Minimally-Invasive Surgery: Reoperative AVR

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Abstract
This article reviews the issues surrounding reoperative aortic valve repairs.

INTRODUCTION
In the past, aortic valve surgery involved the placement of a mechanical prosthesis. In fact, there were only a few generally accepted indications to use a biological valve for primary, aortic valve replacement: (1) the presence of well-established contraindications to continuous anticoagulation; (2) the inability to adequately monitor prothrombin levels; and (3) operative patients whose long-term survival is limited and more dependent on non-valve related issues.\[1,2\]

To improve the long-term outcome of patients receiving biological valves, the hospital mortality rate of aortic valve re-replacement should be identical to that of a primary valve procedure.\[1]\] Reoperations are technically demanding and many patients present in a poor functional state with hemodynamic deterioration. This combination has increased the reoperative mortality rate of failing aortic bioprostheses up to 19%.\[3,4,5\] However, elective replacement of malfunctioning aortic bioprostheses has been performed with results equal to the primary operation.\[1,6\] The presence of concomitant coronary artery disease and pulmonary hypertension has been shown to clearly identify high-risk patients.\[1]\] Patients need careful annual surveillance once the probability of bioprosthetic dysfunction begins increasing 6-7 years after implantation.\[1]\] In regards to valve surveillance, the following variables have been shown to be clinically relevant: a history of endocarditis prior to the first operation; small valvular bioprostheses; perioperative infectious complications; coronary artery disease acquired after the first operation; an increase in pulmonary artery pressure; and a decrease in left ventricular function.\[1]\] Given these factors, proper timing of the reoperation is important. Emergency reoperation of a porcine valve, itself, has been the most important factor in determining overall patient outcome (yielding a consistently high early mortality rate of 25 - 44%).\[4]\]

RE-STERNOTOMY
The evolution of cardiac surgery has led to the popularization of various surgical approaches. Thoracotomy was once used extensively to gain access to mediastinal structures. Then, median sternotomy became the widespread standard to surgically attack cardiovascular disease. However, in reoperative cases, repeating the sternotomy brings definite risks. Prior to proceeding with a resternotomy, the relationship between anterior structures and the posterior aspect of the sternum (as visualized on chest x-ray, or computed tomography [CT]), must be assessed carefully.\[9\] Preparations for emergency femorofemoral cardiopulmonary bypass (CPB) should be complete prior to beginning the resternotomy. Sternal wires from the previous operation should be carefully undone, but left in place as a safeguard during sternal division. An oscillating (not reciprocating) bone saw is then usually used to divide the anterior table. Some authors, then recommend, dividing the posterior table using either a combination of scissors or the Lebsche knife.\[9,10,11\] Following this, the pericardium and other mediastinal structures adhering to the posterior aspect of the sternum should be dissected using rake-retraction before trying to place a small sternal retractor. The pericardial dissection plane can then be developed at the cardiophrenic angle, then advanced cephalad and laterally on the surface of the right heart. Cephalad dissection starts with inominate vein identification; from there, dissection can carry down the superior vena cava - noting location of the right phrenic nerve. Repairing small ventricular or atrial lacerations should not be attempted before releasing the adhesions surrounding the laceration. Repair of great vessel injuries is best done under CPB.\[9\] Active hemorrhage
during a second sternotomy is usually due to adherence of the heart or great vessels to the posterior sternum. Whether this could be prevented by interposition of pericardium or other mediastinal tissue at the time of the first operation, is debatable. The actual incidence of resternotomy hemorrhage is unknown but reported to range between 2 – 6% per patient reoperation. In a descriptive report of 552 patients who had undergone reoperative prosthetic valve surgery, 23 patients (4%) had complications related to opening. Of these, five patients suffered direct entry into the right atrium, 7 patients had lacerated right ventricles, 9 patients had injuries to the aorta, and 2 patients had a previously placed coronary graft divided. Nineteen of the 23 complications occurred during the first-time reoperation and there were 2 overall operative deaths. The first death involved division of a previously placed coronary graft during re-entry and the other was due to laceration of the aorta with subsequent exsanguination.

