Chapter 5
Mitral Valve Surgery

Prakash P. Punjabi and K.M. John Chan

Introduction

In Western developed countries, mitral valve surgery usually involves degenerative or Barlow's valve disease, causing mitral regurgitation; the mitral valve can usually be repaired successfully. However, in developing countries, rheumatic mitral valve disease, causing mitral stenosis or regurgitation or both, is still common and repairing these valves can be more challenging.

Pre operative transoesophageal assessment of the mitral valve is essential. This is usually performed after the induction of anaesthesia and before the commencement of cardiopulmonary bypass. In most cases, this would confirm the findings of transthoracic echo, but new changes may sometimes be identified.

Setup

Optimal setup is very important in mitral valve surgery to maximise exposure and visualisation of the mitral valve. The pericardium should be lifted up on the right side and left free on the left side. This has the effect of rotating the heart upwards and towards the left, bringing the mitral valve into view when the left atrium is opened. A Cosgrove mitral retractor is used. Further visualisation of the mitral valve is

P.P. Punjabi, *Essentials of Operative Cardiac Surgery*,
DOI 10.1007/978-3-319-09906-4_5,

enabled by incising the pericardium on top of the SVC and perpendicular to it. This allows retraction of the heart upwards when the retractors are placed.

The aorta, SVC and IVC are cannulated. An antegrade cardioplegia and a retrograde cardioplegia cannula are inserted. Tapes may be passed around the SVC and IVC. Cardiopulmonary bypass is commenced. A cross-clamp is applied. Cardioplegia is delivered antegradely to start with and then every 20 min retrogradely through a self-inflating balloon catheter while suction is applied to the aortic root.

Excision of Left Atrial Appendage

If the patient is in atrial fibrillation and ablation surgery is contemplated, the left atrial appendage is excised at this stage. The heart is lifted up, exposing the left atrial appendage. This is excised with scissors. It is then oversewn with 4/0 Prolene leaving 5–10 mm above the base of the left atrial appendage. Other methods have also been used, such as stapling the left atrial appendage, ligating it from outside, either with a simple silk tie or by placing a purse string suture, or ligating it from inside by placing a purse string around its base and tightening this. However, these other methods have a higher failure rate compared to excision and suture.

Another important step, especially if ablation surgery is to be performed, is to separate out the back of the heart at the oblique sinus from the oesophagus to minimise trauma to it from the energy waves. While the heart is lifted up with the left hand, the fingers of the right hand are placed onto the back of the heart at the oblique sinus to separate it from the oesophagus. This space will fill with blood or water, thus, forming an insulating layer.

Exposing the Mitral Valve

The venous cannulation lines are placed over on the left side, supported by the mitral retractor.

Left Atriotomy

Our preferred approach to the mitral valve is through a left atriotomy. An incision is made midway between the inter-atrial septum and the origin of the right superior pulmonary vein and extended inferiorly along the left atrium towards the left inferior pulmonary vein, ending a few millimetres inferior to it. The incision is then extended superiorly a few millimetres beyond the end of the right superior pulmonary vein onto the roof of the left atrium. This incision is facilitated by the previous dissection on the SVC. Two small mitral retractors are then inserted and lifted up together, opening up the left atrium and exposing the mitral valve.

We have found that this approach to the mitral valve, together with the steps described earlier which free up the heart and allow its rotation, provides excellent exposure to the mitral valve. To improve visualisation of the mitral valve further, the incision can be extended superiorly and medially underneath the SVC and onto the roof of the left atrium.

Transseptal Approach

If surgery to the right side of the heart is also to be performed, e.g. to the tricuspid valve, the transseptal approach can be used. A vertical incision is made in the right atrium from the right atrial appendage to the inter-atrial septum. The septum is then incised at the foramen ovale.

