Endoscopic Mitral and Tricuspid Valve Surgery After Previous Cardiac Surgery

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Background—The purpose of this study was to evaluate the feasibility and effectiveness of a right video-assisted approach for atrioventricular valve disease after previous cardiac surgery.

Methods and Results—Between December 1st 1997 and May 1st 2006, 80 adults (mean age 65±12 years; 56% female) underwent reoperative surgery using a video-assisted approach without rib spreading. Previous cardiac operations included mitral valve (39%), CABG (29%), congenital (10%), and other (23%). For 25% of patients, this was at least their third cardiac operation. Mean time to redo surgery was 15±12 years. Femoral vessel cannulation and endoaortic clamping were routinely used. Mean preoperative Euroscore was 9.0±2.7 (5 to 20) and predicted mortality was 16.0±14.2% (4 to 86). Median preoperative NYHA class was II and mean follow-up was 25±22 months. Lung adhesions necessitated sternotomy in 4 cases and cannulation problems in another patient. Total operative mortality was 3.8% (n=3), O/E for mortality being 0.24. Procedures were mitral valve repair (45%; n=36), replacement (50%; n=40) and tricuspid valve replacement (5%; n=4). Additional procedures were performed in 44% (n=35). Mean aortic crossclamp and procedure time were 92±37 and 267±64 minutes. Mean postoperative blood loss was 815±1083 mL. Postoperative morbidity included 2 strokes (2.5%). Mean hospital stay was 10.7±6.7 days. Survival at 1 and 4 years was 93.6±2.8% and 85.6±6.4%. There was 1 late reoperation at 5 years. Median NYHA class at follow-up was II. When comparing, all but 1 patient (98.8%) preferred their minimally invasive approach when considering perioperative pain, postoperative rehabilitation, and final esthetic result.

Conclusions—Video-assisted minimal access correction of atrioventricular valve disease after previous cardiac surgery is not only feasible but had lower than predicted mortality and strong patient satisfaction. It should therefore be used more frequently in today’s practice. (Circulation. 2007;116[suppl 1]:I-270–I-275.)

Key Words: mitral valve • tricuspid valve • surgery • reoperation • endoscopic

In the history of cardiac surgery, the mitral valve was initially approached through a right thoracotomy. Indeed, this approach enables a direct exposure and excellent visibility of the entire left (and also right) atrium. With the advent of coronary artery surgery, however, standard median sternotomy rapidly became the unique approach for all cardiac procedures. Because sternal reentry causes a higher morbidity and mortality, the original approach revived in reoperative mitral and tricuspid valve surgery. Based on our extensive experience with Port-Access Surgery (PAS) in primary mitral valve surgery, we extended the application of this technique to mitral and tricuspid valve surgery after previous cardiac surgery. This study reports the feasibility and outcome of this approach.

Methods

Between February 1st 1997 and May 1st 2006 prospective data were collected in 1024 patients who had mitral or tricuspid valve surgery with PAS. The study was approved by the institutional review committee. From this total patient group, we selected 80 patients (7.8%, operated between December 1st 1997 and May 1st 2006) in whom the procedure was a reoperation. The first operation had also been a thoracoscopic procedure in 4 of these cases.

The preoperative characteristics of this group are detailed in Table 1 and their previous cardiac operations in Table 2. The mean number of patent bypass grafts in patients with previous CABG was 1.9±1.1. Table 3 details the coronary grafts, their status at preoperative planning. Mean time to redo surgery was 14.9±11.4 years. Mean preoperative Euroscore was 9.0±2.7 (5 to 20), and predicted mortality was 16.0±14.2% (4 to 86).

All patients were screened preoperatively for adequate vascular access either by 1 additional dye injection in the iliac artery at the time of cardiac catheterization or by angio MRI. We do not perform routine preoperative screening of the ascending aorta.

