

# Minimally Invasive Aortic Valve Replacement

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The conventional technique of aortic valve replacement consists of a full sternotomy, cardiopulmonary bypass, and subsequent replacement of the diseased aortic valve. Minimally invasive aortic valve surgery was introduced in the mid 1990s in an attempt to reduce the trauma of surgery and improve cosmesis. With this trend in mind, Cosgrove and Sabik in 1996 reported the first minimally invasive approach to aortic valve replacement using a right parasternal incision.<sup>1</sup>

Current minimally invasive approaches for aortic valve surgery include right mini-thoracotomy and partial upper sternotomy.<sup>2,3</sup> The parasternal approach was abandoned due to a high incidence of postoperative lung herniation. Although cardiopulmonary bypass is still required, these approaches provided the benefit of smaller incisions, less postoperative pain, reduced blood loss, and quicker return to preoperative function. The key factor during the planning of these operations still remains safety and excellent outcome when compared with a traditional aortic valve replacement.<sup>4</sup>

## Operative Technique

We describe the surgical technique for a right thoracotomy approach. The patient is intubated with a double lumen endotracheal tube to enable lung isolation. A retrograde cardioplegia catheter is placed percutaneously with transesophageal echocardiogram (TEE) guidance.

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Dr. Gillinov reports receiving fees from Edwards Lifesciences and Onyx. Dr. Mihaljevic reports receiving fees from Intuitive Surgical, Edwards Lifesciences and Atricure.

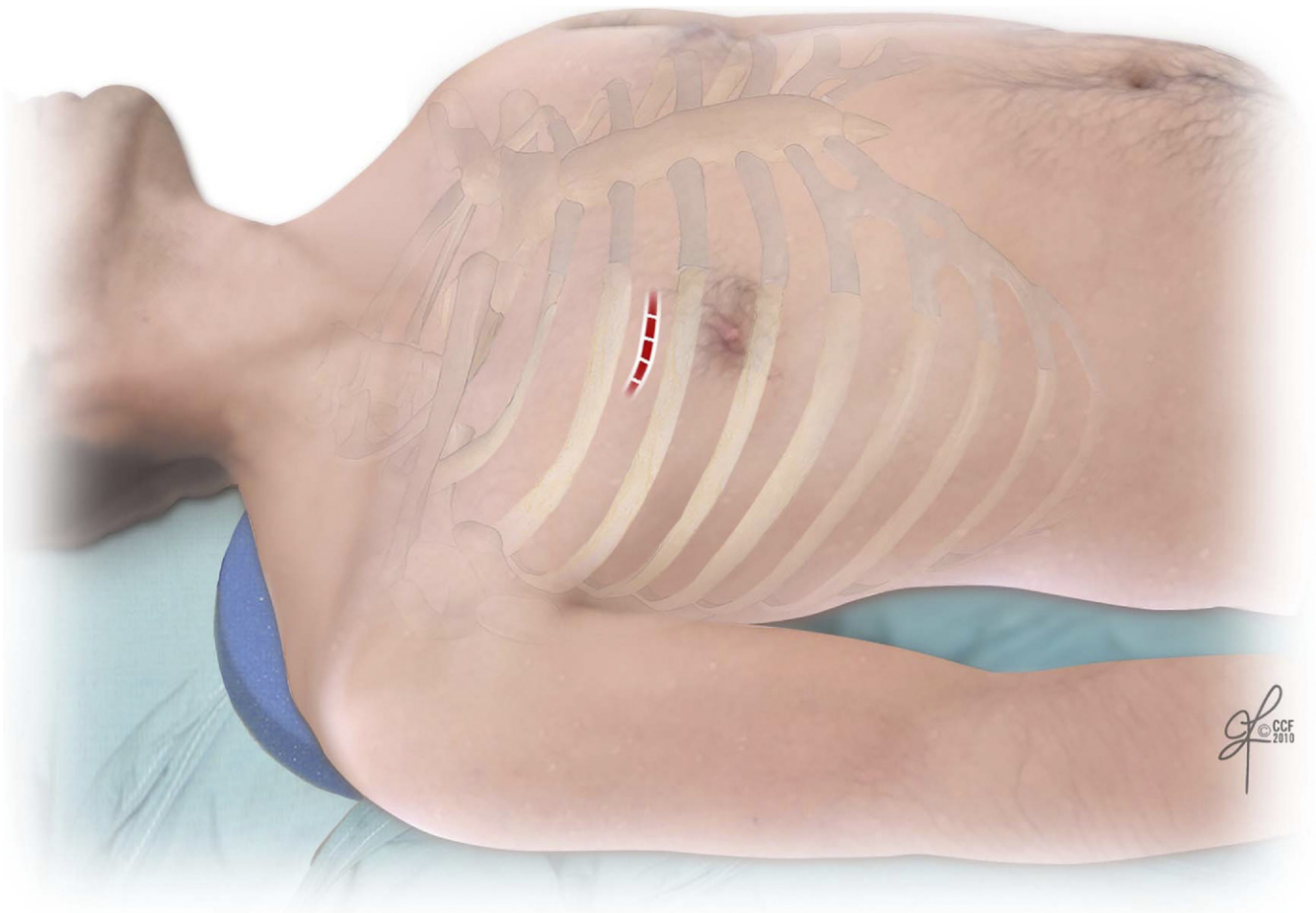
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Surgical access is accomplished with a right mini-thoracotomy through a 6-cm skin incision placed in the second intercostal space. The pericardium is opened and retracted with 2 silk sutures brought out through the chest wall.

