

Transaxillary direct-vision valve surgery: operative technique and technical principles

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Abstract: The transaxillary direct-vision approach was developed as a simplified platform for minimally invasive valve surgery. Rather than compensating for reduced surgical access through endoscopic visualization or robotic technology, the technique preserves direct three-dimensional vision while using long-shafted minimally invasive instruments through a single lateral minithoracotomy. Proper patient positioning, target-oriented incision planning, and systematic pericardial traction bring the heart toward the right lateral thoracic wall and create a short, coaxial working trajectory. Seven pericardial stay sutures secured directly to the skin are central to the exposure, allowing the ascending aorta, right atrium, venae cavae, interatrial groove, pulmonary veins, and left atrial appendage to be reached from the same incision. The platform can be applied to aortic, mitral, and tricuspid valve procedures, atrial septal defect closure, intracardiac mass resection, atrial fibrillation surgery, and left atrial appendage occlusion without changing its fundamental setup. This article describes the technique step by step, emphasizing patient and surgeon ergonomics, incision planning, pericardial traction, exposure of the individual valve targets, and the technical details required to preserve direct vision throughout the procedure.

Keywords: Minimally invasive surgical procedures; cardiac surgical procedures; aortic valve; mitral valve; tricuspid valve



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Introduction

Minimally invasive valve surgery reduces surgical trauma and facilitates postoperative recovery while maintaining clinical outcomes comparable to conventional sternotomy (1,2). Its broader adoption, however, has been limited by the procedural complexity of many minimally invasive platforms. Camera-mediated visualization, additional working ports, specialized equipment, and altered eye-hand relationships may require substantial adaptation by both the surgeon and the operating room team.

The transaxillary direct-vision approach was developed to preserve the fundamental visual and manual principles of conventional surgery through a sternum-sparing access. The concept evolved from right lateral minithoracotomy experience and was progressively applied to mitral, aortic, and tricuspid valve surgery, including combined procedures (3-7). The technique is based on four fundamental elements: direct vision, a short working distance, coaxial alignment between vision, instrumentation and operative target, and central access that permits multiple cardiac structures to be reached without altering the operative setup.

Operative techniques

Preparation

The procedure is performed under general anesthesia with single-lumen endotracheal intubation and transesophageal echocardiographic monitoring. The patient is positioned supine with slight leftward rotation, and the operating table is tilted to elevate the right hemithorax. The primary surgeon stands immediately adjacent to the right lateral chest wall. Table height and tilt are adjusted to minimize the distance between the surgeon's eyes and the operative target while maintaining a natural position of the shoulders, elbows, and wrists.

No endoscope is used to guide the operation. The surgeon views the operative field directly through the thoracotomy. A head-mounted camera may transmit the surgeon's perspective to a monitor positioned behind the primary surgeon, allowing the assistant, anesthesiologist, perfusionist, and scrub team to follow the procedure without interfering with the surgeon's visual axis (*Figure 1*).

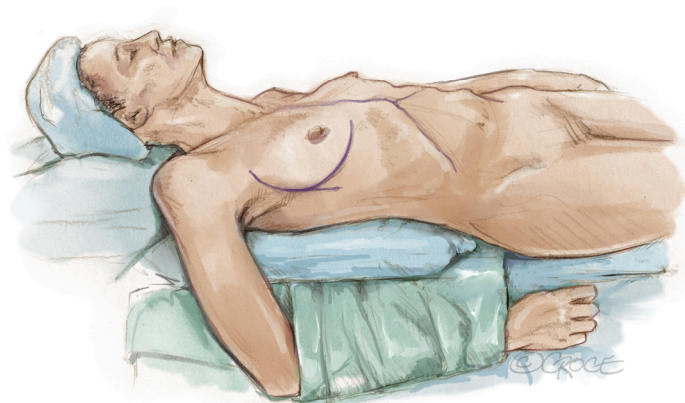
Two principal right-arm positions are used. For mitral and tricuspid valve procedures, atrial septal defect closure, and intracardiac mass excision, the arm is positioned alongside the body and slightly displaced caudally to improve exposure of the right axillary region. For isolated aortic valve replacement and combined aortic-mitral procedures, the arm is elevated above the head to reproduce the thoracic configuration used during preoperative computed tomography (CT). Because the intercostal space is selected on CT imaging, consistency between imaging and intraoperative positioning is particularly important in aortic valve surgery. The relatively small dimensions of the aortic root and valve require precise alignment between the incision and the operative



Figure 1 Operating room ergonomics and direct-vision setup. The operating table is tilted to elevate the right hemithorax, and the primary surgeon stands immediately adjacent to the lateral chest wall, minimizing the distance between the surgeon and the operative target. The procedure is performed under direct three-dimensional vision without an endoscope. A head-mounted camera transmits the surgeon's view to a monitor positioned behind the surgeon, allowing the operating room team to follow the procedure without altering the surgeon's visual axis.

target. Mitral and tricuspid procedures are comparatively more permissive because the atria and atrioventricular valves provide broader operative targets. Arm elevation is also preferred in patients with obesity or abundant breast tissue because it displaces and flattens the axillary and periaxillary soft tissues, reducing the soft-tissue depth between the skin and the chest wall and improving access to the selected intercostal space. In all configurations, the arm and shoulder are carefully padded, and excessive abduction or traction on the brachial plexus is avoided (*Figure 2*).