Macanu et al. reviewed their experience with 100 patients undergoing resternotomy. Eighty-one patients had one repeat sternotomy while the others had undergone multiple sternotomies. All had a valve procedure in the past and were reoperated upon for progressive rheumatic valvular disease or for complications related to the prosthesis. Outcome events included operative hemorrhage in 8 patients, postoperative hemorrhage in 2, seroma in 4, and dehiscence, wound infection, and hematoma in 1 patient each. There was one operative death directly related to resternotomy hemorrhage. When hemorrhage does occur during opening, the natural reaction is to try and gain adequate exposure. However, this is not the appropriate surgical reaction. To do so, would require completing the sternotomy and risk losing control of the isolated tear. A more appropriate response is to immediately heparinize the patient and obtain femoral cannulation (both arterial and venous). Blood lost during the resternotomy should be aspirated with cardiotomy suction and returned to the pump-oxygenator; once bypass is established, core-cooling can commence and flow rates reduced while the sternal division completed. Then, direct repair of the underlying injury can be accomplished. This lethal complication is, of course, best avoided. As an attempt to minimize the risk of re-entry, other surgical approaches to reoperative valve surgery have gained popularity.

MINIMALLY-INVASIVE AVR

“Minimally-invasive” cardiac valve procedures have gradually become more accepted as new technologies and instrumentation develop. In reoperative procedures, these “minimally-invasive” procedures may be of great benefit. One example of this, is the approach described by Byrne and colleagues. In all patients, peripheral cannulation sites are exposed and dissected prior to beginning the partial resternotomy. An “inverted T” partial upper resternotomy is then carried out to the 3rd or 4th intercostal space depending on the estimated position of the aortic valve as documented by TEE. The oscillating saw is used to divide the anterior sternal table while the straight Mayo scissors, under direct visualization, are used to divide the posterior sternal table. The chest wall incision is then extended laterally into the intercostal spaces on both sides. In the setting of a patent LIMA-LAD graft, or other anterior CAB grafts, patients can be placed on CPB early. Mediastinal dissection is usually limited to the ascending aorta for clamping and aortotomy. The aortic valve is then replaced based on specific patient indications.

Reoperative procedures are challenging due to diffuse adhesions and usually, a large incision. This incision increases the operative field and is associated with a higher risk of injury to cardiac structures and bypass grafts. A smaller incision, on the other hand, will reduce the area of pericardiotomy - limiting these effects. The remaining intact lower sternum will preserve integrity of the caudal chest wall which enhances sternal stability and may promote an earlier extubation. One of the key components to “minimally-invasive” approaches is the degree of limited dissection. With reop-AVR, the right atrium is dissected only for the purpose of cannulation. This limited dissection may the principle reason for decreased bleeding and postoperative transfusion requirements. The right ventricle, which is often attached to the sternum, does not need to be dissected. Also, injuries to and manipulation of patent but atherosclerotic vein grafts can be reduced.

Arterial and venous cannulation sites can vary considerably - reflecting the individual choice of the operating surgeon. Other cannulation sites include the axillary artery, innominate vein, percutaneous femoral vein, and percutaneous jugular vein. The use of innominate vein or percutaneous femoral vein cannulation, as well as the use of the retrograde cardioplegia coronary sinus catheter have been helpful in minimizing dissection.
CONCLUSION

The most common cause of valve re-replacement is the structural degeneration of a porcine bioprosthesis. In patients with a biological valve, structural deterioration begins to increase steadily over time (especially in the young). Accelerated follow-up should be the rule in these patients to avoid missing early degeneration; allowing patients to fall into New York Heart Association functional class IV has been shown to affect reoperative mortality directly. The proper use of minimally-invasive techniques will likely continue to improve overall outcomes in reoperative valve surgery, though valve re-replacement remains a serious challenge in modern-day cardiac surgery.

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References

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