MITRAL VALVE REPLACEMENT

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A. Surgical Access to the Mitral Valve

Ensuring a good surgical field of view during mitral valve replacement (MVR) is crucial for evaluating valve structures, performing the procedure effectively, and preventing complications. Typically, in isolated MVRs, after sternotomy, aortic arterial and dual venous cannulation (direct or indirect) is performed to achieve cardiac arrest, followed by passing to total cardiopulmonary bypass by snaring the caval veins.

Effective left atrial and ventricular venting facilitates providing a clear field of view. To visualize the mitral valve structure well, it is necessary to tilt the heart apex toward the patient's left and posterior side. For this purpose, the right-sided pericardium is fixed to the edge of the sternum, and the left pericardium is released. Additionally, mobilizing a small amount of the superior and inferior vena cava and/or applying some traction to the caval snare can assist in this maneuver. In isolated mitral valve operations, left atriotomy is usually the preferred approach. Using a scalpel, the epicardial tissues in the Sondergaard groove are cleared, and left atriotomy is performed approximately 1 cm in front of the right upper pulmonary vein. The atriotomy incision is extended toward the inferior side, ensuring it progresses in a manner suitable for the left atrial position; otherwise, the septum can be damaged, and the right atrium can be opened. If the atriotomy incision is excessively extended superiorly, repair in case of bleeding can be difficult.

In patients undergoing combined procedures involving the tricuspid valve, a right atriotomy and transseptal approach can be an alternative. After a right atriotomy, structures within the right atrium are identified, and septostomy can be performed through the fossa ovalis to access the left atrium and the mitral valve. However, a potential disadvantage of this technique is its predisposition to postoperative conduction problems.

Additionally, in patients with a small left atrium, a superior septal approach may provide better visibility. In this technique, a right atriotomy incision is initiated anteriorly to the superior vena cava, and the incision is extended toward the superior-anterior aspect of the right atrial appendage. Septostomy is performed near the basal portion of the septum, and this is, then, connected with the upper end of the right atriotomy incision. Subsequently, the incision is extended toward the left atrial roof to access the left atrium and the mitral valve. While this technique allows for excellent visualization of the mitral valve, repairing bleeding from the distal portion of the incision can be challenging.

TIPS & PITFALLS

Tips for achieving good surgical visibility:

- Apply traction to the right side of the pericardium as much as possible, allowing the apex to be directed inferiorly to the patient's left and posteriorly.
- Effective venting should be ensured, with the vent cannula placed at the lowest point where the pulmonary veins drain.
- In patients with a small left atrium, a transseptal or superior septal approach may be preferred.

- Direct cannulation of the superior vena cava will facilitate the surgical field, if a transseptal or superior septal approach is chosen.

Possible complications:

- Excessive traction applied to achieve good visibility can lead to lacerations at the atriotomy margins or injury to the caval veins.
- If the Sondergaard plane is not well explored, the atriotomy incision may remain too superior, potentially resulting in accidental right atriotomy; initiating the atriotomy approximately 0.5 to 1 cm anterior to the point where the right superior pulmonary vein enters the left atrium can prevent this.
- While extending the left atriotomy incision inferiorly, attention should be paid to the septum to avoid inadvertent septal damage. Aiming for the region where the right inferior pulmonary vein joins the left atrium can prevent this complication.

B. Excision of the Leaflets

After the left atriotomy, an appropriate left atrial retractor (such as Cooley or Cosgrove) is placed, and visibility of the mitral valve structures is ensured. In cases of limited visibility, gentle traction can be applied using a blunt-tipped coronary aspirator passed through the mitral annulus. Excision begins with the anterior leaflet (from the middle of A2). The anterior leaflet is grasped with a forceps or Allis clamp and incised to leave a minimum (approximately 1 mm) of leaflet tissue at 12 o'clock. The first suture is placed. Incision continues toward the anterolateral commissure for the second suture, followed by the posteromedial commissure for the third suture to complete the resection of the anterior leaflet. If the posterior leaflet is to be preserved, it is separated from the anterior leaflet, and chordae tendineae are cut. It is of utmost importance to cut the chordae tendineae from the fibrous part closest to the papillary muscle to avoid complications such as free wall rupture. If the posterior leaflet is not preserved, it is resected similar to the anterior leaflet, leaving approximately 1 mm of leaflet tissue and cutting the chordae tendineae. During resection in areas of limited visibility, placing annular sutures during resection or placing standard annular sutures at 12-3-6-9 o'clock positions can improve surgical visibility.