A



B

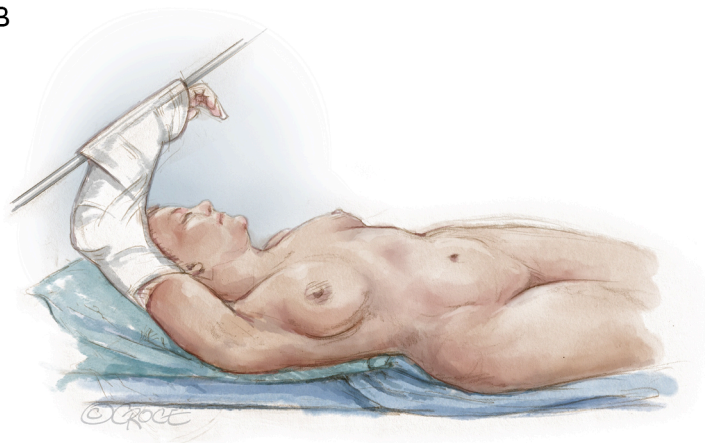


Figure 2 Target-specific patient and arm positioning. For mitral and tricuspid valve surgery, atrial septal defect closure, and intracardiac mass excision, the right arm is positioned alongside the body and slightly displaced caudally to improve exposure of the axillary region (A). For aortic valve replacement and combined aortic-mitral procedures, the arm is elevated above the head to reproduce the thoracic configuration used during preoperative CT (B). This consistency is particularly important because the intercostal space is selected on CT and precise alignment with the relatively small aortic root and valve is required. Arm elevation is also used in patients with obesity or abundant breast tissue because it flattens the axillary and periaxillary soft tissues, reducing the distance between the skin and chest wall. All pressure points are padded, and excessive shoulder or brachial plexus traction is avoided. CT, computed tomography.

Exposure

The intercostal space is selected according to the operative target and the patient's thoracic anatomy. For aortic valve procedures, the level of access is determined preoperatively on CT, with the patient positioned as closely as possible to the intraoperative arm-up configuration. The objective is to identify the intercostal space that provides the most direct and perpendicular trajectory toward the aortic root. Mitral, tricuspid, and right atrial procedures are generally more permissive because the atria and atrioventricular valves represent broader operative targets; in these cases, the third or fourth intercostal space is usually appropriate.

A 4–6 cm skin incision is made along the right anterior axillary line and centered over the selected intercostal space. Whenever patient anatomy permits, the incision follows the lateral extension of the natural inframammary crease, allowing the scar to remain almost completely concealed. The pleural cavity is entered without rib division. A carbon dioxide line is introduced into the right hemithorax, with continuous insufflation at 2 L/min, and a soft-tissue retractor is positioned.

After systemic heparinization, cardiopulmonary bypass is initiated through the selected peripheral cannulation strategy. Mechanical ventilation is discontinued and the breathing circuit is temporarily disconnected, allowing the right lung to collapse away from the operative field. Limited intercostal spreading is used only briefly, generally for a few minutes, during pericardial opening. Its purpose is to provide direct visualization of the pericardium caudally toward the diaphragm and cranially toward the aortic reflection. The rib spreader is removed once the pericardiectomy has been completed (*Figure 3*).

The pericardium is opened longitudinally. Cranially, the incision is extended high over the ascending aorta, reproducing the anterior pericardial opening commonly

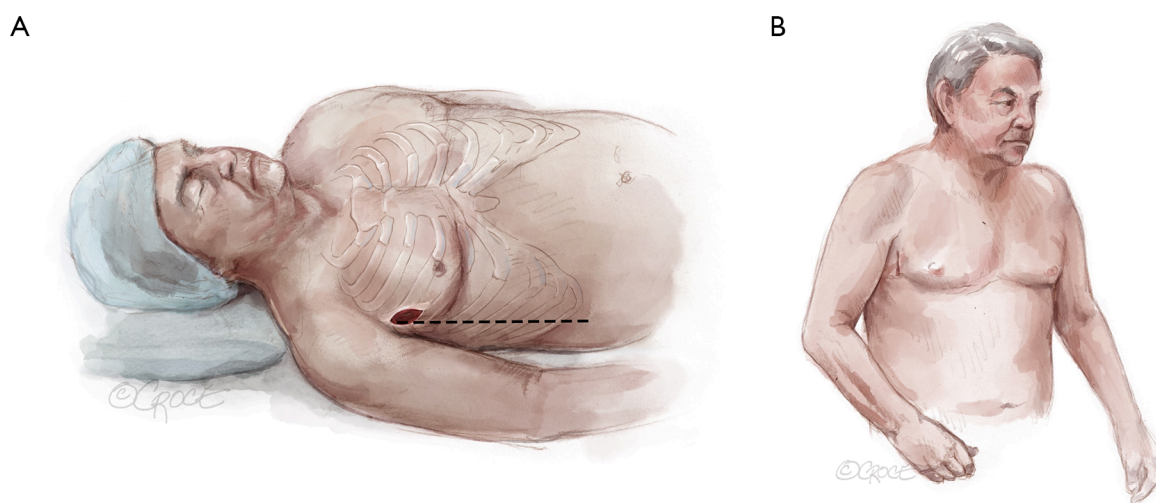


Figure 3 Incision planning and initial thoracic exposure. A 4–6 cm incision runs along the right anterior axillary line and is centered over the selected third or fourth intercostal space (A). Whenever anatomy permits, it follows the lateral extension of the natural inframammary crease (B). The pleural cavity is entered without rib division, and carbon dioxide is insufflated at 2 L/min. Limited intercostal spreading is used only during pericardial opening and is discontinued once adequate cranial and caudal exposure has been obtained.