Alternatively, an incision is made in the right atrium parallel to the inter-atrial groove about 2 cm above it. The incision is extended superiorly to the junction with the left atrium. The septum is then incised horizontally at the lower edge of the foramen ovale. It is extended superiorly to join the right atrial incision, continuing onto the roof of the left atrium. The retractor is then placed on the septum or a stay suture is applied to expose the mitral valve.

Assessing the Mitral Valve

A systematic analysis of the mitral valve is performed. The mitral valve is first inspected. Note is made of any excessive leaflet tissue, leaflet perforations, ruptured chordae or ruptured papillary muscles. The lesion is then determined using a pair of nerve hooks (Fig. 5.1). A reference point, such as P1 or the commissures, is chosen. Each part of the mitral valve leaflet is lifted up in turn and compared to the reference point to determine if there is leaflet prolapse or restriction. A variety of techniques can be used to repair the mitral valve, depending on the lesion.

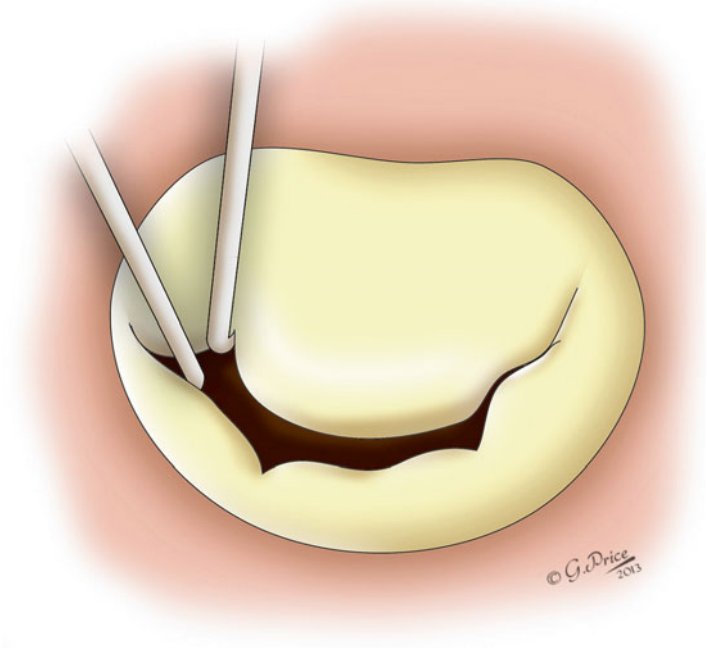

FIGURE 5.1 Assessing the mitral valve using a pair of nerve hooks (Printed with permission © Gemma Price)

Posterior Leaflet Prolapse

Prolapse of the posterior leaflet and, in particular, P2 prolapse is most easily repaired (Fig. 5.2). It may be due to excessive leaflet tissue as in Barlow's disease, chordal or papillary muscle rupture or both. The aim of the repair is to restore the surface of coaptation with the anterior leaflet. This is usually achieved by excision of the prolapsing posterior leaflet.