In chordal-sparing techniques, the anterior leaflet is incised at the A2 position, and resection is performed up to the A1-A3 border. Then, the leaflet is divided into two parts longitudinally, and the leaflet tissue is resected, leaving the chordae

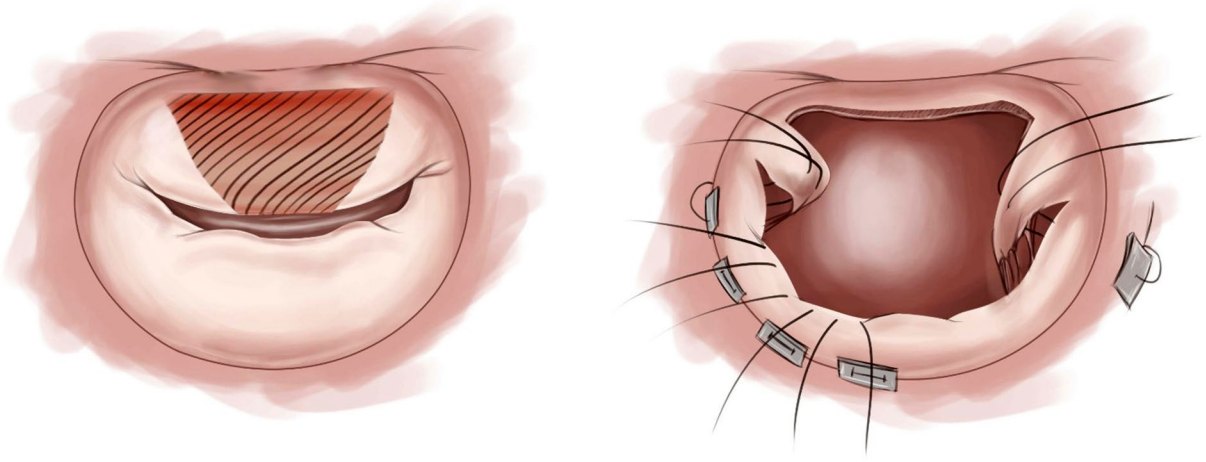

Figure 14.1. A broadly used method for leaflet-sparing mitral valve replacement; the anterior leaflet is incised at the A2 position, and resection is performed up to the A1-A3 border. Then, the leaflet is divided into two parts longitudinally, and the leaflet tissue is resected, leaving the chordae intact. Subsequently, the A1 segment is sutured to the anterolateral commissure, and the A3 segment is sutured to the posteromedial commissure along with the leaflet sutures. In posterior leaflet preservation, the posterior leaflet is folded and sutured to the annulus with leaflet sutures.

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TIPS & PITFALLS

Tips for resection:

- Providing posterior traction on the annulus can be beneficial when achieving good visibility of the mitral unit is challenging.
- In cases where the anterior annular region is poorly visualized, starting with passing posterior annular sutures and using them for traction may be helpful.
- Placing annular sutures for traction in areas where visibility is difficult during resection can be beneficial.
- If chordal preservation is planned, careful evaluation of the subvalvular units and planning chordal resection at this stage is necessary.

Possible complications:

- Excessive resection in the middle portion of the anterior leaflet may damage the aortomitral fibrous structure, and deep sutures in this area may lead to aortic insufficiency.
- Deep sutures in the A3 segment may cause damage to the conduction pathways and rhythm problems.
- Deep sutures in the posterior annular region may lead to injury to the circumflex coronary artery or coronary sinus.
- If resection is applied from the deep portion during chordal resection, the papillary muscle structure may be disrupted, leading to free wall rupture.