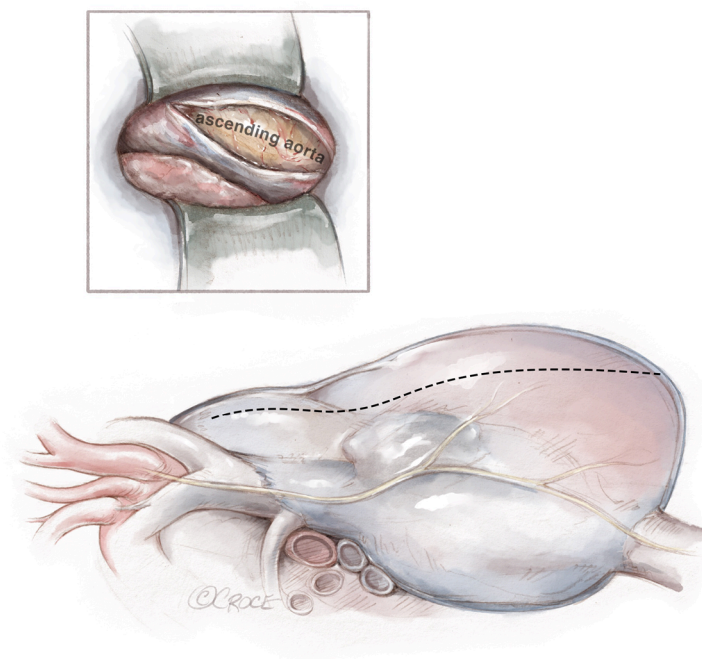


Figure 4 High longitudinal pericardial opening. The pericardium is opened longitudinally, extending cranially high over the ascending aorta and caudally toward the diaphragm while preserving the phrenic nerve. The high cranial extension creates a posterior pericardial curtain that permits placement of posterior stay sutures away from the phrenic nerve and keeps the right lung separated from the operative field after ventilation is resumed.

performed through median sternotomy. Caudally, it is continued toward the diaphragm while preserving the phrenic nerve (*Figure 4*). Extending the pericardiotomy above the ascending aorta creates a high posterior pericardial curtain with two important advantages. First, the posterior pericardial stay sutures can be placed at a safe distance from the phrenic nerve, reducing the risk of traction-related injury. Second, the elevated posterior curtain acts as a barrier between the lung and the operative field, keeping the right lung away from the surgical target after separation from cardiopulmonary bypass and resumption of ventilation.

Exposure is created using seven pericardial stay sutures distributed around the pericardial opening. The sutures are brought directly to the edges of the skin incision and secured externally rather than passed through separate transthoracic stab incisions. The anterior sutures elevate the anterior pericardium and right ventricular surface, whereas the posterior sutures draw the heart toward the right lateral thoracic wall. Their tension is adjusted sequentially until the relevant anatomical structures are centered within the operative access (*Figure 5*).

This maneuver reduces the distance between the operative valve target and the chest wall to approximately 10 cm and directs the traction vector toward the thoracotomy itself. The resulting exposure preserves alignment among the surgeon's visual axis, the surgical instruments, and the operative target. After pericardial traction, the ascending

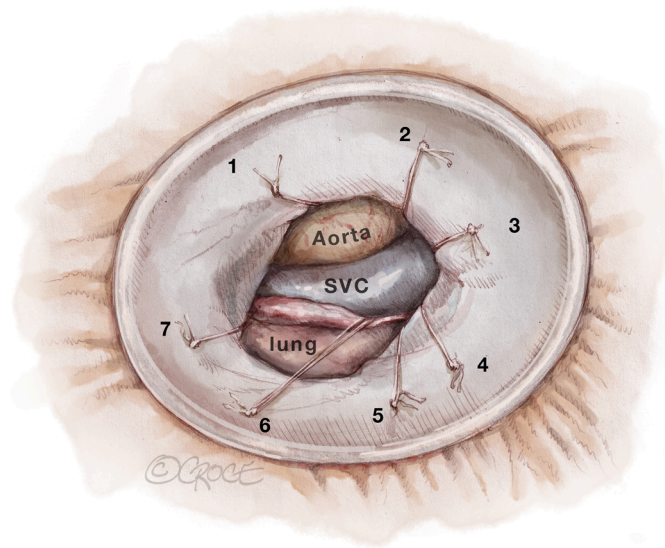


Figure 5 Seven pericardial stay sutures. Seven stay sutures are distributed around the pericardial opening and secured directly to the skin edges of the thoracotomy. The anterior sutures elevate the anterior pericardium and right ventricular surface, whereas the posterior sutures draw the heart toward the lateral chest wall. Direct fixation to the incision preserves the traction vector toward the access, reduces the working distance, and centers the operative target. SVC, superior vena cava.

aorta, right atrium, superior and inferior venae cavae, right superior pulmonary vein, interatrial groove, transverse sinus, and left atrial appendage are identified. From this central position, the operative strategy can be directed toward the aortic, mitral, or tricuspid valve, the interatrial septum, or the left atrial appendage without changing the incision or the surgeon's position (*Figure 6*).

