fact, be along the posterior aspect of the mitral prosthesis (Figure 4A and B). From the 3D TEE image, it appeared that the defect was a narrow channel along the annulus. The colour 3D image was critical in this case, demonstrating the true extent of the defect resulting in a wide high velocity jet of paravalvular regurgitation (Figure 4B). Under TEE guidance, an Amplatzer Duct Occluder device (10/8 mm) was delivered across the paravalvular defect (Figure 5A). Full volume colour 3D TEE demonstrated a moderate amount of residual paravalvular regurgitation despite device placement (Figure 5B). During this time, consideration was given to exchanging the device with a larger duct occluder however given the extent of the defect visualized by 3D TEE, placement of a second device appeared to be the best option. A second Amplatzer Duct Occluder device (10/8 mm) was delivered and placed adjacent to the first under TEE guidance (Figure 6A). Following release of both devices, colour 3D TEE demonstrated significant reduction of paravalvular mitral regurgitation (Figure 6B). The patient tolerated the procedure well and a TTE conducted 2 days later confirmed reduction of her paravalvular regurgitation from severe to mild.

Discussion
Clinically significant paravalvular mitral regurgitation is a rare but important complication of MVR, in some cases requiring explantation and replacement to resolve symptoms of associated heart failure or haemolysis. In one study, a 3.8%/year event rate of para-prosthetic valve leak was reported in patients receiving a St Jude mechanical valve in the mitral position. Because of the morbidity and

Figure 1  (A) Two-dimensional TEE at the mid-esophageal level of mitral bioprosthesis demonstrating the severe paravalvular leak (arrow). There is also a small jet of central mitral regurgitation. (B) Real-time live 3D TEE image of the mitral annulus and bioprosthesis en-face from the left atrium. The paravalvular defect is crescent-shaped. The tip of the guidewire, passed retrogradely from the left ventricle, is seen crossing the defect (arrow).

Figure 2  An Amplatzer Duct Occluder device (arrowhead) has been introduced and deployed across the defect without impingement of the adjacent mitral bioprosthesis. The second guidewire is seen posterior to the device (arrow). AA, left atrial appendage.
Figure 3  (A) Two-dimensional TEE image with colour of mitral bioprosthesis demonstrating a significant reduction in the paravalvular leak after placement of two Amplatzer occluder devices. The degree of paravalvular regurgitation is significantly reduced after device placement (compare with Figure 1A, prior to device placement). (B) Real-time 3D TEE assisted in the placement of this second Amplatzer Duct Occluder device (10/8 mm) deployed posterior to the first device occluding the majority of the paravalvular defect.

Figure 4  (A) Real-time live 3D TEE image of the mitral annulus and mechanical prosthesis en-face from the left atrium. The paravalvular defect is along the posterior aspect of the prosthesis ring (arrow) directly opposite to the aorta (Ao). Its location was confirmed by the full volume colour 3D image obtained showing a large degree of paravalvular regurgitation through this defect during systole [arrow head in (B)].

Figure 5  (A) Real-time live 3D TEE image of the mitral annulus and mechanical prosthesis en-face from the left atrium after introduction of the first Amplatzer occluder device (arrow) through the defect. The tip of the guidewire used for deployment is also visualized (arrowhead). (B) Full volume colour 3D TEE shows reduction of the paravalvular regurgitation following introduction of the device (arrow), however the degree of leak remains significant (compare with Figure 4B).
mortality associated with repeat sternotomy, percutaneous closure of para-prosthetic leaks has been viewed as an attractive alternative to cardiac surgery in patients at high risk for re-operation. Currently, there is no percutaneous device dedicated to the closure of paravalvular regurgitant leaks, but operators have extrapolated the use of other percutaneous devices to this problem. Septal and duct occluder devices are emerging as the most commonly used percutaneous devices for paravalvular leak closure.\(^2\)

Two-dimensional TEE has become an important tool in guiding the placement of guidewires and devices in the cardiac catheterization laboratory. RT3D TEE surpasses the limits of 2D TEE and is emerging as a new and exciting tool in its ability to detect the position of a device or catheter relative to its surroundings.\(^3\) We have demonstrated the utility of RT3D TEE to guide percutaneous closure of a paravalvular leak. RT3D TEE allows en-face views of the paravalvular leak and provides unique views of the catheter and device placement. These clearly define the relationship between the defect and the device which cannot be attained as easily by any other imaging techniques. Our second case demonstrated the novel use of full volume colour to define the extent of the regurgitant jet and provides information critical to device sizing and placement. In the past, repair of paravalvular regurgitation relied solely on the image obtained from the 2D, colour Doppler, and fluoroscopic images. Without the en-face view, which can only be obtained using 3D TEE, the true shape and size of the defect, which is often irregular or crescent shaped, cannot be appreciated. This additional information allows the operator to determine whether the device has adequately encompassed a large defect or an additional device is required. 3D views also provide excellent detail of the position of the device with respect to the prosthesis thereby reducing the risk of inadequate device deployment or impingement of the prosthesis. These views are especially vital in a scenario where a large device or more than one device is required for repair. Thus the advantages 3D TEE over 2D TEE for paravalvular leak repair include: the rapid assessment of the size and shape of the defect, the assessment of the extent of the regurgitation with the use of 3D colour Doppler, and more accurate positioning of devices in relation to surrounding structures.

The above cases highlight the need for close cooperation and constant communication between the echocardiographer and the interventionalist to simultaneously integrate 3D, 2D TEE and fluoroscopic imaging in such technically difficult cases. With the advent of full volume colour and RT3D TEE, the ability to guide percutaneous closures in ‘live’ fashion has become a reality.

Conflict of interest: none declared.

References