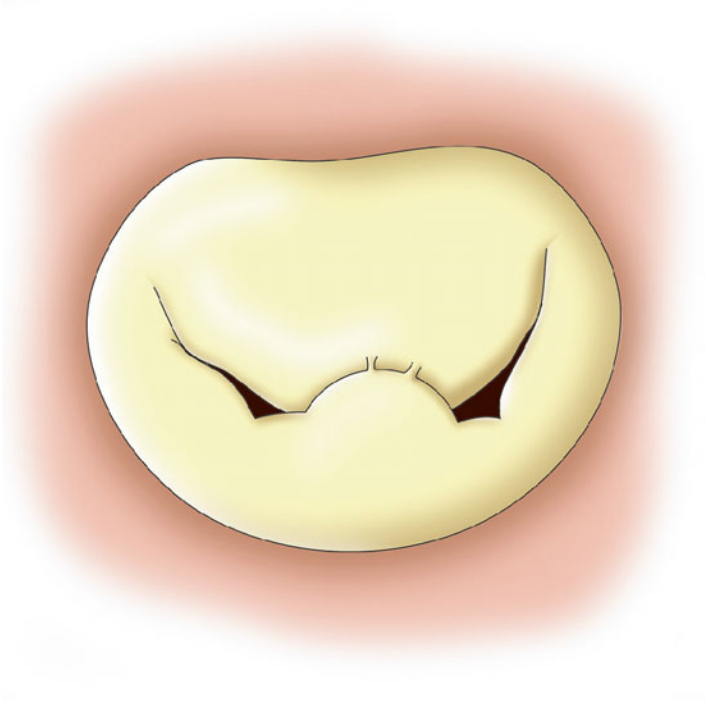

FIGURE 5.2 Prolapse of P2 due to ruptured chordae (Printed with permission © Gemma Price)

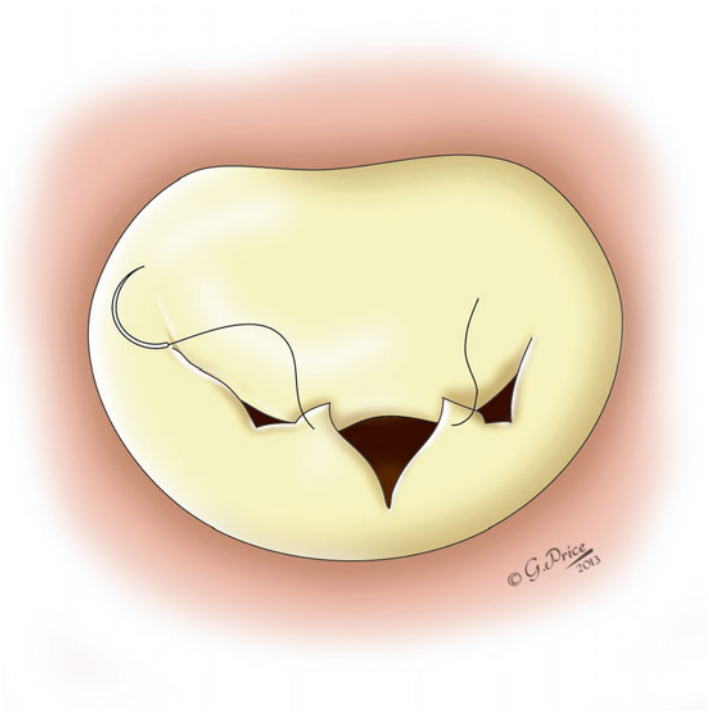

FIGURE 5.3 Triangular resection of P2 prolapse (Printed with permission © Gemma Price)

Triangular Resection

The prolapsed leaflet can be excised in a triangular fashion down to the annulus (Fig. 5.3). The leaflets are then re-approximated using interrupted mattress 4/0 Prolene sutures.

"P" Repair

Our preferred method of posterior leaflet repair is by excising the prolapsing leaflet in a trapezoidal fashion down to the annulus (Fig. 5.4). The remaining leaflets either side of