C. Suture Techniques

In MVR, Teflon pledget-reinforced polyester sutures are commonly used (Figure 14.2). Sutures are typically placed in an everting mattress configuration. The advantage of this technique is that, if a suture breaks during tying, the free pledget can be easily located. However, a disadvantage is that it may slightly narrow the annulus diameter, although this is usually not problematic in MVR. The suture technique used during MVR can vary depending on the surgeon's personal experience and the type of prosthesis being used. For bioprosthetic valves, the subannular (non-everting) technique, where the sutures pass from the ventricle to the atrium, is usually preferred. This method is thought to provide the strongest seating of the valve on the annulus. In the supraannular (everting) technique, sutures pass from the atrium to the ventricle (Figures 14.3 and 4). While placing sutures subannularly, particularly for bioprosthetic valves, ensure that the portion of the suture remaining in the ventricle is not caught on the stent ring to place a prosthesis of the maximum appropriate diameter on the annulus.

Additionally, besides these techniques, the prosthetic mitral valve can be implanted onto the annulus using a single continuous suture technique (Photo 14.1). The main disadvantage of the continuous suture technique is the possibility of total valve dehiscence, if there is any damage to the suture material. Therefore, it is more appropriate to divide the annular ring into several segments and apply it with multiple sutures to prevent this.

D. Valve Implantation

i. Measurement

After resection of the mitral valve and placement of annular sutures, the annulus ring is measured using an appropriate valve sizer. At this stage, it is crucial to know the hemodynamic properties of the prosthetic valve to be implanted. If a prosthetic valve with a small effective orifice area is implanted based on the patient, patient-prosthesis mismatch is inevitable. If the appropriately sized prosthetic sizer cannot be placed on the annulus, it should be checked whether inadequate resection has been performed, or if valve-sparing surgery has been performed, a reassessment for classic MVR should be considered. Additionally, it should be noted that, in patients undergoing both aortic and MVR, implanting a mitral valve that is too large due to its proximity to the aortic valve may narrow the aortic annulus and cause problems.

ii. Valve Positioning

In bileaflet mechanical prostheses, the mechanical valve leaflets can be positioned to match the anatomical orientation of the mitral valve.