Operation

Aortic cross-clamping and myocardial protection

A low-profile flexible aortic clamp is introduced directly through the main thoracotomy. No additional transthoracic clamp port is required, thereby avoiding a further intercostal access and its potential contribution to bleeding and postoperative pain.

Unlike a conventional transthoracic clamp, the flexible clamp follows a short, direct trajectory into the chest, allowing smooth passage around the ascending aorta under direct vision. Particular attention is paid to the pulmonary artery, left atrial appendage, and surrounding structures. Clamp position is important. For mitral and tricuspid valve procedures and for intracardiac mass surgery not requiring left atrial appendage excision or occlusion, the clamp is usually positioned at the level of the transverse sinus. When aortic valve replacement or left atrial appendage excision or occlusion is planned, the clamp is positioned more distally on the ascending aorta, beyond the level of the right pulmonary artery, to preserve access to the aortic root and transverse sinus (*Figure 7*).

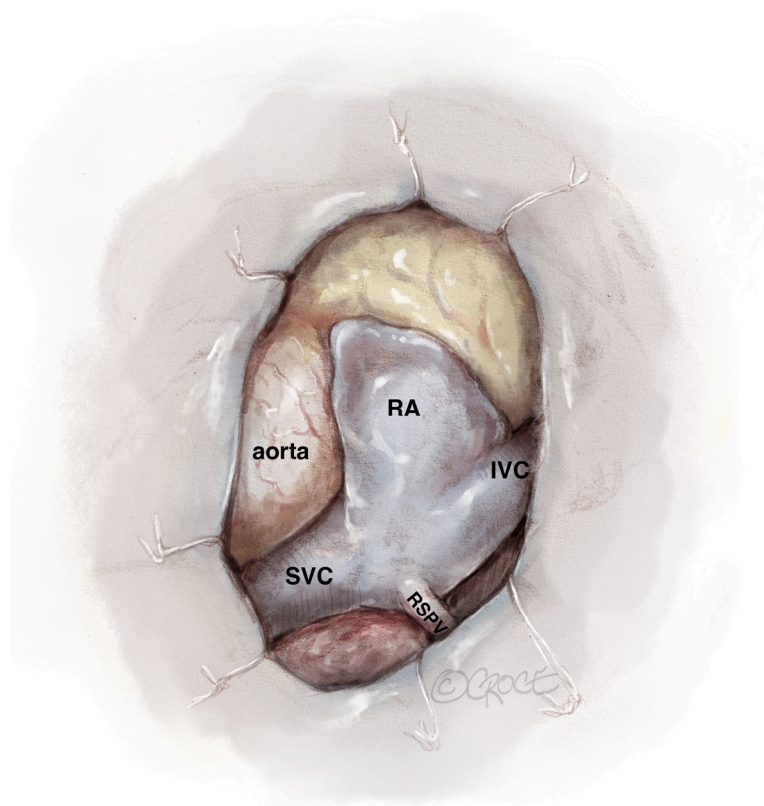


Figure 6 Central exposure of the cardiac anatomy. After pericardial traction, the ascending aorta, superior and inferior venae cavae, right atrium, right superior pulmonary vein, interatrial groove, transverse sinus, and left atrial appendage are accessible through short working trajectories. This central exposure forms the anatomical basis of the unified transaxillary platform and permits access to all three valves and associated atrial structures without changing the incision or surgeon position. IVC, inferior vena cava; RA, right atrium; RSPV, right superior pulmonary vein; SVC, superior vena cava.

Once applied, the clamp is preferably rotated toward the assistant, in the direction of the left hemithorax. This maneuver produces a slight leftward rotation of the ascending aorta. During mitral valve surgery, this displacement facilitates more effective retraction of the left atrium and improves mitral exposure. It also widens access to the transverse sinus, which is particularly useful when left atrial appendage occlusion is planned.

After cross-clamping, cardioplegic arrest is obtained through the ascending aortic root cannula. In patients with significant aortic regurgitation, cardioplegia may be delivered directly into the coronary ostia after aortotomy. The myocardial protection strategy is otherwise identical to that used through conventional sternotomy.

Mitral valve exposure

The left atrium is opened through the interatrial groove, and the atriotomy is extended longitudinally, parallel to the interatrial septum, according to the dimensions of the left atrium and the planned procedure.