Patients with isolated mitral valve regurgitation were scheduled for MVP. Complex or mixed pathology, patients with previous mitral valve procedures (MVP or MVR), or patients with severely depressed left ventricular function were considered for MVR. Four

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I-270
TABLE 1. Preoperative Characteristics (n=80)

<table>
<thead>
<tr>
<th>Variable</th>
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<tr>
<td>Mean age (range)</td>
<td>65.1±11.9 years (29–84)</td>
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<tr>
<td>Female</td>
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<td>Mean body mass index, kg/m²</td>
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<td>Severely impaired</td>
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<td>Mean LVEDD (n=57)</td>
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<td>Mean LVEDVI (n=43)</td>
<td>97.8±28.8 mL/m²</td>
</tr>
</tbody>
</table>

COPD indicates chronic obstructive pulmonary disease; PVD, peripheral vascular disease; IDDM, insulin dependent diabetes mellitus; LVEDD, left ventricular end-diastolic diameter; LVEDVI, left ventricular end-diastolic volume index.

patients had an isolated tricuspid valve procedure. The median preoperative degree of mitral and tricuspid valve regurgitation was 3 and 1, respectively.

Postoperatively, chest tubes were routinely kept for 48 hours. Postoperative analgesia consisted of 10 mg piritramide (Dipidolor, Janssen-Cilag) IV and 10 mg piritramide IM at the time sedation was stopped in the ICU. Once the patient was extubated, analgetics were only given at the request of the patient. The patients were anticoagulated with fenprocoumon (Hoffmann) for 3 months and were then switched to acetylsalicylic acid unless they were in atrial fibrillation or had undergone mechanical valve replacement.

Operative Technique

The technical details have been described extensively in previous publications and are summarized here.1-11

In all patients a double-lumen endotracheal tube is placed. The anesthesiologist percutaneously introduces a 14F or 17F DLP venous cannula (Medtronic DLP) through the right internal jugular vein. In all cases cardiopulmonary bypass was instituted via the femoral vessels. A limited 5-cm skin incision is made under the right nipple in men and in the right inframammary groove in women (Figure 1). A working-port is made in the fourth intercostal space and the thoracic cage is embedded with CO₂. No rib spreader is used. Extensive lung adhesions may necessitate a change of strategy. The inferior venous cannula (21F to 28F, Medtronic DLP) is positioned in the right atrium under echoguidance. Seldinger technique is used to diminish dissection and avoid vessel clamping. The arterial cannulation (21F or 23F) is done using the same technique and its Y-arm allows introduction of an endoaortic balloon (EndoClamp, Cardiovascular).

In tricuspid valve surgery, both caval veins are snared. Myocardial preservation was obtained by arresting the heart (cold antegrade crystalloid cardioplegia) and hypothermic cooling (range: 20°C to 31°C, mean 27.2°C). In 1 patient with 2 patent mammary artery grafts, the mitral valve was replaced on the beating heart with spontaneous cooling of the patient to 30°C.

In cases where surgical ablation of atrial fibrillation was performed, we used the monopolar radiofrequency probe (CardioBlade, Medtronic). The left atrial appendage was excluded in patients with a history of TIA or CVA.

TABLE 2. Previous Operations (n=80)

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MV indicates mitral valve procedure; CABG, coronary artery bypass grafting; ASD, atrial septal defect closure; AV, aortic valve procedure; HTX, heart transplantation; ASC, ascending aortic replacement; PFO, patent foramen ovale closure; VSD, ventricular septal defect closure; SUBV. MEMBR, subvalvular aortic Membrane resection; TV, tricuspid valve procedure.
Follow-Up

All patients were followed at the outpatient clinic 6 to 8 weeks postoperatively. Further follow-up was done by the referring cardiologist. Our follow-up was performed from March to May 2006 by contacting patient, general practitioner, and cardiologist to obtain complete clinical and echocardiographic follow-up. Patients were also questioned about perioperative pain sensation, how fast postoperatively they had regained professional or expected activity, and whether they were pleased with the postoperative esthetic result.9–10

Mean clinical follow-up was 25 ± 11 months (154 patient-years) and 100% complete.

The New York Heart Association functional class at follow-up (n = 73) was class I in 30 patients, class II in 35 patients, class III in 7 patients, and 1 patient in class IV. At follow-up 56% of the patients were in sinus rhythm, 29% in atrial fibrillation, and 15% had pace-maker rhythm.