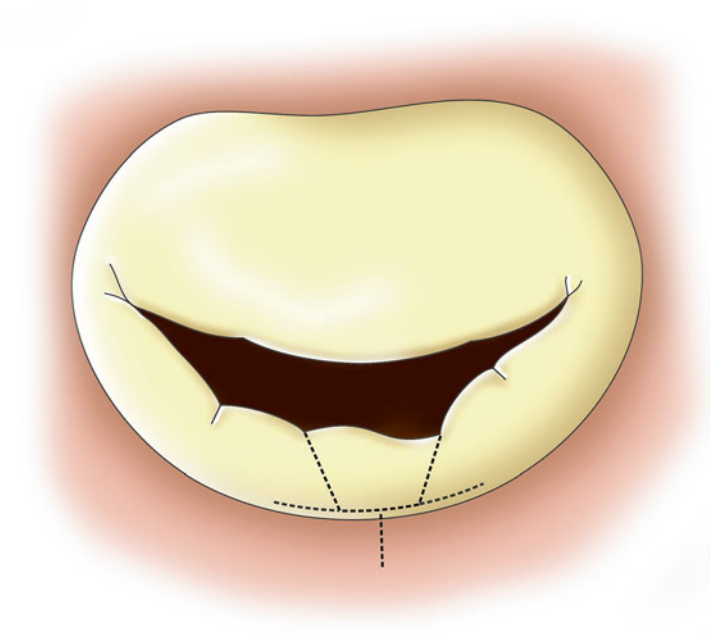

FIGURE 5.4 "P" repair of the posterior leaflet. *Dotted lines* indicate the line of resection (Printed with permission © Gemma Price)

this is incised a few millimetres. This reduces the tension on the annulus and, thus, on the approximated leaflets. It also avoids excessive folding of the annulus when it is approximated and, so, could prevent kinking of the circumflex coronary artery as it passes below the mitral annulus. This is especially important in elderly patients with non-calcified coronary arteries.

The exposed annulus is then approximated using interrupted pledgeted 2/0 Ethibond mattress sutures, starting from the mid-point of the annulus, which needs to be re-approximated. Two sutures are usually needed. The leaflets are then re-approximated using interrupted mattress 4/0 Prolene sutures (Fig. 5.5).

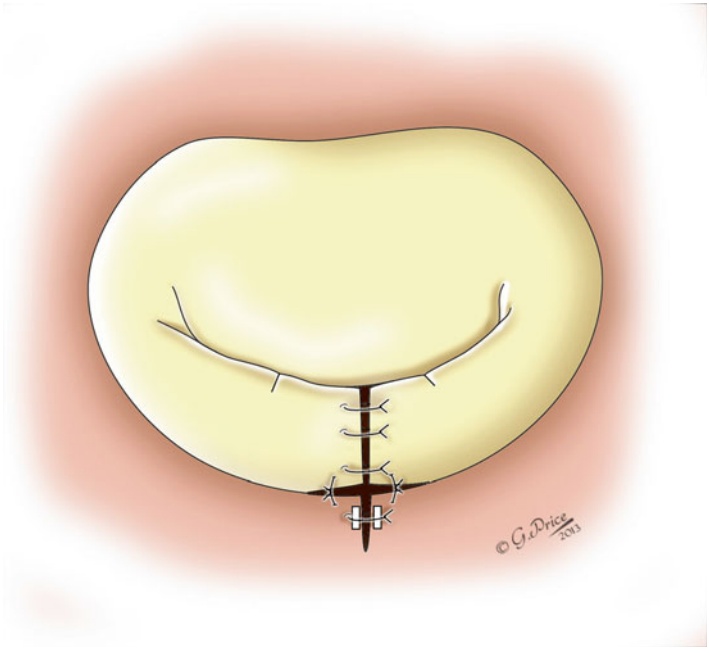

FIGURE 5.5 Completed "P" repair of the posterior leaflet (Printed with permission © Gemma Price)

We have found that the majority of posterior leaflet prolapses can be successfully repaired using this technique. It is easy to perform and is reproducible.

Quadrangular Resection and Sliding Plasty

The prolapsing leaflet can also be excised in a quadrangular fashion (Fig. 5.6). This can be combined with a sliding plasty, especially if there is excessive leaflet tissue which needs to be reduced in height, e.g. in Barlow's disease.