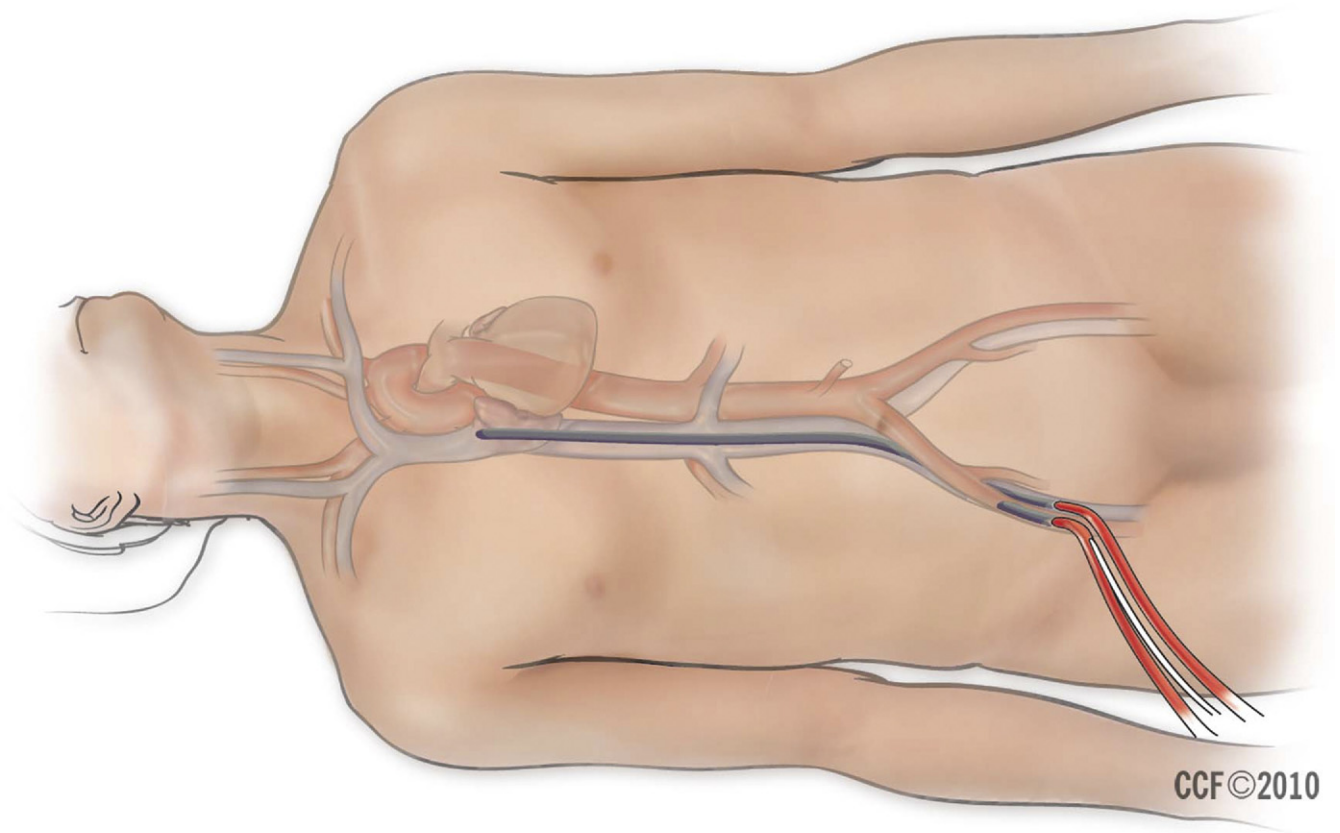
Femoral vessels are exposed via a small oblique incision in the right groin. The patient is heparinized. Venous cannulation is performed under TEE guidance. The cannula is placed through the right femoral vein into the right atrium with the tip lying in the superior vena cava. When the venous cannula is in place, the arterial cannula is placed through the right femoral artery using the Seldinger technique. Antegrade cannula is placed in the ascending aorta under direct visualization. The operation is performed with normothermic cardiopulmonary bypass.

The aorta is cross-clamped directly through the thoracotomy with a flexible aortic clamp. Antegrade and retrograde blood cardioplegia are used for myocardial protection. After cardiac arrest is achieved, the aortic valve is exposed through an oblique aortotomy. Three 2-0 silk commissural sutures are placed to expose the entire valve. The native valve is excised and the annulus is debrided. Prosthesis size is chosen after sizing the annulus with valve sizers. Valve implantation is performed using 2-0 Ethibond pledgeted sutures placed on the ventricular side of the annulus. Aortotomy is closed with 2 layers of running 4-0 Prolene sutures.

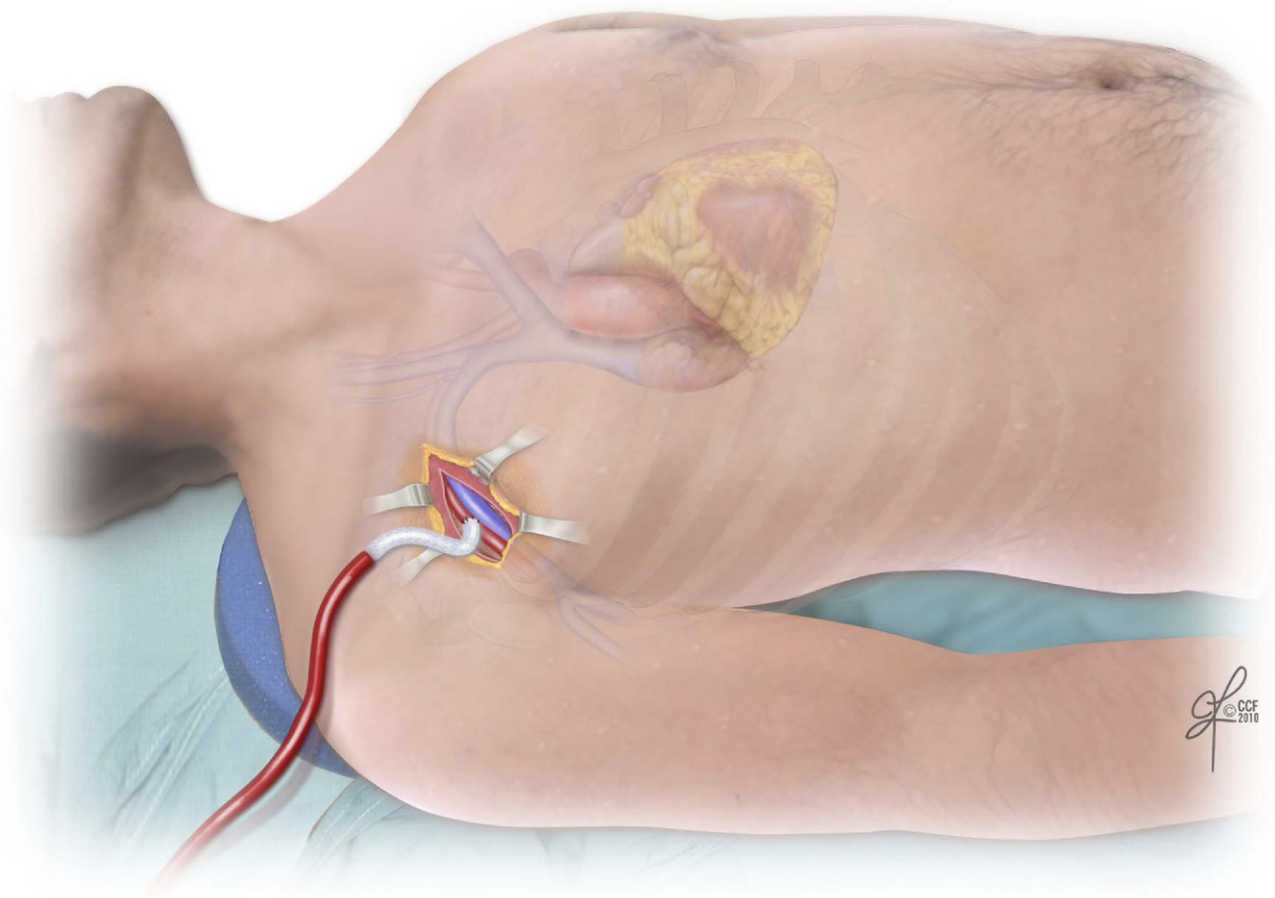
While on cardiopulmonary bypass, ventricular pacing wires are placed on the surface of the right ventricle and brought out through the skin. In the event of inadequate cardiac rhythm, external defibrillation is performed through externally placed defibrillator pads. The patient is weaned from cardiopulmonary bypass (CPB) and TEE is used to assess adequate function of the prosthesis. A right chest tube is placed via a separate stab incision in the 5th intercostal space; the ribs are reapproximated, and wound closure is performed.