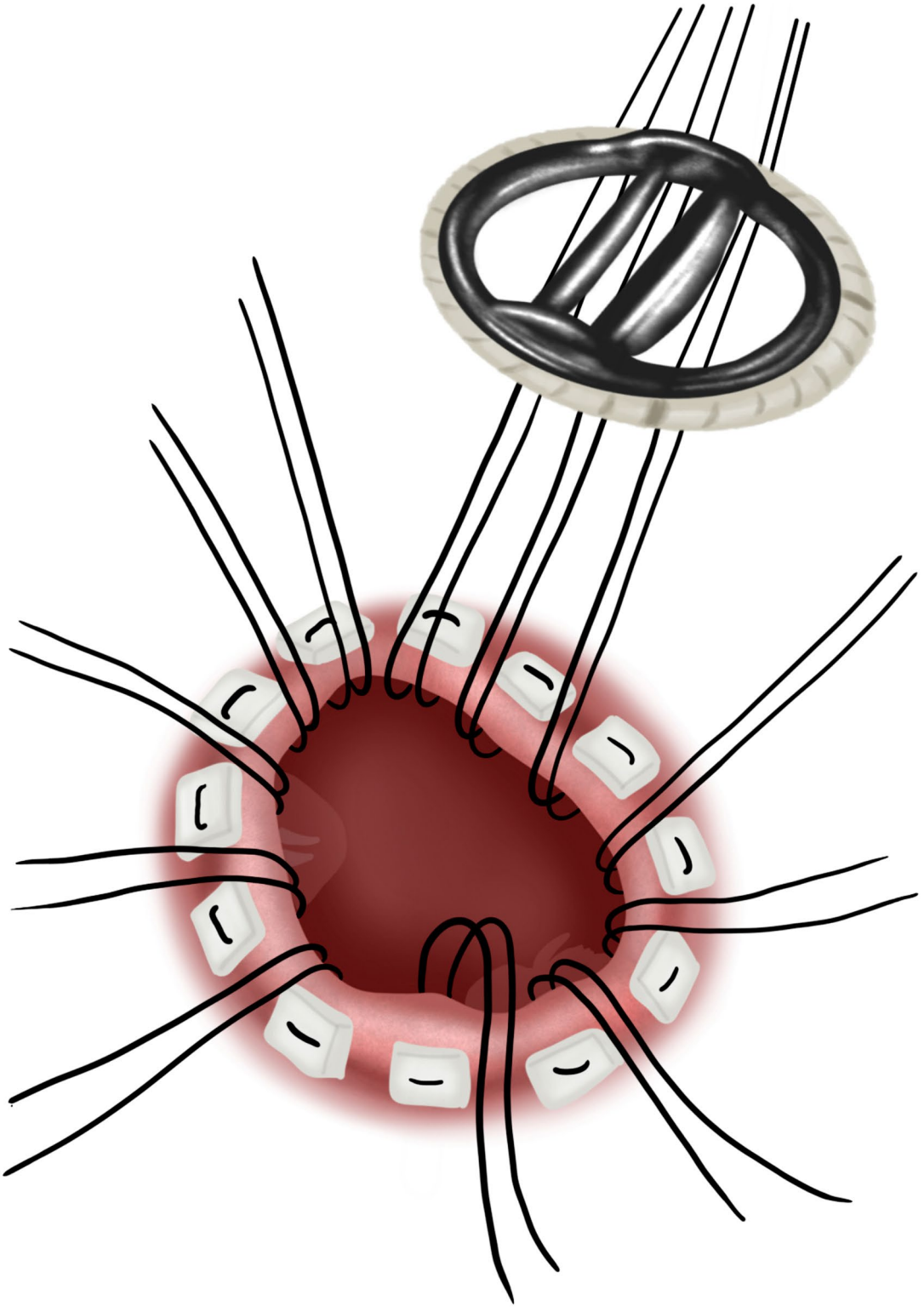

Figure 14.2. A common method for mitral valve replacement is using everting pledgeted sutures. The sutures are typically placed in an everting mattress configuration. The advantage of this technique is that if a suture breaks during tying, the free pledget can be easily located.

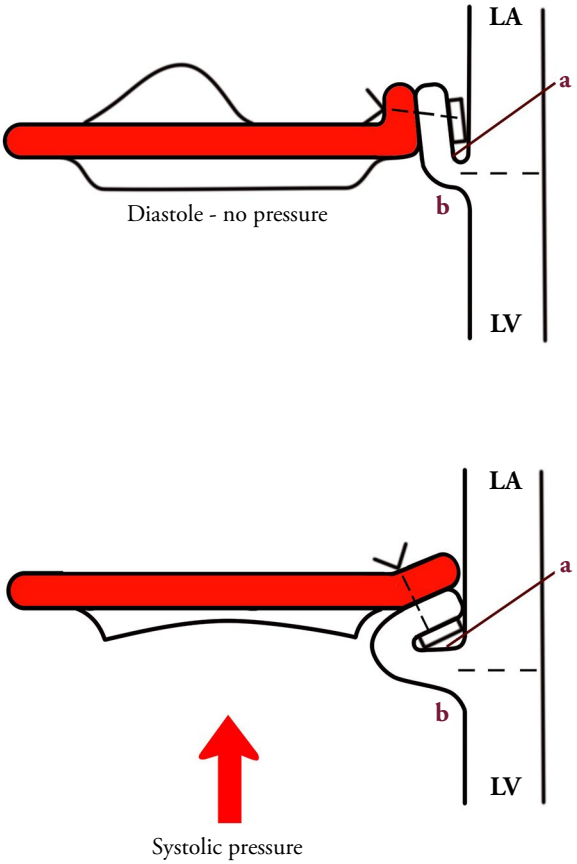

Figure 14.3. In the supraannular (everting) technique, sutures pass from the atrium to the ventricle. The major advantage of this technique is the lower probability of paravalvular leakage. During the systole, higher pressure gradients between left atrium and left ventricle can be supported with the pledgeted sutures.
LA: Left atrium; LV: Left ventricle.