Artificial Neochordae

Artificial neochordae can also be used, especially if there is a large portion of the posterior leaflet prolapsing. The principle

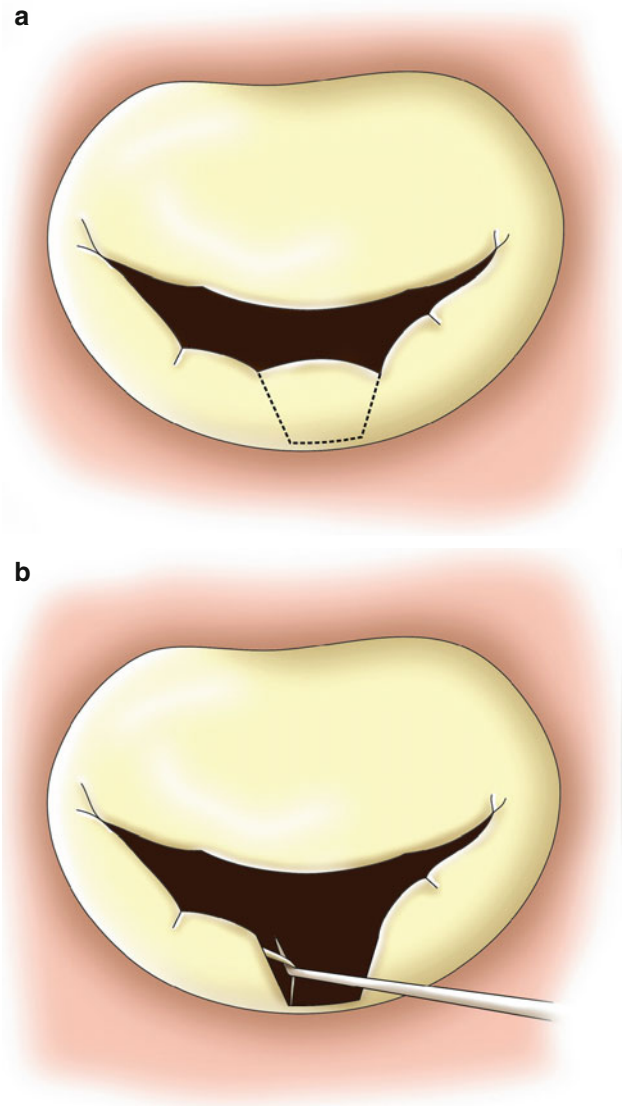

FIGURE 5.6 (**a**) Quadrangular resection of posterior leaflet prolapse. *Dotted lines* indicate the line of resection (Printed with permission © Gemma Price) (**b**) Quadrangular resection of posterior leaflet prolapse (Printed with permission © Gemma Price) (**c**) Quadrangular resection of posterior leaflet prolapse (Printed with permission © Gemma Price)

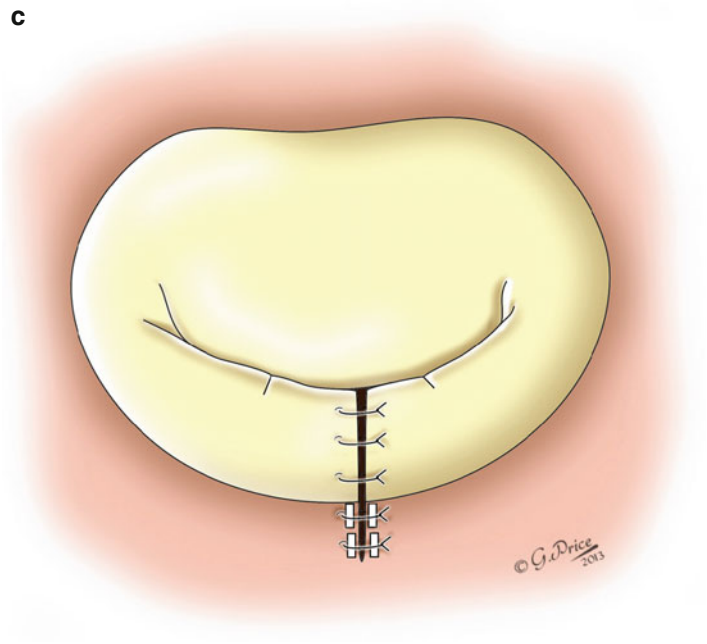

FIGURE 5.6 (continued)

and technique for this are described in the section below on anterior leaflet prolapse. The application of this technique to posterior leaflet prolapse, the so called "respect do not resect" principle, has recently gained popularity.

