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Minimally invasive cardiac valve surgery

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Cardiac surgery is the last area of clinical surgery to adopt and embrace minimally invasive surgical techniques. Since the onset of arthroscopic knee surgery in 1975 and laparoscopic cholecystectomy in 1985, huge advances in videoscopic, thoracoscopic, and small incision surgery have taken place in all specialties that now allow for changes in traditional approaches to cardiac valve surgery The advent of minimally invasive cardiac surgery occurred in 1995 with coronary artery bypass surgery. In 1996, the Brigham and Women's Hospital, along with other units,[1-3] introduced minimally invasive cardiac valve surgery for patients who had isolated valve pathology without coronary disease. Our experience now totals over 600 patients, including 300 minimally invasive mitral valve repair/replacements and 300 minimally invasive aortic valve replacements. This new technology involves smaller incisions, the mandatory use of transesophageal echocardiogram (TEE) for monitoring operation quality and air removal, newer perfusion techniques, and modifications in the standard valve repair/replacement techniques.

With this blending of TEE, better perfusion techniques, and new exposure, the safety and quality of valve operations have been beyond reproach. The operative mortality is less than conventional open sternotomy cases and there is a shorter length of stay in the ICU and post-ICU, leading to a lower cost than conventional procedures. There are also less blood transfusions, atrial fibrillation, and post-hospital rehabilitation requirements. Above all, patients have indicated that there is a faster return to normality over conventional operative approaches. This brief report summarizes our experience from July, 1996 - February, 2000.

Clinical rationale

With the advent of minimally invasive techniques to many areas of surgery, it became apparent in the 1990s that minimally invasive surgical techniques could be applied to cardiac surgery. These procedures were delayed because of intra-cardiac air problems and

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Table 1: The demographics of the 2 groups undergoing minimally invasive cardiac valve surgery

1a.	**Aortic (283)**	
	M/F	177/106
	AGE	25-93, 68
	FUNC.CLASS	2.4
1b.	**Mitral (302)**	
	M/F	170/132
	AGE	20-90, 62
	FUNC.CLASS	2.4

Table 2: The devices and operations performed

2a.	**Aortic**	
	Pericardial	126
	St.Jude	86
	Homograft	40
	Porcine	29
	Repair	2
		283
2b.	**Mitral**	
	Pericardial	0
	St.Jude	38
	Homograft	0
	Porcine	6
	Repair	258
		302

the fine line between life and death in every cardiac procedure. In July 1996, at the Brigham and Women's Hospital, we performed our first aortic valve replacement through a minimally invasive 8 cm right parasternal incision in a man with severe aortic stenosis.[4] Since that case, a consistent approach to the performance of these techniques in every patient with isolated valve, has led to a considerable experience with these new techniques.

During this time incisions have changed, operative techniques have become refined, and the approach to perfusion has become one of miniaturization of cannulation techniques, reducing the possibilities of air interference with cardiopulmonary bypass and allowing the streamlining of techniques in both the ICU and postoperative recovery sites.

Clinical material

Tables 1a and b summarize the demographics in the two major patient groups undergoing minimally invasive cardiac valve surgery for aortic and mitral valve disease. The complete gamut of pathology requiring surgical intervention has been treated.[5] The demographics indicate a wide age range, particularly in the aortic valve area, and include many patients in their 90s previously not considered ideal patients for valve replacement. These patients are now increasingly referred for valve replacement because of the ability to perform these operations in a less traumatic manner. Of note, in the aortic series, 37 patients of the entire cohort have undergone minimally invasive reoperative aortic valve replacements, having had either prior coronary bypass surgery with intact coronary artery bypass grafts, or a prior aortic valve replacement which has become dysfunctional either due to perivalvular leak or structural valve degeneration.

Tables 2a and b list the devices used and operations performed. Because our group is a center for mitral valve repair, the vast majority of patients have undergone mitral valve repair for predominantly "floppy" myxomatous valves.[7,8,9] However, mitral valve replacement has been carried out in 44 patients, using both porcine and prosthetic valves. In the aortic area, all forms of valve devices have been utilized through the small incisions, including homograft aortic root replacements and stentless porcine grafts. Associated procedures have been fairly rare. In a few instances in patients with the ideal anatomy, a right coronary bypass was carried out, but these smaller incisions at the present time preclude the use of simultaneous coronary bypass during valve operations for most patients.

Operative technique

Table 3: Operative outcomes in the mitral and aortic groups

3a.	**Aortic**		
	Op Mortality	5/283	(1.7%)
	Transfusion	40/283	(14.1%)
	Stroke	8/283	(2.8%)
	Wound infection	3/283	(1.1%)
	Bleeding	15/283	(5.3%)
	New AF	21/283	(7.4%)
	Late death	15/283	(5.3%)
	Late reoperation	2/283	(0.7%)
3b.	**Mitral**		
	Op Mortality	2/302	(0.75%)
	Transfusion	30/302	(10%)
	Stroke	9/302	(3.3%)
	Wound infection	2/302	(0.75%)
	Bleeding	7/302	(2.3%)
	New AF	13/302	(4.3%)
	Late death	6/302	(2%)
	Late reoperation	4/302	(1.3%)

TEE is mandatory for every patient. The TEE documents the quality of the operation, and most importantly, insures that there is complete removal of intra-cardiac air, one of the early criticisms leveled at this technique.

The mitral valve technique involves exposure of the valve via a trans-right atrial septal incision using a small cannulae for perfusion, with assisted vacuum suction, all performed through a *lower* mini-sternotomy. Once the septum is opened and retracted, mitral valve repair, as well as mitral valve replacement, can be carried out in the usual fashion. When the operation is completed and tested, the septum is closed, the right atrium is closed, and the patient is weaned from bypass.