Data Analysis

The design of the study was retrospective. However, all preoperative, operative, and in-hospital data are collected prospectively. Postdischarge data were collected retrospectively. Data are expressed as the mean ± SD. Survival and event-free estimates were determined by Kaplan-Meier analysis and expressed as proportion ± SE. The Kaplan-Meier analysis for survival was performed using the total patient population of 80 patients according to the intention to treat principle. For freedom from reoperation analysis, we wanted to focus this on endoscopically treated patients and therefore censored the 5 patients who underwent an immediate intraoperative conversion to sternotomy on the day of operation.

Analysis was performed with the Statistica package Release 5.1 (StatSoft).

The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

Results

Hybrid therapy was planned preoperatively in 2 cases. Patients were not considered for hybrid therapy if occluded grafts served either small or collateralized territories. The choice for percutaneous intervention and timing was made on an individual basis.

To optimize peripheral vascular access, 1 patient underwent a dilatation and stenting of the iliac artery and another an ileo-femoral bypass.

Operative Outcome

Immediate intraoperative conversion to median sternotomy was required in 5 cases, 4 because of extensive lung adhesions and 1 because of cannulation problems. No other patient required conversion.

Procedures performed are depicted in Table 4. Mean aortic cross-clamp, cardiopulmonary bypass, and procedure times were 92 ± 37 (range 35 to 262), 147 ± 43 (range 75 to 273), and 267 ± 64 minutes (range 150 to 445), respectively.

Caval snaring was uneventfull in all cases. In 1 fourth redo case, it was anticipated to be hazardous because previous operative reports mentioned very dense adhesions. Therefore, both inferior and superior venous canulae were armed with a side arm through which an endoluminous balloon (Talent, Medtronic) was introduced. Correct positioning was guided by TEE, and balloon inflation caused endoluminous caval closure (Figure 2).

If right ventricular free wall dissection for temporary pacemaker wire insertion is hazardous, the wire can be placed intracavitary through the tricuspid annuloplasty or bioprosthesis (Figure 3).

Postoperative Course

Mean postoperative bloodloss was 815 ± 1083 mL (range 90 to 6590 mL; median 445 mL). Mean ICU time was 2.9 ± 4.9

TABLE 3. Type and Status of the Previously Performed Coronary Bypass Grafts at Preoperative Evaluation (n=32)

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<th>%</th>
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<tr>
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</table>

GSV indicates greater saphenous vein; LIMA, left internal mammary artery; RIMA, right internal mammary artery; PTCA, percutaneous transluminal coronary angioplasty; RCA, right coronary artery; LAD, left anterior descending artery

TABLE 4. Procedures Performed (n=80; Including 5 Conversions to Sternotomy)

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<thead>
<tr>
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</table>

MVP indicates mitral valve repair; MVR, mitral valve replacement; TVP, tricuspid valve repair; TVR, tricuspid valve replacement; AF, Atrial Fibrillation; ASD, Atrial Septal Defect

*Including 6 patients with paravalvular leak closure.

**Including 1 patient with paravalvular leak closure.
days (range 1 to 36; median 2 day) and mean hospital stay was 10.7±6.7 days (range 2 to 43; median 9 days).

Total 30 day mortality was 3.8% (n=3; Observed/Expected ratio=0.24). One 44-year-old ex drug addict had a severely degenerated and calcified bioprosthesis which desintegrated peroperatively. She underwent mechanical valve replacement but died on POD 2 due to a generalized intraoperative stroke. A second 77-year-old patient was operated in septicemia secondary to mitral valve endocarditis. She further deteriorated in septic shock with expiration on POD 2. Finally, a third patient developed respiratory failure with evolution to MOF and ultimately expired on POD 13.

Reexploration for bleeding occurred in 6.7% (n=5). Other postoperative interventions included a peripheral embolec- tomy after removal of a preoperatively inserted intraaortic balloon pump and 1 ICD implantation. Other postoperative morbidity is shown in Table 5. Of note is the absence of perioperative myocardial infarction.