Anterior Leaflet Prolapse

Prolapse of the anterior leaflet is more challenging. Our preferred method of repairing this lesion is with the use of artificial neochordae. This is usually combined with triangular resection in the case of A2 prolapse. The aim, again, is to restore the surface of coaptation of the prolapsing anterior leaflet with the posterior leaflet. A 5/0 goretex is usually used with Gore-Tex pledgets.

If repair of both the anterior and posterior leaflets are necessary, it is advisable to place the neochordae on the papillary muscles for the anterior leaflet repair before complete repair of the posterior leaflet, as the visualisation is much improved.

Artificial Neochordae

The prolapsing leaflet is determined and the papillary muscle to which the neochordae should be attached is chosen. The pledgeted neochorda is placed through the fibrous tip of the papillary muscle and passed in the direction to which the leaflet is prolapsing. The neochorda is not tied onto the papillary muscle. This ensures equal distribution of tension and length in the two neochordae which are attached to the leaflet from each papillary muscle. The neochorda is passed through the edge of the prolapsing leaflet from below upwards. A pledget is passed through this. The stitch is the passed round the edge of the mitral leaflet and through it and the pledget again so that the length of the neochorda is fairly fixed but can still be adjusted. The length of the neochorda is estimated by approximating the free edge of the anterior leaflet onto the anterior annulus [1].

If repair of the posterior leaflet is necessary, it is performed at this stage. The final length of the artificial neochorda is determined by approximating the free edge of the anterior and posterior leaflets using nerve hooks, ensuring that they both meet in the same place.

We have been able to repair most cases of anterior leaflet prolapse using the above technique. It is an easy technique, is reproducible and has excellent durability.

Use of Native Chords

Other techniques for anterior leaflet repair have been described, such as papillary muscle repositioning and chordal transposition. The principle in these other repair techniques is similar to that using artificial neochordae, but the native

chords are used instead of artificial neochorda. Although good results have been reported using these techniques, there is some concern with the use of the native chords, especially in degenerative disease, as these chords are invariably involved in the disease process.

Chordal Transposition

The chords are transposed, either from a normal posterior leaflet (the flip-over technique) or from an adjacent anterior leaflet.

Papillary Muscle Repositioning

In papillary muscle repositioning, the papillary muscle supporting the chords of the prolapsing anterior leaflet is cut vertically. The tip of the cut papillary muscle to which the chords are attached is then attached lower down to the same papillary muscle. The distance moved is equivalent to the prolapsed height of the anterior leaflet, thus, correcting the prolapse. The amount of correction using this technique is limited to the length of the papillary muscle which can be repositioned.

Edge to Edge Repair (Alfieri Stitch)

The principle in this technique is to stitch the prolapsed anterior leaflet onto a normal posterior leaflet opposite it. It can be used on its own in highly selected cases and is sometimes used in combination with any of the techniques described above.

Annuloplasty

We routinely perform an annuloplasty following all mitral repairs. The annuloplasty serves to support the annulus and prevents subsequent dilatation of the annulus. In functional mitral regurgitation due to ischaemia or dilated

cardiomyopathy, it also serves to restore the normal size and shape of the mitral annulus.

Band Annuloplasty

Our preferred approach in most cases of degenerative mitral regurgitation is to use a band annuloplasty. The size of the band is determined using the supplied manufacturer's sizers matched against the inter-trigonal distance. It can also be sized by matching the sizers to the anterior leaflet of the mitral valve. The trigone is usually located above the commissures. It is usually seen as a dimple, especially when the anterior leaflet is pulled towards the posterior leaflet.

Interrupted, non-pledgeted, 2/0 Ethibond, horizontal, mattress sutures are placed around the posterior annulus, starting at each fibrous trigone. Care should be taken to ensure that the band is stitched onto the fibrous trigone at each end. This is important, as failure will occur if the band is not anchored to the trigones.