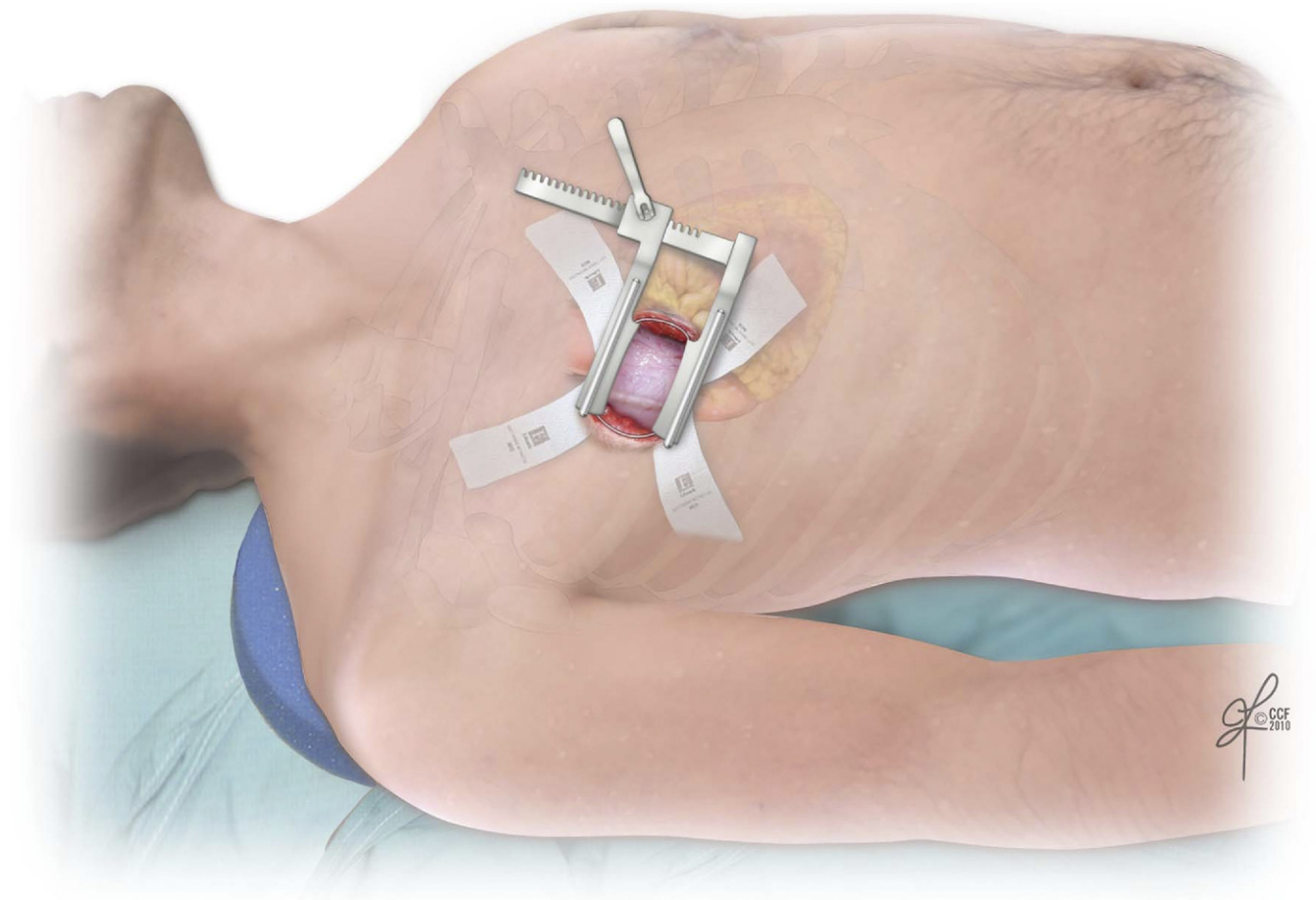
**Figure 1** The patient is positioned supine and a 6-cm incision is made in the 2nd intercostal space. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)