**Out of Hospital Follow-Up**
Late death occurred in 4 patients. Causes were sudden death, pneumonia (2×), and heart failure (3 years postoperatively). Survival at 1 and 4 years was 93.6±2.8% and 85.6±6.4% (Figure 4).

There was 1 late reoperation at 5.2 years. Cause was a paravalvular leak and this patient underwent AVR, CABG, and MVP through median sternotomy. Freedom from reoperation was 100% at 1 and 83.3±15.2% at 6 years (Figure 5). Other follow-up events included 1 dilatation of the external iliaca artery, 1 gastric bleeding, and 1 patient with a lymphocoele.

When comparing, all but 1 patient (98.5%) preferred their minimally invasive approach when considering perioperative pain, postoperative rehabilitation, and final esthetic result.

**Echocardiographic Follow-Up**
Late transthoracic echocardiographic (TTE) follow-up (mean 20.8±21.7 months) was available in 92.2% of patients. In 32 MVP patients, the grade of regurgitation was nil in 13 patients, 1 in 13 patients, 2 in 5 patients, and 3 in 1 patient. None of the MVR or TVR patients had a paravalvular leak. In TVP patients, regurgitation was absent in 4 patients, grade 1 in 4, and grade 2 and grade 3 in 1 patient each.

**Discussion**
Minimal invasive surgery has become a routine technique for primary mitral and tricuspid valve surgery.8–12 Based on our own experience, we extended this technique to redo operations. Our current findings confirm previously published reports. Indeed, Onnasch et al reported their findings in 39 patients who underwent redo mitral valve surgery using PAS.13 They demonstrated the safety of this approach in reoperations. Practical and potential benefits of this approach are: the avoidance of sternal reentry, limited cardiac dissec- tion and no dissection of patent grafts, decreased transfusion rate, decreased wound complications, decreased overall mor- bidity, and a decreased length of stay. Each of these factors potentially contributes to a decreased (peri)operative mortality. Indeed, our observed 30-day mortality of 3.8% was well below the predicted mortality using the logistic Euroscore. Other authors have published conflicting results regarding operative mortality. Burfeind et al14 published their experience in mitral surgery after prior cardiac surgery using either PAS, repeat median sternotomy or right thoracotomy. Blood transusion and mortality were reduced in the Port-Access group, but cardiopulmonary bypass times were longer. Bolotin et al15 however, found no difference in mortality and cardiopulmonary bypass times, but in their series postoperative intubation time, blood transusion, and hospital stay were significantly reduced.

The mean blood loss in the current study was still important but can be explained by excessive bleeding in 4 patients.

### TABLE 5. Postoperative Morbidity Other Than Death and Reintervention (n=80)

<table>
<thead>
<tr>
<th>Type of Complication</th>
<th>Total No.</th>
<th>Total % of 80</th>
</tr>
</thead>
<tbody>
<tr>
<td>Postoperative TIA</td>
<td>2</td>
<td>2.5</td>
</tr>
<tr>
<td>Pneumonia or respiratory failure</td>
<td>7</td>
<td>8.8</td>
</tr>
<tr>
<td>Subcutaneous emphysema</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>New onset atrial fibrillation</td>
<td>12</td>
<td>15.0</td>
</tr>
<tr>
<td>Pacemaker implantation</td>
<td>8</td>
<td>10.0</td>
</tr>
<tr>
<td>Myocardial infarction</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Renal insufficiency requiring dialysis</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Wound infection</td>
<td>1</td>
<td>1.3</td>
</tr>
<tr>
<td>Postoperative drainage of right pleural effusion</td>
<td>1</td>
<td>1.3</td>
</tr>
</tbody>
</table>

---

**Figure 2.** Balloonoclusion of the Inferior Caval Vein (IVC).

**Figure 3.** Temporary pacemaker wire inserted through a bioprosthesis.
Indeed, the mean blood loss was $815 \pm 1083$ mL with a median of 445 mL.

In their experience of reoperative mitral valve surgery, Bolotin et al.\textsuperscript{15} had a blood transfusion requirement of 2.9 U in the minithoracotomy group compared with 5.5 U in the sternotomy group. These results suggest an advantage in red blood cell transfusion rate.