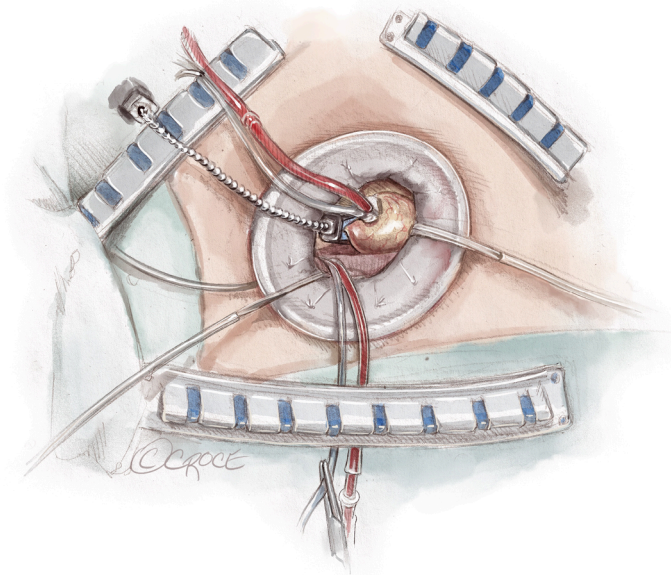


Figure 7 Flexible aortic cross-clamp. A low-profile flexible aortic clamp is introduced directly through the main thoracotomy without an additional port and passed around the ascending aorta under direct vision. Rotation of the clamp toward the assistant produces slight leftward displacement of the ascending aorta, facilitates left atrial retraction during mitral surgery, and widens access to the transverse sinus when left atrial appendage occlusion is planned.

A dedicated atrial retractor is introduced through the thoracotomy and positioned to elevate the interatrial septum. Exposure is then completed by placing posterior and anterior annular sutures. When these sutures are brought under tension and secured on suture organizers positioned outside the operative field, they draw the mitral annulus approximately 4–5 cm closer to the surgeon, center the valve within the thoracotomy, and temporarily reproduce the annular stabilization provided by an annuloplasty ring.

Valve analysis is performed only after all annular sutures have been placed and optimal exposure has been obtained. This sequence provides a stable and reproducible view of the entire mitral apparatus and permits accurate assessment of the mechanism of regurgitation.

The posterolateral orientation of the transaxillary access provides both a short working distance and a perpendicular view of the mitral valve plane. This geometry facilitates detailed analysis of the anterior and posterior leaflets, commissures, and annulus and provides a central trajectory toward the subvalvular apparatus. Both papillary muscles are directly visible, positioned to the right and left of the operative field. Compared with a more anterolateral access, this trajectory provides particularly favorable direct exposure of the posteromedial commissure and posteromedial papillary muscle. The chordae tendineae and papillary muscles can therefore be inspected and treated without substantial instrument angulation.

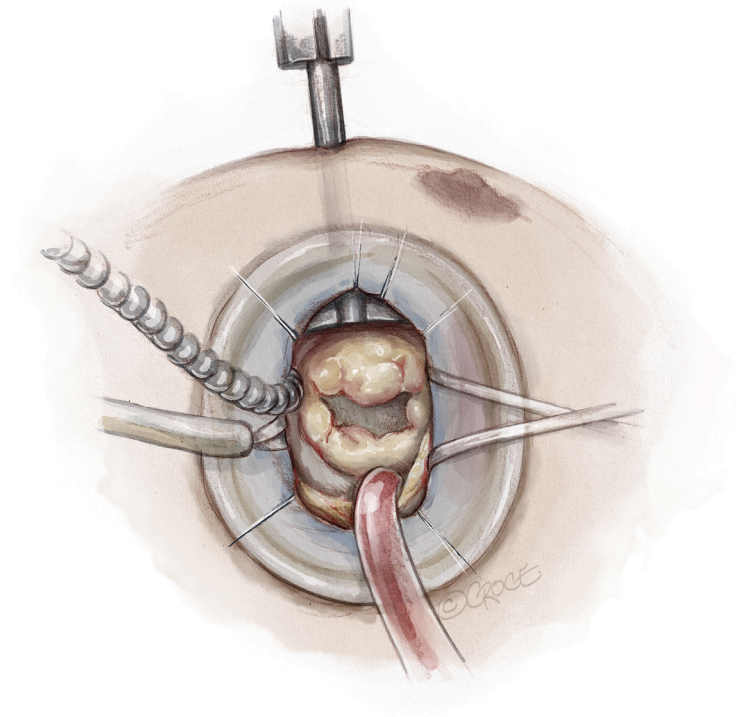


Figure 8 Direct mitral valve exposure. The left atrium is opened through the interatrial groove, and a dedicated atrial retractor elevates the interatrial septum. Posterior and anterior annular sutures are placed, tensioned, and secured on external suture organizers. This brings the annulus approximately 4–5 cm closer to the surgeon, centers the valve, and stabilizes the annular plane before valve analysis. The posterolateral trajectory provides an almost perpendicular view of the leaflets and commissures and direct central access to both papillary muscles, with particularly favorable exposure of the posteromedial commissure and papillary muscle.

Mitral repair or replacement is performed according to standard surgical principles using long-shafted minimally invasive instruments, without altering the reconstructive strategy because of the access (*Figure 8*).

Right atrial, tricuspid, and interatrial septal procedures

After bicaval control, a longitudinal right atriotomy is performed parallel to the atrioventricular groove. Because of the orientation of the transaxillary access, the atriotomy appears almost horizontal within the operative field.