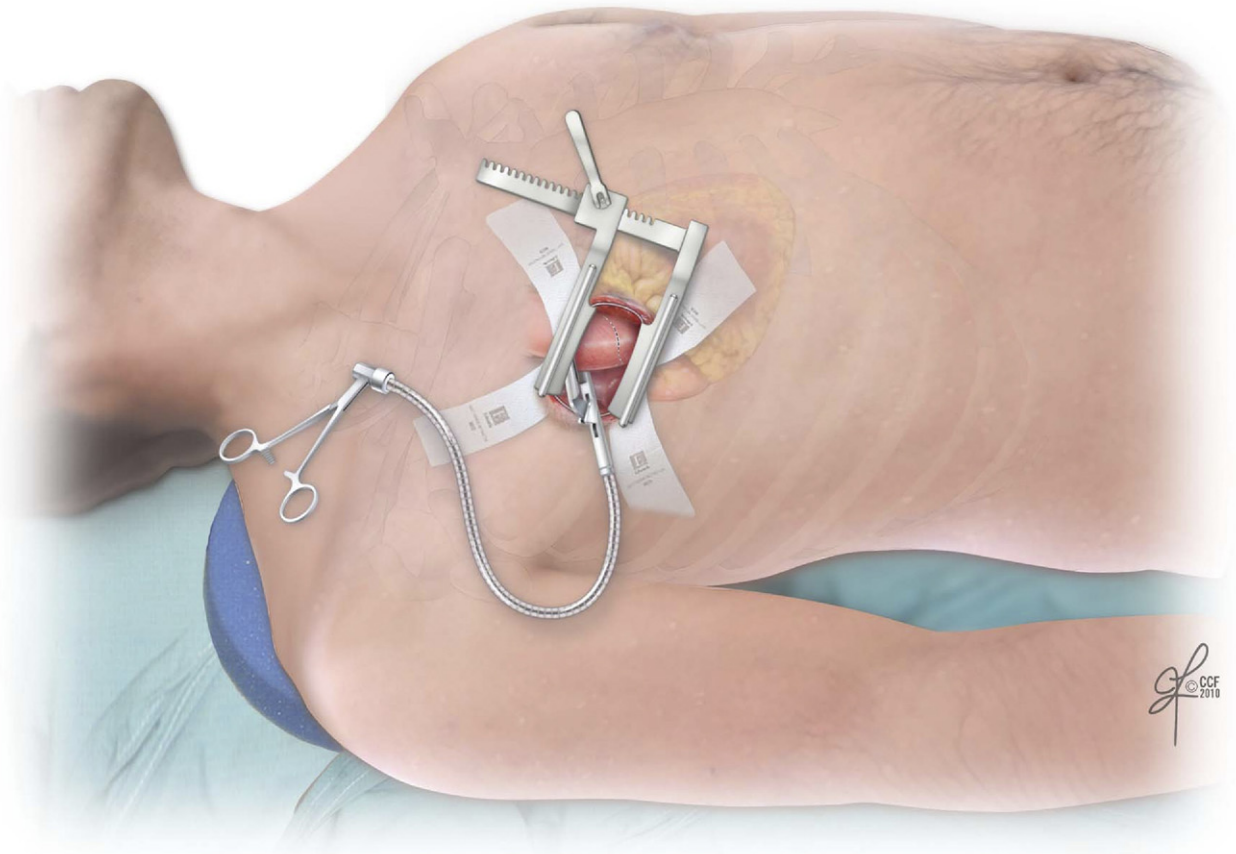
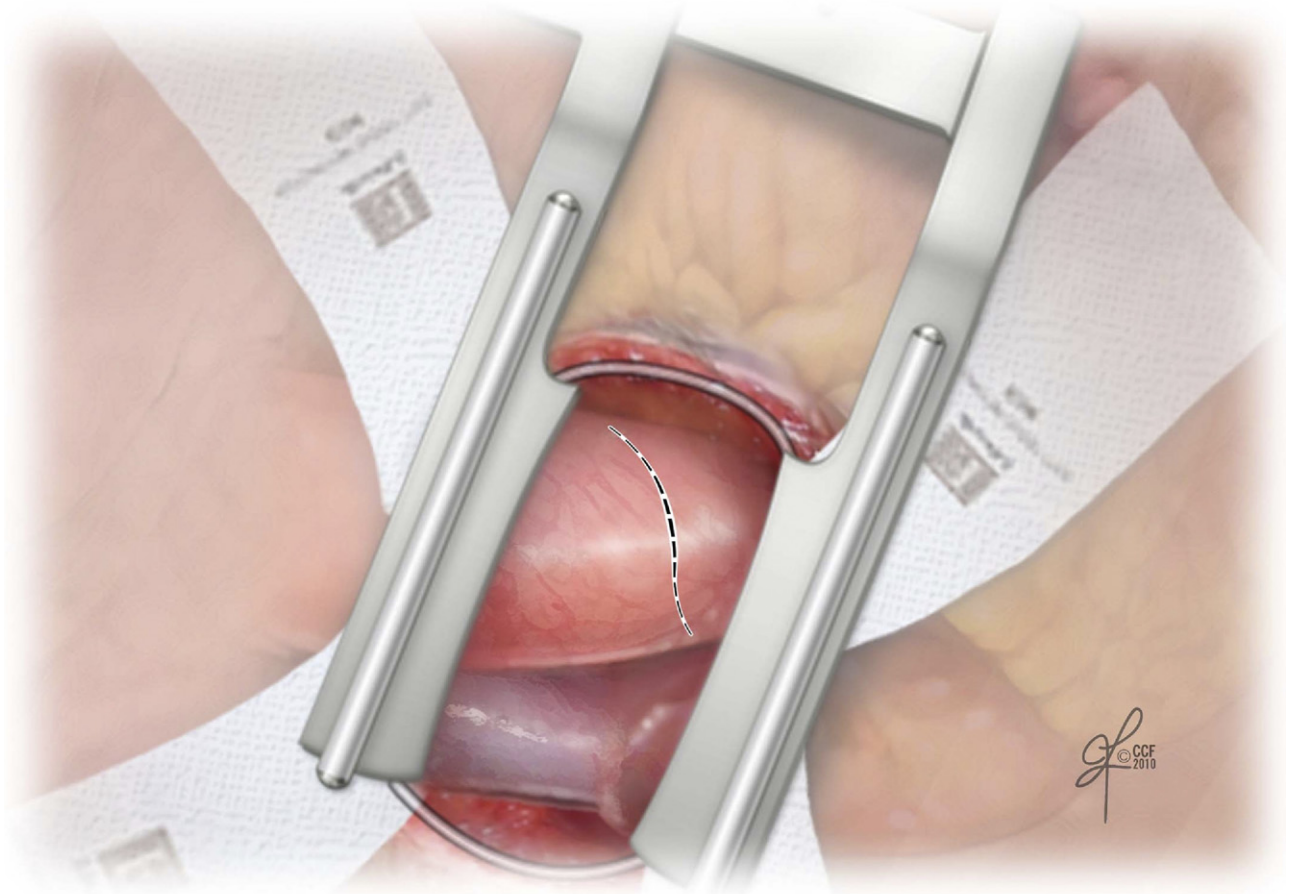
**Figure 2** Cannulation strategies: Right groin exposure to cannulate the femoral artery and vein. Cannulation is performed using Seldinger technique under TEE guidance. Venous cannula is advanced into the superior part of the right atrium to ensure optimal drainage. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)



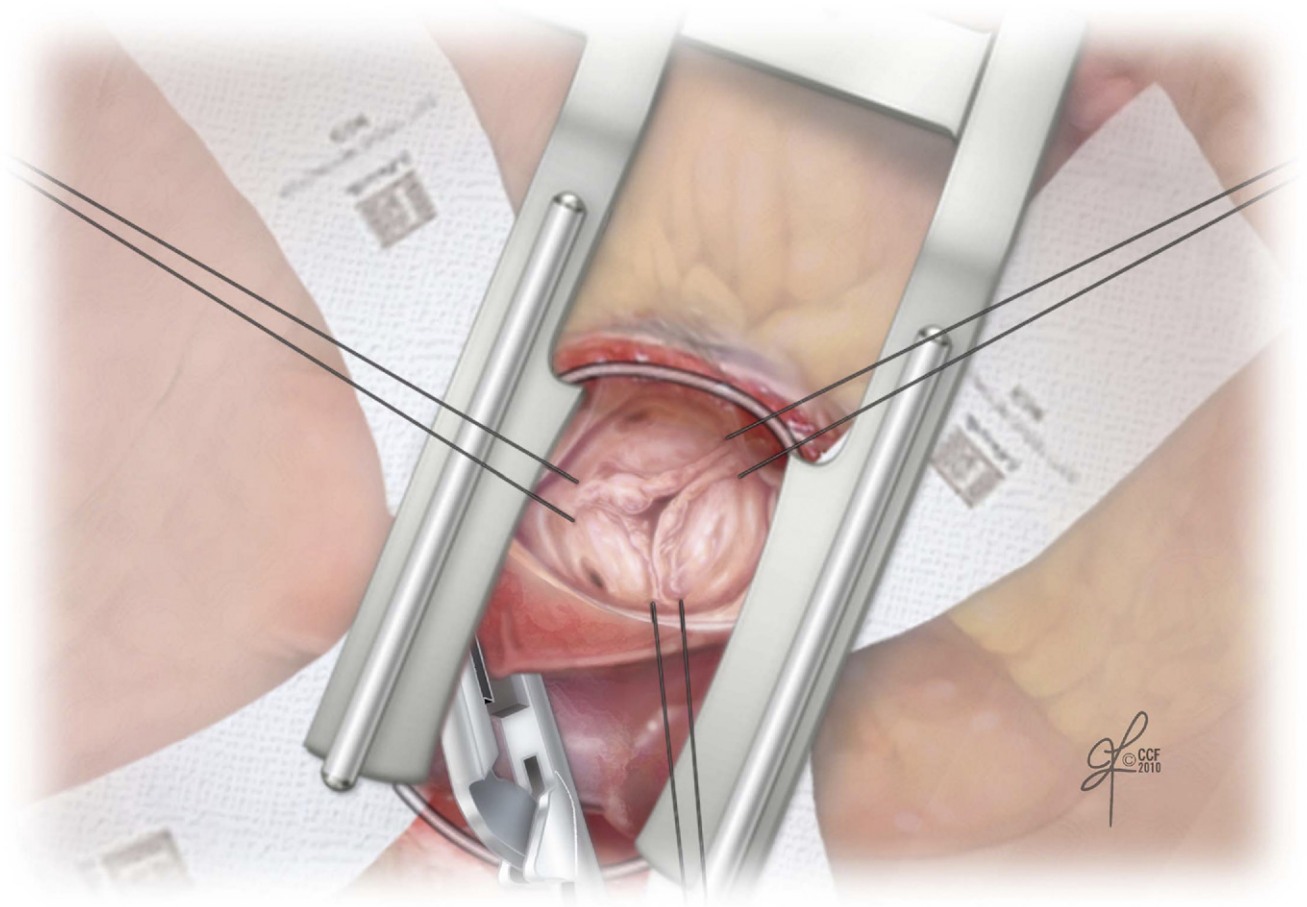
**Figure 3** Axillary artery cannulation may be considered in patients with atherosclerosis of the aortic arch, descending aorta or femoral arteries in whom retrograde perfusion is contraindicated. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)