Patients with open coronary bypass grafts are particularly at risk in redo cases via median sternotomy. An injury to a patent graft may be fatal. An anterolateral right thoracotomy avoids the dissection of patent grafts, thereby reducing operative risk.\textsuperscript{16,17} However, a possible downside of this approach may be the risk for suboptimal myocardial protection. This is why 2 patients underwent a hybrid approach. Intraoperative myocardial protection in our series was obtained by systemic cooling and cardiac arrest by administration of cold antegrade crystalloid cardioplegia. Alternatively, slight systemic cooling and beating heart surgery may be performed.\textsuperscript{5} Indeed, Thompson et al reported excellent results in 125 patients (22 patients with previous CABG) who underwent mitral valve replacement using a right thoracotomy beating heart technique.\textsuperscript{17} We mainly used cardiac arrest and systemic cooling in the present study and were satisfied with the cardiac outcome as evidenced by the absence of perioperative infarction. Byrne et al reported similar results in 21 patients operated on via right anterolateral thoracotomy.\textsuperscript{16} Akins et al reviewed series of over 100 patients undergoing reoperative mitral valve replacement through median sternotomy. Mortality was between 10% and 15.3%. In their own series of 219 patients with reoperation through sternotomy for failed mitral valve prosthesis, mortality was 6.8%.\textsuperscript{18} Our currently observed operative mortality of 3.8% compares favorably to this although one should emphasize that our series includes both valve repair and valve replacement and that in our series not all first cardiac procedures were mitral valve interventions. Therefore, we may not directly compare both patient groups. However, it does indicate that the mortality rate in our series is well within favorable limits.

A prerequisite to apply the present technique is adequate vascular access. This is carefully checked preoperatively.
either during heart catheterization or by angio MRI. This strategy enables detection of iliac or common femoral artery disease, the extent of which will determine the feasibility of this technique and also avoid vascular complications associated with retrograde arterial flow and endoaortic balloon manipulation. The present series clearly demonstrates the feasibility of this approach, even in reoperations and in selected patients with peripheral vascular disease. In addition, the presence of peripheral vascular disease but adequate iliac access does not preclude the use of the endoaortic balloon. Indeed, the 2 TIAs occurring in elderly patients were postoperative and not perioperative events. The 1 intraoperative stroke leading to death occurred in a young patient without any evidence of vascular disease. She probably died because of embolization of her desintegrated calcified bioprosthesis. In addition, recent data have suggested a lower load of cerebral microemboli when using the endoaortic balloon as compared with the transthoracic clamp.

Of note is that 4 patients previously underwent ascending aortic replacement (see Table 2): 2 with a separate vascular prosthesis, 1 patient as part of a mechanical conduit for aortic root replacement, and 1 with a biological conduit (Shellhigh). The earliest reintervention was after 1.5 years and the longest after 13 years. No particular events occurred. This demonstrates, well within the limits of a small clinical experience, that the Endoclamp (Cardiovations) may be safely inflated within a vascular prosthesis, at least once ingrowth has occurred.

One may argue that the use of the Euroscore is not an appropriate tool to compare clinical versus predicted outcome. Indeed, the Euroscore has been reported to overestimate the operative mortality. The level of overestimation is different for each surgical subcategory and highest (factor 2) for coronary surgery.

In the absence of other, better, evaluation tools, we used the Euroscore as a predictor for clinical outcome and found the clinical negative outcome to be diminished by a factor 4 versus the predicted outcome. Therefore, even tough overestimation may interfere in the Euroscore, we believe we can attribute the favorable clinical outcome to the technique used.

In conclusion, our experience provides further evidence that redo mitral and tricuspid valve surgery with Port-Access is a feasible technique with a reduced operative mortality. Cornerstones of the technique are adequate vascular access and optimal myocardial protection. This technique has become our standard technique to correct atrioventricular valvular disease both in primary and reoperative procedures.

Disclosures

Hugo Vanermen serves as a consultant for Cardiovations and Edwards Lifesciences.

References


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