Two atrial stay sutures are then placed. The first is positioned along the inferior edge of the atriotomy and secured to an external suture organizer. The second is placed along the superior edge and exteriorized transthoracically, following the same trajectory used for the left/right atrial retractor. This suture stabilizes and retracts the right atrial wall, allowing subsequent insertion of the right atrial retractor and increasing its effectiveness in exposing the tricuspid valve.

This configuration provides direct visualization of the entire right atrial anatomy, including the tricuspid annulus, anterior, posterior, and septal leaflets, commissures,

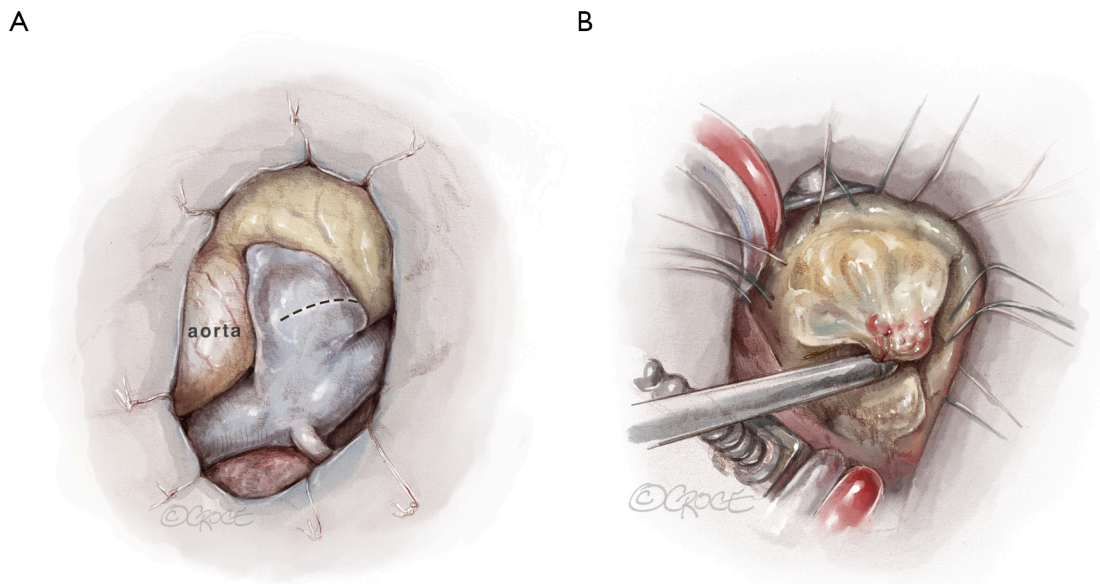


Figure 9 Right atrial, tricuspid, and septal exposure. After bicaval control, a longitudinal right atriotomy is performed parallel to the atrioventricular groove and appears almost horizontal within the operative field (A). An inferior stay suture is secured to an external organizer, whereas a superior stay suture is exteriorized transthoracically to stabilize the atrial wall. A right atrial retractor then exposes the tricuspid annulus, leaflets, commissures, subvalvular apparatus, coronary sinus, atrioventricular node region, and interatrial septum (B). The same exposure permits tricuspid repair or replacement, atrial septal defect closure, and transseptal removal of intracardiac masses.

subvalvular apparatus, coronary sinus, atrioventricular node region, and interatrial septum. For tricuspid valve repair, the annulus, leaflets, and subvalvular apparatus are systematically inspected under direct vision. Annuloplasty sutures are placed using long-shafted minimally invasive instruments, with particular caution in the region of the atrioventricular node. The same exposure permits tricuspid valve replacement when indicated.

The interatrial septum can be accessed without modifying the operative setup. Atrial septal defects, patent foramen ovale, and intracardiac masses can be treated through the same right atriotomy. When a left atrial myxoma is approached transseptally, the septal incision is extended only as required to permit *en bloc* removal of the mass and complete inspection of its attachment site (Figure 9).

Aortic valve exposure

For aortic valve surgery, the arm-up position and access through the third or fourth intercostal space create a direct trajectory toward the ascending aorta and aortic root.

After cross-clamping and cardioplegic arrest, a standard aortotomy is performed. Aortic stay sutures are placed along the edges of the aortotomy and brought under tension to draw the aortic root toward the thoracotomy and center the valve within the operative field. The short working distance and near-perpendicular alignment between the surgeon and the aortic valve plane provide a uniform *en face* view of the annulus across all three sinuses, without one segment being less visible than the others.

