Post-mitral replacement issues: When echo matters

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Introduction

Mitral valve (MV) disease is common among patients presenting for cardiac surgery, whether as an isolated lesion that presents for surgical correction, or as an incidental finding that requires intraoperative consideration. Data from the Society of Thoracic Surgeons (USA), showed that from 2000 to 2007, there were over 200,000 operations performed in the United States that involved the MV, of which included 58,370 isolated MV procedures (Figure 1). While the indications for isolated MV surgery were not elucidated in this study, historical data suggests that valve replacement is more common for stenotic lesions, while regurgitation is the dominant indication for valve repair. In the STS study, patients undergoing MV replacement were more likely to be older, female and symptomatic with a worse functional class. While the incidence of mitral stenosis declined among the MV surgery cases from 30% in 2000 to 14% in 2007 there was a concurrent decrease in the percentage of valves replaced versus repaired over this period (from 58% to 39%). Interestingly, there has been a significant increase in the use of bioprostheses for MV replacement (32% in 2000 to 63% in 2007) in contrast to mechanical valves in the US.

Much of this change in MV surgery has been the result of improved surgical techniques, availability of superior valve prostheses and a decrease in complications that has encouraged physicians to extend the benefits of MV surgery to more patients with MV disease. It is important to consider that a decrease in complications has been made possible by a vast improvement in intraoperative imaging for MV surgery. Intraoperative transesophageal echocardiography (TEE) has become indispensable during MV surgery since it can provide immediate feedback to surgeons about the success of the surgery, or failure requiring prompt correction.
The intraoperative patient

The guidelines for imaging prosthetic valves from the American Society of Echocardiography (ASE) includes assessment of mitral prostheses after implantation. While the guidelines include imaging using transthoracic echocardiography or TEE, there are special considerations when using TEE in the intraoperative environment.

The intraoperative environment presents unique challenges for the echocardiographer. The pre-cardiopulmonary bypass period is usually associated with reduced preload and myocardial depression in the anesthetized patient. Additionally, the open chest, pericardial cavity and positive pressure ventilation also influence preload. The post-bypass phase, is a more labile period during which loading conditions change often, inotropic and chronotropic drugs are used liberally, and the heart is frequently electrically paced. All of these factors must be considered during TEE assessment of prosthetic valves in the mitral position.

What to look for?

The potential for suboptimal results of surgery should not be underestimated. The primary issues to consider are: (a) prosthetic valve seating, (b) prosthesis leaflet motion, and (c) impact on adjacent structures.

Valve seating

An inappropriately seated valve is the most significant problem requiring prompt return to cardiopulmonary bypass and surgical correction. Defective seating may present as a dehiscence or as a paravalvular leak. Dehiscence is fortunately rare in the operating room and is more common in a prosthesis affected by endocarditis. Paravalvular leaks on the other hand, are more common. These should be distinguished from ‘washing jets’ that are designed in prosthetic valves to avoid areas of stagnation of flow in the crevices of the valve that could promote thrombus formation. Almost all types of valves have their ‘signature’ washing jets. In mechanical valves, the washing jets are (i) located between the occluder and valve ring, (ii) extend less than 2.5 cm in length, and (iii) are usually less than five in number (Figure 2). Stented biologic valves usually have a small central washing jet.

Paravalvular leaks on the other hand, are located outside the sewing ring and vary in severity. Small leaks usually resolve after some period after bypass and may
be followed up for change in severity. Afterload is an important variable to consider when managing any regurgitant lesions, including paravalvular leaks. More significant leaks are problematic and need to be fixed immediately (Figure 3). However, if a return to bypass is not feasible or considered a high risk, closure of the leak may be considered using percutaneous closure devices (Figure 4).