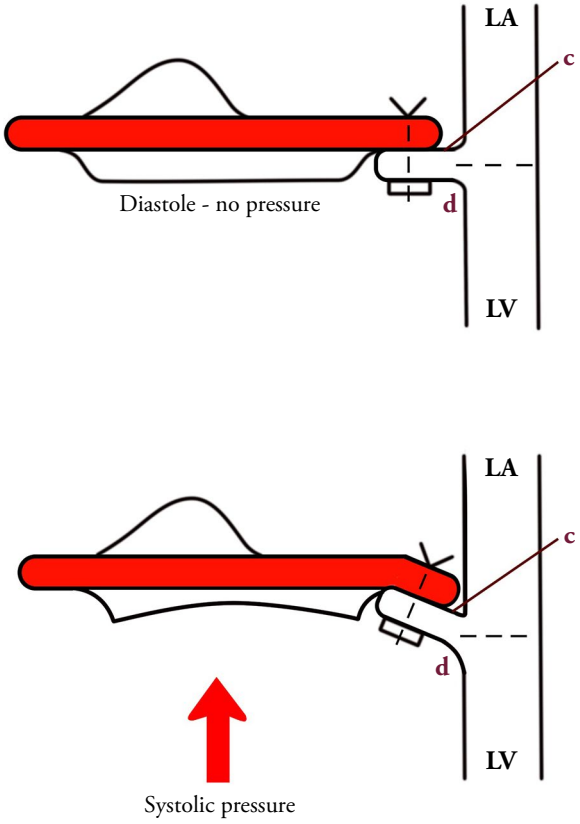

Figure 14.4. Non-everting pledgeted suture technique.
LA: Left atrium; LV: Left ventricle.

However, in cases where valve-sparing surgery is performed, it can be anticipated that the subvalvular mitral unit may interfere with the movement of the prosthetic valve. In such cases, the mechanical valve can be rotated on the strut during suturing or afterwards to be positioned at a different angle from the anatomical orientation and placed on the annulus (Figure 14.5).

iii. Bioprosthetic Valve Implantation Considerations

While replacing the valve with a bioprosthetic valve, it is critical to ensure proper positioning of the part of the valve that remains within the ventricle during implantation. Attention should be paid to appropriate sizing. In particular, in patients with a small left ventricle, it should be remembered that bioprosthetic valves may cause obstruction of the left ventricular outflow tract.

iv. Chordal-Sparing Surgery

Considering the structural integrity of the mitral valve with the left ventricle and the importance of chordae tendineae in preserving the geometric shape and function of the left ventricle, chordal-sparing surgical techniques have been described. The most basic of these techniques is to pass the sutures through the posterior leaflet from the annular ring without resecting the posterior leaflet and to adhere the posterior leaflet to the posterior aspect of the annular ring. If there is excess tissue in the posterior leaflet, a similar procedure can be applied by resecting a part of the posterior leaflet in an elliptical shape while preserving the primary chordae. These techniques not only preserve the subvalvular unit