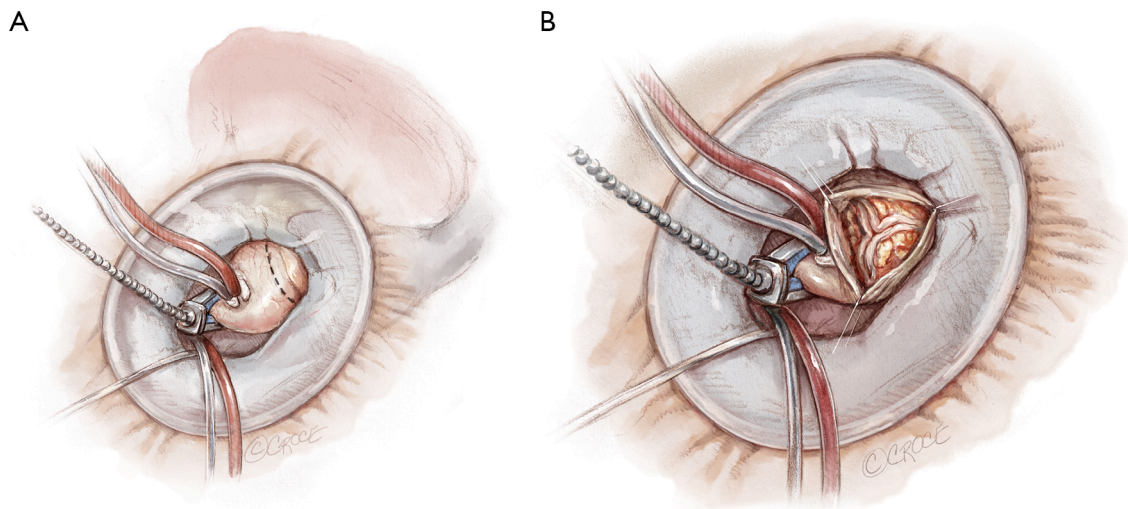


Figure 10 Aortotomy and aortic valve exposure. After aortic cross-clamping and cardioplegic arrest, a standard aortotomy is performed (A). Aortic stay sutures draw the root toward the thoracotomy and center the valve. The short working distance and near-perpendicular trajectory provide a uniform en face view of the annulus across all three sinuses (B). The native leaflets are excised, the annulus is debrided and sized, and a sutured, rapid-deployment, or sutureless prosthesis is delivered and seated perpendicularly under direct vision, with continuous visualization of the annulus, prosthetic components, and coronary ostia.

The native leaflets are excised, annular calcium is carefully removed, and the annulus is sized in the usual manner. The favorable geometry facilitates perpendicular delivery and seating of the prosthesis, whether a conventional sutured, rapid-deployment, or sutureless valve is used. It also improves visibility of the prosthetic components throughout implantation, simplifying valve positioning and allowing continuous verification of the relationship among the prosthesis, annulus, and coronary ostia (*Figure 10*).

Left atrial appendage occlusion

The left atrial appendage can be reached through the same transaxillary access. When the appropriate intercostal space has been selected, the transverse sinus lies almost directly in front of the thoracotomy.

Rotation of the flexible aortic clamp toward the assistant opens the transverse sinus and improves exposure of the left atrial appendage. Exposure can be further enhanced by placing a right atrial suspension suture directed caudally. A flexible plastic retractor is positioned within the transverse sinus to maintain it fully open and provide direct visualization of the appendage down to its base.

A traction suture is placed at the apex of the left atrial appendage. The epicardial clip delivery system is advanced along this suture toward the base and positioned under direct vision. Before deployment, the entire base must be included, and the relationship among the clip, left atrial appendage, left superior pulmonary vein, and left circumflex coronary artery must be carefully verified. Transesophageal echocardiography is used to confirm complete exclusion and the absence of a significant residual stump (*Figure 11*).

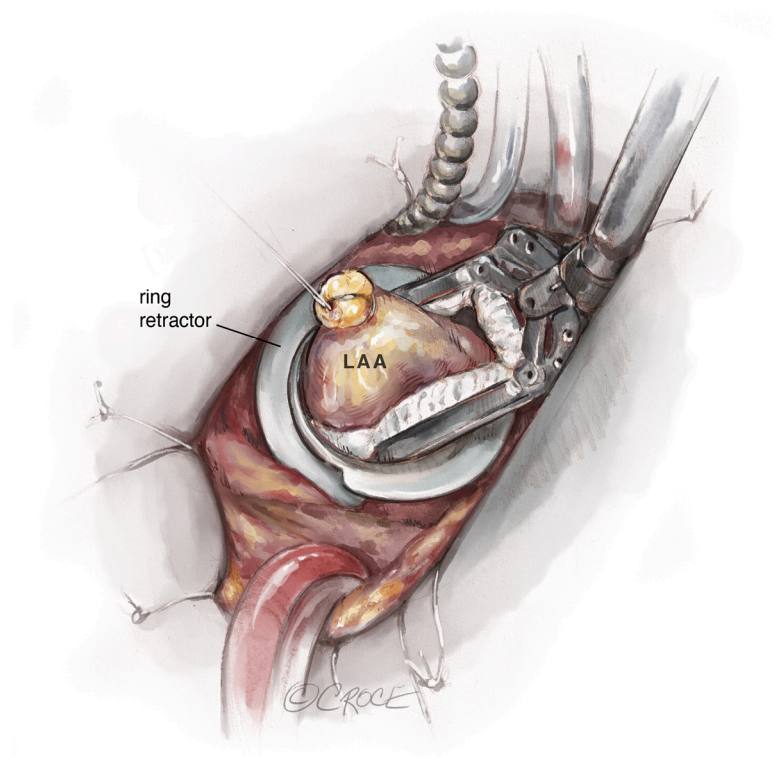


Figure 11 Left atrial appendage occlusion. Rotation of the flexible aortic clamp toward the assistant opens the transverse sinus. A caudally directed right atrial suspension suture and a flexible plastic retractor further expose the appendage to its base. A traction suture is placed at the appendage apex, and the epicardial clip delivery system is advanced along this suture to the base. Before deployment, complete inclusion of the appendage base and its relationship to the left superior pulmonary vein and left circumflex coronary artery are verified. The same exposure also permits surgical excision and direct polypropylene closure using a cut-and-sew technique. LAA, left atrial appendage.