If resection of P2 had been performed with approximation of the annulus, the sutures are tied either side of the approximated annulus and not across it. This avoids excessive tension on the approximated annulus.

We believe a band annuloplasty is preferable to a ring annuloplasty in degenerative mitral regurgitation as it maintains the normal physiological 3-dimensional dynamics of the mitral valve and annulus. For example, during systole, the mitral annulus is known to move towards the apex of the left ventricle and reduce in size while, during diastole, it recoils back towards the left atrium and increases in size. There is also some evidence that, during diastole, pressure on the aortic root may push the anterior mitral annulus inwards, thus, helping to close the mitral valve.

Ring Annuloplasty

A complete ring annuloplasty can be inserted in a similar way to that described for a band annuloplasty. In this case,

the sutures are also placed all around the anterior annulus. There are several types of rings available, including rigid rings, semi-rigid rings and flexible rings. Insertion of a complete rigid or semi-rigid ring annuloplasty fixes the size of the annulus in systole and restricts the normal physiological 3-dimensional movement of the mitral annulus. Even a flexible ring would restrict the dynamic movement of the mitral annulus during the cardiac cycle. We, therefore, avoid the use of a complete ring in degenerative mitral regurgitation.

A compete ring annuloplasty may be preferred in cases of functional mitral regurgitation due to ischaemia or dilated cardiomyopathy. In these cases, a rigid or semi-rigid ring which is 2 sizes smaller than the measured size is used. For example, if the mitral annulus is sized at 30, a size 26 ring is used. The mitral annulus in these cases is usually dilated and, in the case of functional ischaemic mitral regurgitation, there is also restriction of the leaflet, usually at P3 and sometimes P2, also. The use of an undersized ring annuloplasty helps to restore the normal mitral annular size and leaflet coaptation. Good long-term results have been reported using this technique.

Newer, specially designed rings can be used for functional ischaemic mitral regurgitation and dilated cardiomyopathy. The Etiologix Carpentier-Adams-McCarthy ring, for example, is designed for use in functional ischaemic mitral regurgitation. This ring specifically undersizes the annulus at P3. The Geoform ring is another of the newer rings designed to over-correct the septal-lateral mitral annular size. It has been used in functional mitral regurgitation due to dilated cardiomyopathy. Although early results from these newer rings appear promising, long-term results on their durability is awaited.

Testing the Valve Repair

The competency of the mitral valve is tested by injecting water or saline through the valve into the left ventricle. The mitral valve should be able to hold a reasonable pressure of water, with no more than trace mitral regurgitation.

The final test of the repair is performed using transoesophageal echocardiography when the patient is off cardiopulmonary bypass with a systolic blood pressure above 100 mmHg. There should be no more than trace mitral regurgitation.

Mitral Valve Replacement

Except for rheumatic mitral valve disease, mitral valve replacement should be performed with preservation of the subvalvular apparatus to both the anterior and posterior leaflets of the mitral valve.

Interrupted, everting, pledgeted, 2/0 Ethibond, horizontal, mattress sutures are placed from the left atrial side so that the pledgets are on the left atrial side. For the posterior leaflet, the stitches are placed through it, such that the leaflet is folded onto itself, maintaining its attachment to the subvalvular apparatus. For the anterior leaflet, the smooth part of it can be resected to reduce its height, taking care not to resect any of the primary chords which attach to the free edge of the leaflet. The stitches can then be placed through the leaflets to re-approximate them again. This maintains the subvalvular apparatus to the anterior leaflet.

Once all the sutures have been placed around the annulus, it is then passed around the valve ring from below upwards so that when the sutures are tied, the knot lies on the left atrial side.

Closure

The left atrium is closed by a single continuous layer of Prolene, starting at either end of the incision.

Reference

1. Punjabi PP, Chan KMJ. Technique for chordae replacement in mitral valve repair. Ann Thorac Surg. 2012;94:2139–40.