Prosthesis leaflet motion

Leaflets of the prosthesis can be affected by several factors that restrict their motion. Consideration is given to two primary issues: (a) what is restricting leaflet motion, and (b) is the leaflet stuck in the closed or open position. Examples of factors restricting leaflet motion include (i) suture material that can prevent adequate motion, (ii) mechanical obstruction from a thrombus, pannus, or surgically excised tissue, or (iii) a primary defect in valve construction. The last issue is rare as valve leaflet motion is usually checked prior to surgical insertion. If the leaflets are stuck in the closed position, there will be an obstruction to flow in diastole, leading to high gradients and an effective mitral stenosis. In contrast, if the leaflets are stuck in the open position, there is inadequate closure in systole, leading to severe mitral regurgitation. A careful assessment of motion of all leaflets is therefore essential, in order to identify any abnormality that requires immediate surgical attention.

Impact on adjacent structures

The mitral and aortic valves are separated by an intervalvular fibrosa that can be impacted by either surgery on either valve, or infective processes that affect these valves. While infective processes can result in delayed complications, technically challenging surgery on the MV can result in inadvertent injury to
the fibrosa and affect coaptation of the aortic valve cusps leading to aortic regurgitation.

How to look for these complications?

Intraoperative TEE is indispensable in this setting and several modalities are available and all should be used to their potential. These include (i) two-dimensional (2D) imaging, (ii) color flow Doppler, (iii) spectral Doppler, (iv) three-dimensional (3D) imaging including color 3D echocardiography.

2D Echocardiography

The principal views used to assess the MV should be used to assess the prosthetic valves as well. Prosthetic devices produce a variety of ultrasound artifacts due to their echo-reflective properties. The most obvious among these are acoustic shadows produced in the far field (Figure 5). These shadows will preclude imaging any structure distal to the valve. In the mid-esophageal long axis view, shadow artifacts from the mitral sewing ring may obscure the left ventricular outflow tract thereby making assessment of aortic regurgitation difficult (Figure 6). One method to overcome this limitation is to make this assessment in the deep transgastric long axis view. Excessive motion of the sewing ring could suggest a valve dehiscence. Stuck leaflets are best assessed using 2D or 3D imaging, while their hemodynamic effects can be assessed with Doppler imaging.

Color flow Doppler (CFD)

Intraoperatively, CFD is invaluable in detecting turbulent flow across a defective valve. While some turbulent flow is expected from all prosthetic valves, CFD may detect abnormally located flows, as in valve dehiscence or paravalvular leaks (Figure 3), or abnormally timed flow, as in mitral regurgitation.

Spectral Doppler

Spectral Doppler modalities (pulsed wave and continuous wave) are used to assess transvalvular flow patterns. Flows across prosthetic valves in the mitral position are usually higher than 1 m/s and therefore, are best assessed using continuous wave Doppler (CWD). The simplified Bernoulli equation (pressure gradient = four times the square of the peak velocity) is
used to calculate transvalvular gradients. Apart from the actual gradient, the contour of the slope also provides information on prosthesis function. A prolonged pressure half-time (greater than 120 msec) should alert the echocardiographer to the potential for valve dysfunction.²

3D Echocardiography

Among the various applications of 3D echocardiography, perhaps one of the most useful is the assessment of prosthetic valves in the mitral position. The ability of 3D TEE to image the mitral prosthesis in the en-face view from the left atrial perspective allows visualization of the prosthesis without interference from artifacts. Additionally, real-time imaging enables assessment of valve ring seating⁷ and motion of leaflets of a mechanical or biologic valve (Figure 4). The addition of color flow Doppler to full volume 3D imaging adds the ability to determine location of abnormal jets. This feature can be valuable to surgeons and interventional cardiologists for helping guide placement of percutaneous closure devices (Figure 4) or surgical closure of the leak.

Summary

Despite the declining incidence of mitral valve replacement, it remains a commonly performed operation. Intraoperative TEE provides the opportunity to assess the immediate results of surgery and allows corrective action should an abnormality be detected. It should be recognized, however, that there are several caveats that must be borne in mind in the intraoperative environment when assessing prosthetic valves. All modalities should be used since each provides complementary information for a complete assessment.

References