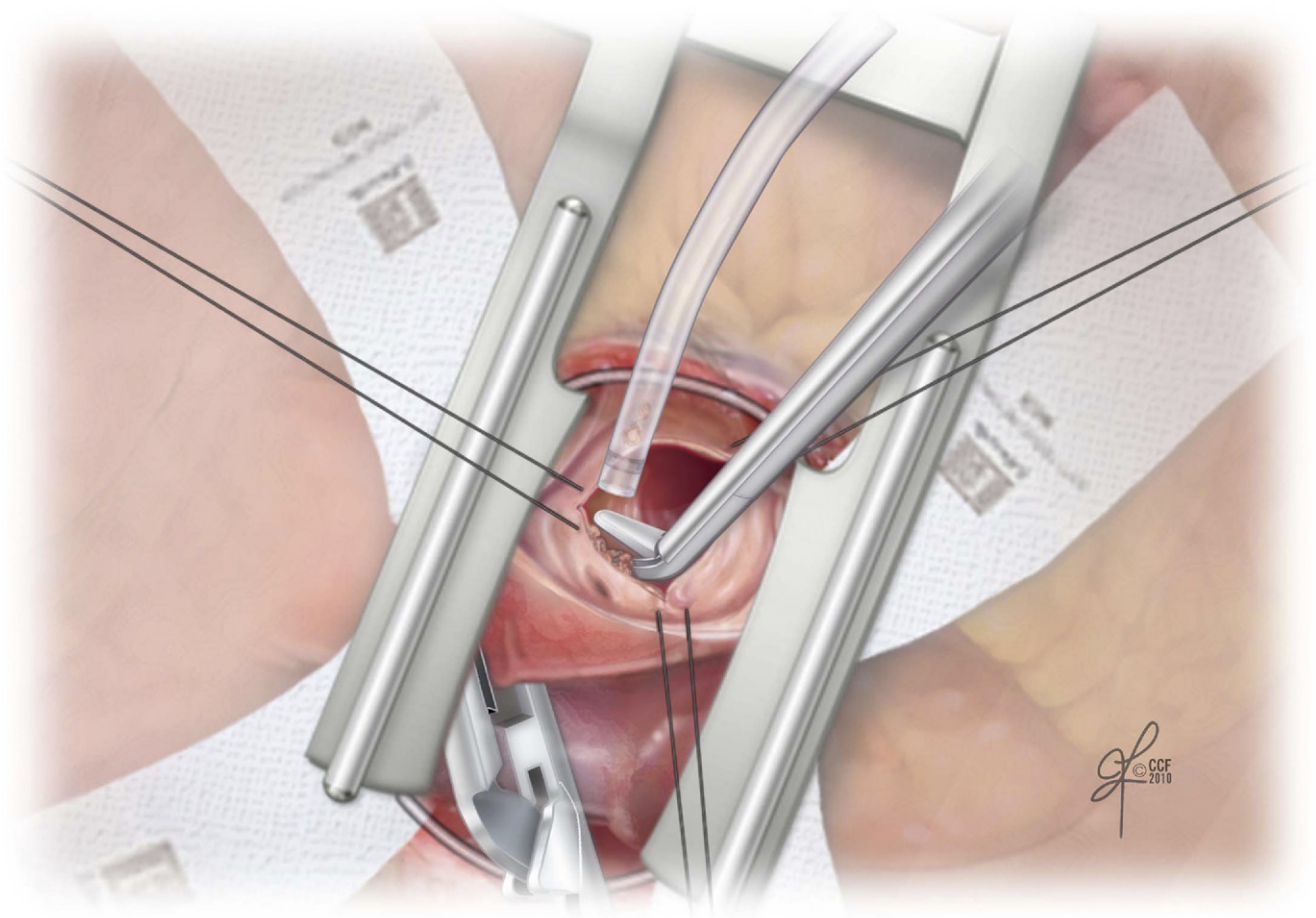
**Figure 4** A soft tissue retractor is placed and lateral aspect of the pericardium is visualized. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)



**Figure 5** The right phrenic nerve is identified and pericardium is incised anterior to the nerve and suspended. The aorta is crossclamped with a flexible clamp and oblique aortotomy is made. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)