The proximity and quality of exposure also permit surgical excision of the appendage. In our early experience, before specifically designed epicardial occlusion devices became available, the left atrial appendage was treated using a cut-and-sew technique, with surgical excision followed by direct closure using polypropylene sutures.

What not to do

The procedure should not be continued through an incision that is incorrectly aligned with the operative target. Early enlargement or repositioning of the access is safer than attempting to compensate for unfavorable geometry through excessive instrument angulation.

Pericardial stay sutures should not be exteriorized through remote transthoracic stab incisions, as this redirects traction away from the operative access and increases the working distance. Excessive or asymmetric traction should also be avoided, particularly near the phrenic nerve, venae cavae, and right superior pulmonary vein.

A low threshold should be maintained for extending the incision or converting to sternotomy whenever safe cannulation, myocardial protection, de-airing, quality of repair, or adequate hemostasis cannot be ensured.

Completion

After completion of the intracardiac procedure, the atriotomy or aortotomy is closed using standard techniques. The heart is filled progressively, and de-airing is performed through the aortic root cannula under transesophageal echocardiographic guidance. After adequate de-airing, the aortic clamp is removed and cardiac rhythm is restored as required.

The patient is weaned from cardiopulmonary bypass. Transesophageal echocardiography is then used to confirm ventricular function, valve competence, prosthetic function, and the absence of intracardiac air.

The pericardial sutures are released sequentially, and the operative field is inspected for bleeding. Thoracic drainage is placed through a separate small opening or through an existing cannulation site according to institutional practice. Because the ribs are not divided, no chest-wall reconstruction is required. The intercostal space, muscle layers, and skin are closed conventionally.

When operative conditions, hemostasis, and physiological parameters are favorable, an ultra-fast-track strategy with extubation in the operating room can be considered (8).

Comments

Clinical results

Published experience supports the applicability of the transaxillary platform across different valve targets. In a comparative series including 454 transaxillary mitral procedures, propensity-matched analysis of 402 patients showed a 30-day mortality of 0.25% and postoperative stroke rate of 0.7%. The approach was associated with shorter ventilation, intensive care unit stay, and hospitalization than full sternotomy (3).

In a consecutive series of 1,000 isolated transaxillary aortic valve replacements, the 30-day major adverse cardiac and cerebrovascular event rate was 1.9%, including 0.9% mortality, 0.8% perioperative stroke, and 0.6% myocardial infarction (4).

In an ultra-fast-track transaxillary mitral cohort of 356 patients, 79% were extubated within 6 hours and 45% were extubated in the operating room. Overall 30-day mortality and stroke rates were both 0.3% (8).

These data derive from experienced centers and should not be interpreted as eliminating the need for structured training, appropriate patient selection, and institutional quality monitoring.

Advantages

The principal advantage is preservation of the natural surgeon-patient interface. Direct three-dimensional vision and physiological depth perception reduce the visuomotor translation required by camera-mediated platforms. Although long-shafted minimally

invasive instruments remain necessary, the surgeon retains direct visual control and a familiar operative strategy.

The incision provides central rather than target-specific access. Aortic, mitral, tricuspid, and associated atrial procedures can be performed using the same patient orientation, surgeon position, and basic operating room setup. Only the anatomical target changes; the platform does not.

The technique requires no endoscopic tower or robotic system, and the flexible aortic clamp is introduced through the main thoracotomy rather than an additional port. This reduces dependence on complex technology and eliminates an additional intercostal access.

The lateral incision avoids sternotomy and rib division and is generally concealed beneath the resting arm or along the lateral extension of the inframammary crease, providing a favorable cosmetic result. The short working distance and standardized exposure also support procedural efficiency, an important consideration because prolonged aortic cross-clamp time is associated with adverse postoperative outcomes (9).

Caveats

Preoperative imaging remains essential. Severe iliofemoral vascular disease may preclude peripheral arterial cannulation, whereas extensive right pleural adhesions, major chest-wall deformity, or a markedly leftward ascending aorta may compromise access.

The approach is exposure-dependent. A technically correct skin incision alone is insufficient. Optimal results require appropriate table tilt, target-specific arm positioning, correct intercostal-space selection, and systematic pericardial traction.

The seven-stay-suture technique must be learned and reproduced consistently. Inadequate traction leaves the operative target deep within the chest, whereas excessive traction may distort the venae cavae, pulmonary veins, or atrial wall.

The transaxillary approach does not eliminate the learning curve or the need for conventional surgical judgment. Programs should begin with selected isolated procedures and progress to valve repair, multivalve surgery, and combined operations only after the team has achieved reproducible cannulation, exposure, myocardial protection, and de-airing.

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Footnote

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Conflicts of Interest: The author has no conflicts of interest to declare.

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