In the aortic position, all types of aortic valves have been placed through the small *upper* mini-sternotomy incision, including homograft root replacement, stentless porcine valves, and the conventional stented bio-prosthetic and prosthetic valves.

Once patients are weaned off bypass, the vast majority are extubated the same afternoon and spend approximately one day in the ICU. The average hospital length of stay is approximately 4-6 days.

Results

The results of operative therapy in both the mitral and aortic group are indicated in tables 3a and b.

In the mitral valve series, there has been no mortality in the mitral valve repair group, but there has been a 2% mortality in the mitral valve replacement group. Postoperatively, the morbidity is also described in this table, including postoperative bleeding, wound infections, cerebral vascular accidents, and reoperations.

Similarly in table 3a, the postoperative mortality in the aortic series is described. Operative mortality and associated morbidity are shown. Early in our series, bleeding was higher, but there was a very low incidence of wound infections, neurologic events and reoperations.

Discussion

Several surgical groups, including Gundry's group from Loma Linda[2] and Cosgrove's group from the Cleveland Clinic,[1] discussed the concept of minimally invasive valve surgery in early 1996. In July that same year, we began our own series. What is apparent from our experience with this approach is the ability of patients to recover from valve surgery faster. There is less blood utilization, which has been confirmed by a number of different studies, including Cosgrove, Gundry and Chitwood.[1,2,10,11]

Common questions

Who are candidates for this procedure?

At the present time, any patient who has isolated aortic, mitral, or tricuspid disease (without concomitant coronary artery disease) is a candidate for minimally invasive valve surgery. However, in a few

instances, isolated right coronary artery bypass has been carried out when the exposure was optimal in the minimally invasive incision.

Patients who are extremely ill (NYHA class IV) from valvular heart disease, (ie, with a ruptured papillary muscle or extremely low cardiac output), should undergo a complete sternotomy. The reason is that a complete sternotomy tends to be a little faster than the minimally invasive incisions, thus minimizing anesthesia time and the inflammatory aspects of cardiopulmonary bypass as much as possible. Patients who have severe chest wall deformities may not be candidates for minimally invasive surgery since the exposure can be hampered if there is severe pectus excavatum or carinatum. Another group of patients that should not have minimally invasive surgery are those who cannot have a TEE probe placed; the removal of intra-cardiac air depends upon the use of transesophageal monitoring.

Are some operations with isolated valve disease too difficult to perform with minimally invasive valve surgery (ie, anterior leaflet mitral valve repair, in conjunction with posterior leaflet pathology of the mitral valve)?

The answer to this question is no. With the trans-septal approach and lower mini-sternotomy incision, it is quite straightforward to operate on anterior leaflet pathology, including the use of commissuroplasty stitches and new chord formation by Gortex sutures.

If one does the trans-septal approach through the right atrium, is there a higher incidence of arrhythmias?

Again, the answer is no, given the reduced trauma, the incidence of atrial fibrillation may be lower. In addition, the use of these incisions for severe aortic valve disease, with the proper visualization techniques, such as supra-commissural stitches to pull the annulus up into the wound, make these procedures really quite straightforward.

Can the efficacy of the operation be as good through small incisions?

As noted in both the aortic and mitral valve group, there have been a minimal number of reoperations. In the aortic group, only two reoperations were carried out, both for failed aortic valve repairs. There is 0 incidence of reoperation for perivalvular leak, suggesting that the operations are performed competently. In the mitral valve repair group, there have been four reoperations, mostly due to failed valve repairs on very complicated valves. One patient who had a mitral valve repair also had moderate aortic regurgitation which progressed following his mitral valve repair requiring a reoperation aortic valve replacement. In addition, one patient with a mitral valve repair, sustained a dissection at the site of a cardioplegia needle. This was repaired through a similar incision at the same operation by opening up only one additional interspace.

With the exception of a slightly higher incidence of postoperative bleeding in the aortic valve patients in our early experience, all other postoperative complications have been markedly reduced by not performing the full sternotomy. For example, the incidence of sternal wound infection is very low. Only patients who have had procedures such as prior radiation therapy to the chest have had a serious wound problem.

The post-hospital course in these patients has been gratifying. Patients going to rehabilitation centers have been kept to a minimum.[10] The length of hospitalization has been relatively short, with most patients currently discharged from the hospital by their fourth postoperative day. There has been a reduction in blood utilization with these techniques, particularly in the reoperative aortic valve group where there has been excellent results

in elderly patients, some in their 90s, because of the reduction in trauma.

The quality of postoperative experience and return to normality has been evaluated in a study that compared minimally invasive valve surgery to conventional open sternotomy in the patients not having concomitant coronary bypass.[10] It became evident in the first 100 patients that, not only was there a moderate decrease in pain, but most importantly when evaluated by independent clinical evaluators, there was a quicker return to work. The return to normality was much more rapid versus the conventional sternotomy as well, despite a slightly longer pump time and ischemia time at operation.

Summary and conclusions

The experience at Brigham and Women's Hospital has proven to us that minimally invasive valve surgery is a paradigm for the future. These procedures reduce costs and hospitalization and improve the patient's sense of well-being. Despite the somewhat increased difficulty of learning these procedures, the patient's quality of care is maintained at the highest possible standards with the use of TEE to monitor the quality of the operation and prevent intra-operative air embolus.

The minimally invasive cardiac surgery techniques discussed in this summary are a step in a process of evolution that will eventually allow acquired cardiac surgical procedures for both coronary artery bypass and valve surgery to be performed through very small incisions with complex videoscopic and perhaps even robotic procedures.[11] These techniques will further reduce trauma and increase overall patient well-being.

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