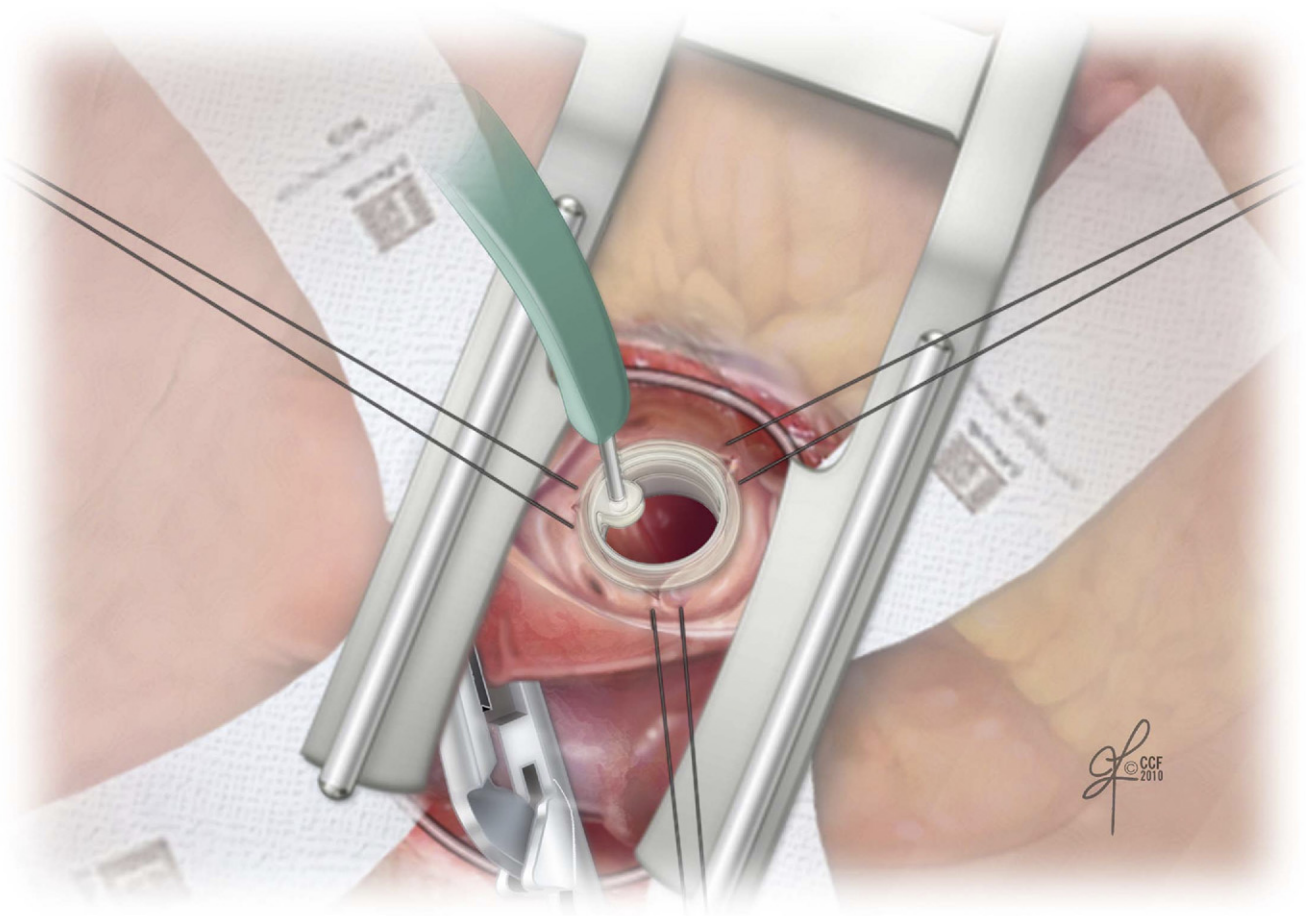


**Figure 6** The aortic valve is exposed by placing three 2-0 silk sutures through the commissures. This brings the valve into the field, making it accessible for excision of the native valve leaflets and debridement of the annulus. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)