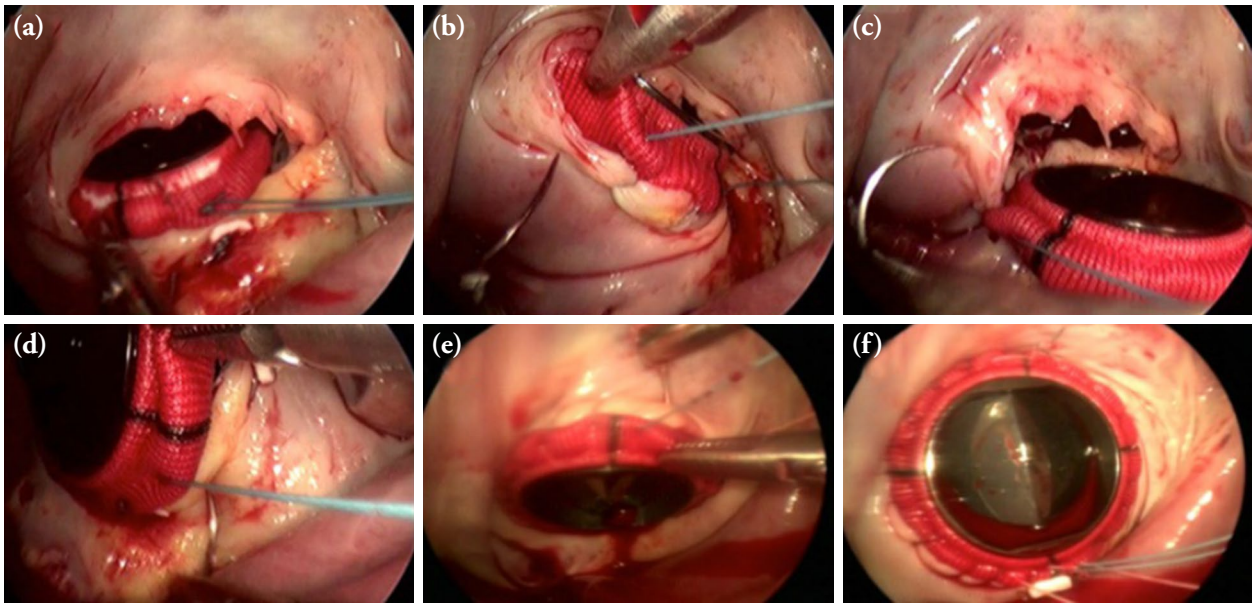

Photo14.1. Continuous suture technique. Starting from the 6 o'clock position, the mitral valve is first sewn through the annulus and then through the valve ring. Continuous suture technique is applied with backhand technique up to the 9 o'clock position and with forehand technique up to the 12 o'clock position. The other suture piece at the 6 o'clock position is taken and continued in the opposite direction of clockwise up to the 3 o'clock position with backhand technique and up to the 12 o'clock position with forehand technique.

of the mitral valve but also reduce the incidence of posterior wall rupture. Various techniques have been described for preserving the chordae of the anterior leaflet as well. These techniques primarily involve preserving the segment of the anterior leaflet attached to the primary chordae, resecting other parts, and anchoring the remaining tissue to the mitral annulus with annular sutures or additional sutures. The most important issue to consider during chordal-sparing surgery is to ensure that the subvalvular unit or remaining leaflet tissues does not impede the movement of the implanted prosthetic valve. If there is any doubt, changing the angle of the valve or rotating it after implantation may help to resolve the problem.

v. Testing and Decalcification of the Valve

After implantation of the prosthetic valve into the annulus, it is crucial to manually check the valve's effective functioning and leaflet movements before closing the atriotomy. It should be ensured that the prosthetic valve and all sutures are properly seated on the annular ring. If there is any doubt about the leaflet movements, simply rotating the prosthetic valve to change the orientation may resolve the issue. If the valve is found to be non-functional despite all maneuvers, reconsideration of implantation is necessary.

TIPS & PITFALLS

Tips for Implantation:

- Ensure clear visualization of the entire annulus structure during measurement. In cases of poor visibility, incorrect measurements may be applied. Applying traction to the placed annular sutures will improve visibility.
- While selecting the valve size, the appropriate valve size should be chosen according to the patient's body surface area. If adequate resection has been performed, the likelihood of patient-prosthesis mismatch is very low.
- In patients with a small left ventricle, particularly if chordal-sparing surgery has been performed, direct placement of the mechanical valve in an extra-anatomic position may be beneficial for leaflet mobilization.