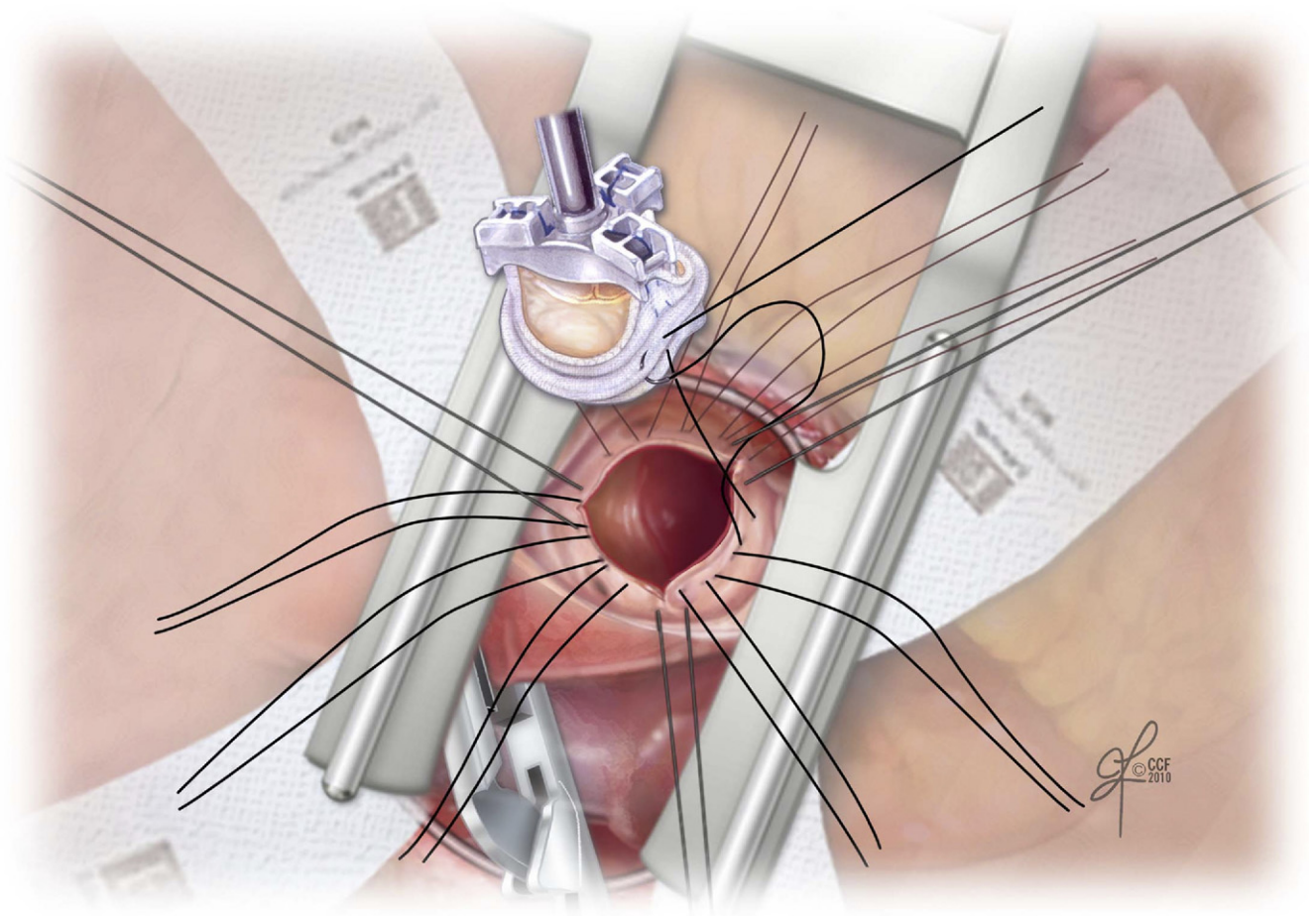


**Figure 7** The leaflets are excised and annulus is debrided. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)

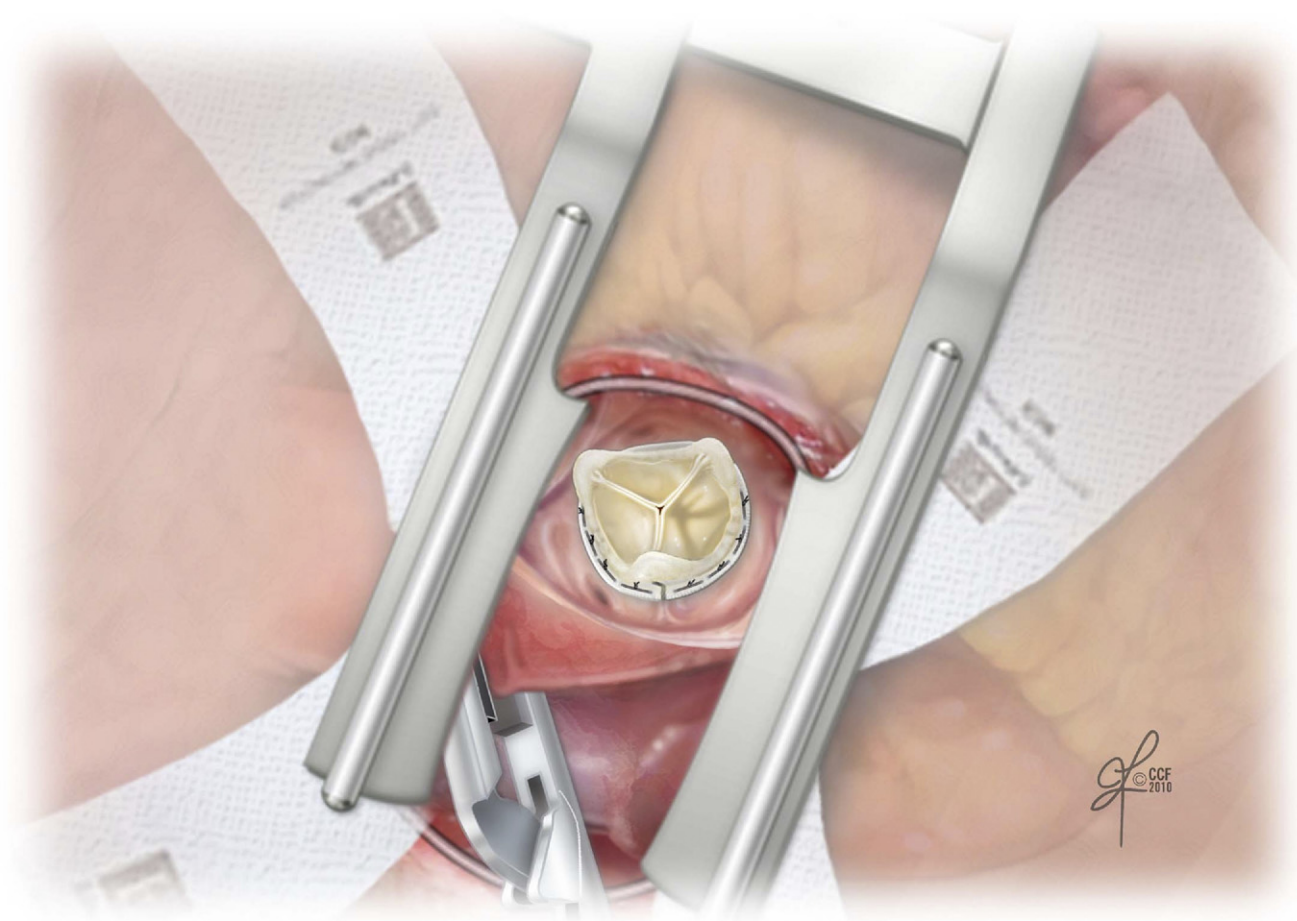




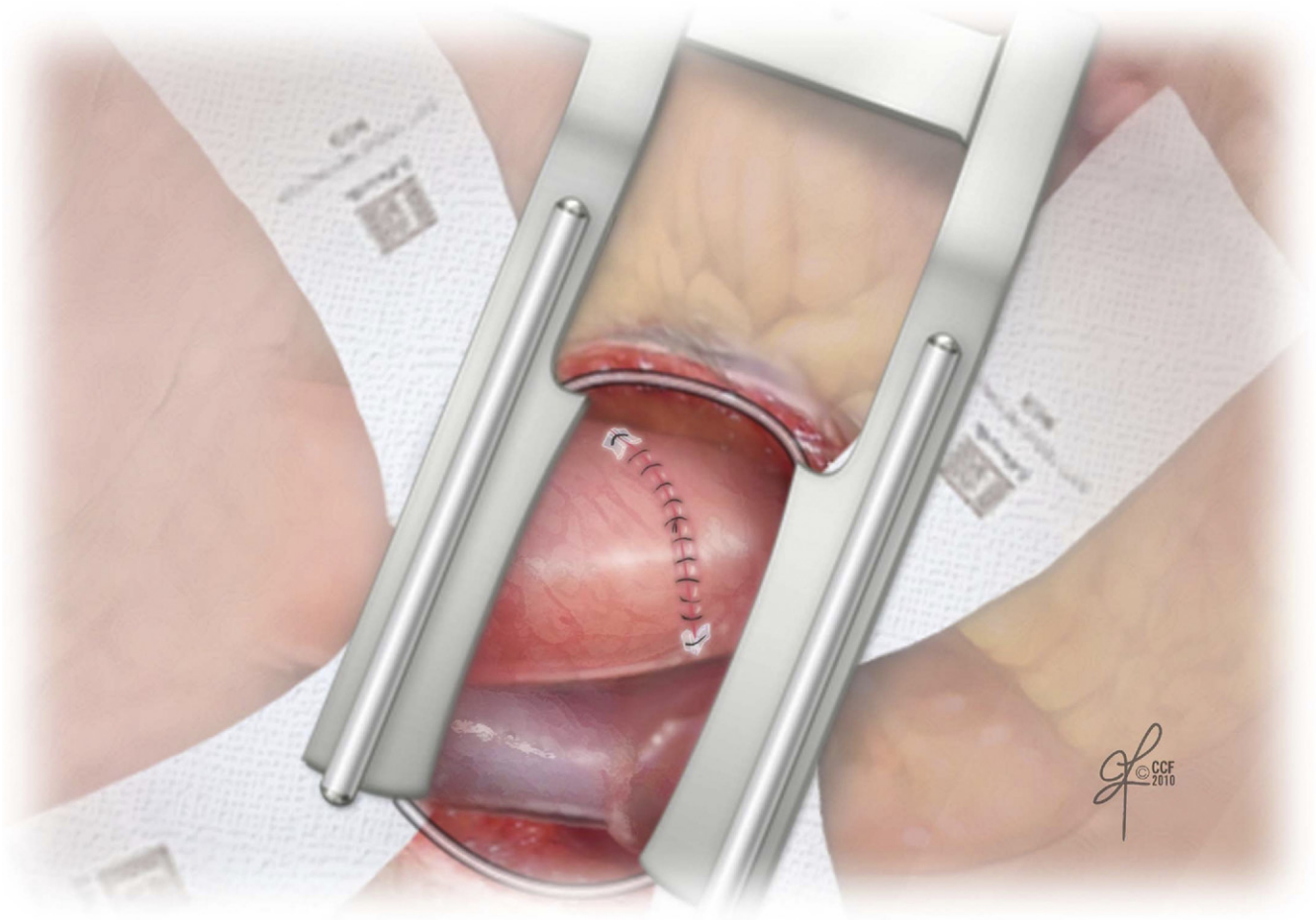
**Figure 8** Valve sizers are used to measure the orifice. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)



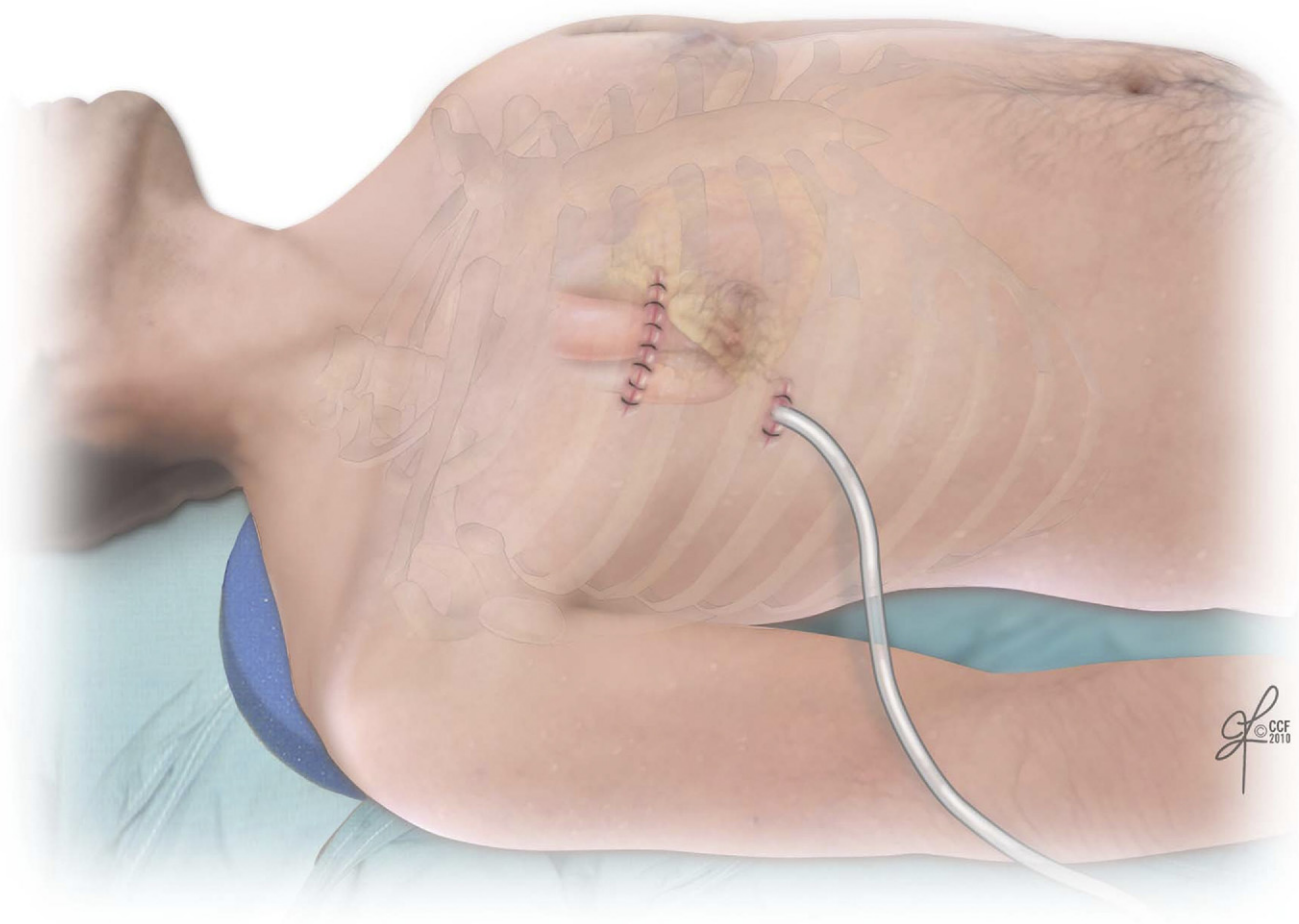
**Figure 9** The appropriate size valve is placed. 2-0 Ehtibond sutures are placed in the annulus with the pledget on the ventricular side. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)



**Figure 10** The valve is seated in the annulus and coronary ostia are visualized. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)



**Figure 11** The aortotomy is closed with running 4-0 Prolene suture. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)



**Figure 12** After pacing wires are placed, a right chest tube is placed via a separate stab incision. (Reprinted with permission, Cleveland Clinic Center for Medical Art & Photography © 2010-2011. All Rights Reserved.) (Color version of figure is available online at <http://www.optechtcs.com>.)

## Additional Technical Points

To avoid common pitfalls, the following may need consideration:

- (1) Preoperative planning and selection are key to the success of any surgical procedure. For a right thoracotomy approach we recommend a noncontrast computed tomography of the aorta for evaluation of atheroma or other aortic diseases (dissection, vascular anomalies), which would preclude retrograde perfusion. In such cases cannulation strategy via direct aortic cannulation or axillary artery cannulation should be alternated.
- (2) In case of injury to the right internal mammary pedicle, it may need to be ligated.
- (3) Placement of the ventricular wires while the heart is still decompressed on CPB is advised. Hypertrophy and limited incision make this nearly impossible to do safely while off CPB.
- (4) The opening of the pericardium should be anterior to the phrenic nerve and retraction sutures should be placed far from it to prevent both direct and traction injury to it.
- (5) Myocardial protection is of utmost importance. We deliver cardioplegia every 15 minutes, to maintain arrest. In the case of no retrograde access, antegrade

cardioplegia is administered via the ostia with flexible cannulas intermittently throughout the procedure.

## Discussion

Minimally invasive aortic valve replacement has undergone many refinements in the last decade. Partial upper sternotomy represents a minimally invasive approach of choice for isolated aortic valve repair or replacement at Cleveland Clinic. The mini right thoracotomy is used less commonly. Despite increased technical complexity of minimally invasive approaches, safety and efficacy of operations are not compromised, and lesser invasiveness results in shorter hospital stay and faster recovery.<sup>4,5</sup>

## References

1. Cosgrove DM 3rd, Sabik JF: Minimally invasive approach for aortic valve operations. *Ann Thorac Surg* 62:596-597, 1996
2. Gillinov AM, Banbury MK, Cosgrove DM: Hemisternotomy approach for aortic and mitral valve surgery. *J Card Surg* 15:15-20, 2000
3. Svensson LG, D'Agostino RS: "J" incision minimal-access valve operations. *Ann Thorac Surg* 66:1110-1112, 1998
4. Mihaljevic T, Cohn LH, Unic D, et al: One thousand minimally invasive valve operations: early and late results. *Ann Surg* 240:529-534, 2004
5. Cohn LH, Adams DH, Couper GS, et al: Minimally invasive cardiac valve surgery improves patient satisfaction while reducing costs of cardiac valve replacement and repair. *Ann Surg* 226:421-426, 1997