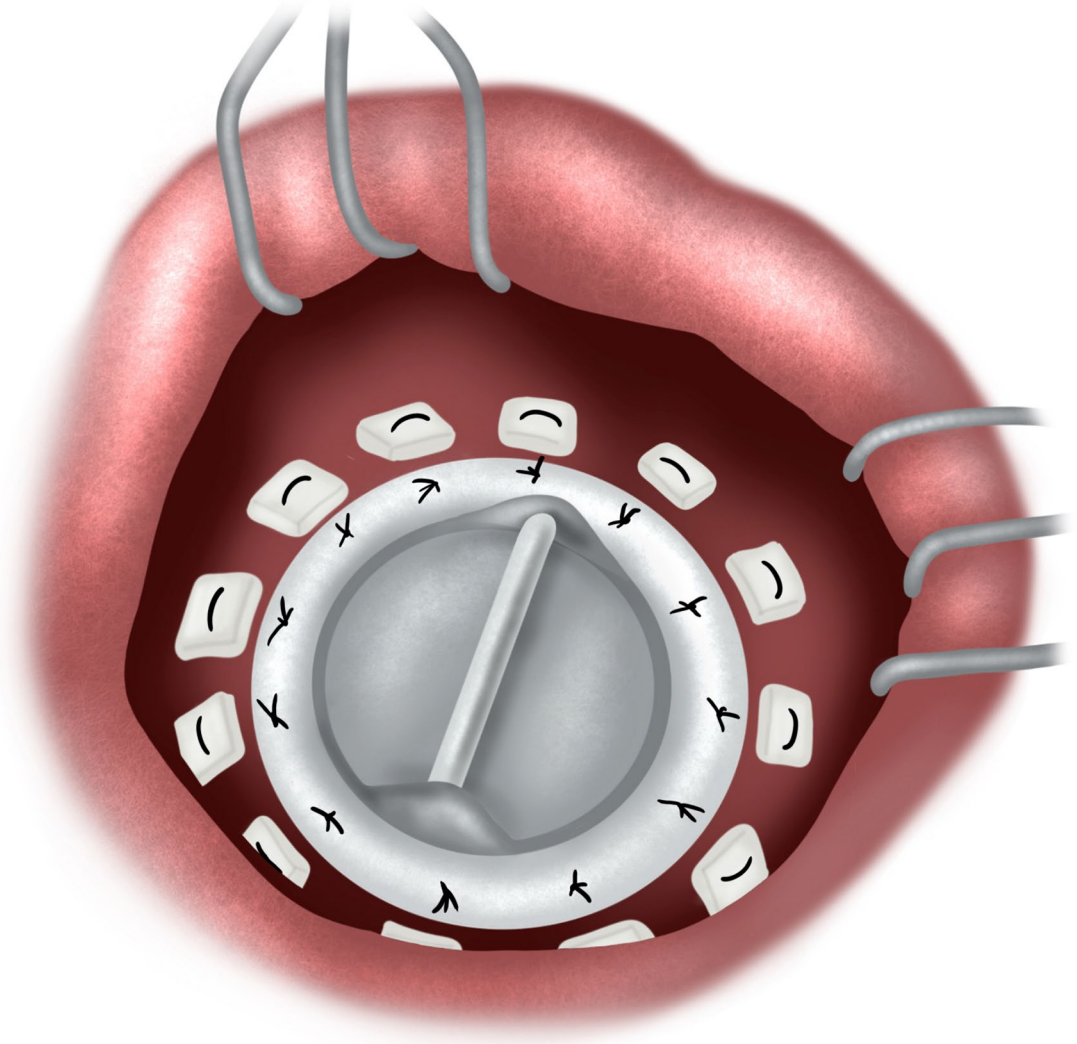

Figure 14.5. Non-anatomical positioning of the mitral valve prosthesis. The mechanical valve can be rotated on the strut during suturing or afterwards to be positioned at a different angle from the anatomical orientation and placed on the annulus. This method is useful particularly during the leaflet-sparing replacement. The redundant native leaflet tissue may cause the early pannus formation, if the prosthesis placed in anatomical position.

- If sutures for bioprosthetic valve implantation are subannular, it must be ensured that all pledgets are securely attached to the annulus; for this purpose, a small mirror can be used.

E. Closure of the Atrium

i. Left Atrial Closure

After confirming that the prosthetic valve is implanted and functional, closure of the atriotomy is performed. The classic left atriotomy incision can be closed with a continuous technique using 3/0 prolene suture. Starting with one stitch from each end of the atriotomy incision and covering sufficient tissue thickness at the ends will reduce the risk of bleeding from the incision edges. Additionally, when the tissue is weak at the ends, initial sutures can be reinforced with Teflon pledgets. During closure of the atriotomy incision, it should be ensured that the endothelium of both atria meets end-to-end along the incision line.

ii. Right Atrial Closure

When a transseptal approach is used, the septum is closed with 3/0 or 4/0 prolene suture using a continuous technique. Subsequently, the right atriotomy incision can be closed with 4/0 prolene suture using either a single-layer continuous technique or a double-layer continuous technique. In the double-layer closure technique, the first suture line is passed from opposite edges of the incision to form a "U" shape, then continued along the incision without crossing the first line, and finally tied off at the starting point. With this technique, in patients with a large right atrium, increasing the thickness of the suture line can also be applied to reduce right atrial volume.

iii. Superior Septal Approach

In the superior septal technique, closure of the atriotomy starts from the most distal point of the left atrium roof. Since reaching the proximal part of the incision may be difficult, careful passage of all sutures is crucial to prevent potential bleeding. Closure of the septum starts from a point near the base of the septum with a separate prolene suture, and sutures are connected to each other at the point where the left atriotomy and septostomy incisions merge. Then, the right atriotomy incision is closed with a continuous technique using the same suture.

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