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Minimally Invasive versus Standard Approach for Excision of Atrial Masses

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ABSTRACT

Background. Minimally invasive cardiac surgical procedures have become ubiquitous over the past decade. In many cases, these techniques have been associated with decreased morbidity, shorter length of stay, decreased pain, faster recovery, and superior cosmetic results. The purpose of this study was to compare outcomes using a minimally invasive (mini-thoracotomy) versus standard (sternotomy) approach to the surgical resection of atrial masses.

Methods. Analysis was based on 34 consecutive patients who underwent atrial mass resection at the New York-Presbyterian Hospital/Columbia Presbyterian Medical Center in New York, NY. The reference (REF) group included 18 patients who underwent excision of an atrial mass via a standard approach (sternotomy). The minimally invasive (MI) group included 16 patients who underwent excision of an atrial mass via a mini-thoracotomy.

Results. There were no statistically significant differences between the REF and MI groups based on demographic or preoperative characteristics. Tissue diagnosis of the masses resected included myxoma (n = 24), fibroblastoma (n = 3), B-cell lymphoma (n = 1), and other benign masses (n = 6). Cardiopulmonary bypass (70.5 versus 76.5 minutes; $P = .57$) and aortic cross-clamp times (32.7 versus 47.3 minutes; $P = .14$) did not differ significantly between the REF and MI groups, nor did intraoperative transfusion of packed red blood cells (0.35 versus 0.38 units; $P = .93$). As assessed by intraoperative transesophageal echocardiogram, there were no moderate to severe valvular abnormalities observed following chest closure. Intensive care unit length of stay (46.1 versus 26.2 hours; $P = .15$), overall hospital length of stay (6.39 versus 5.06 days; $P = .18$), and time to extubation (0.78 versus 0.44 days; $P = .44$) all trended toward shorter duration in the MI group compared with the REF group—although none of these differences achieved statistical significance. Postoperative transthoracic echocardiograms were obtained in 14 of 34 (41.2%) patients; none revealed any new or significant abnormalities. All patients survived to hospital discharge; one patient in the REF group expired during the follow-up period. Among the 34 patients, 26 patients (76.4%) were at least 2 years postoperative from their resection; 25 of the 26 (96.1%) were alive at 2-year follow-up, and the remaining 8 were alive at 1-year follow-up. All patients were free of recurrence at last follow-up.

Conclusions. Minimally invasive atrial mass excisions can be accomplished reliably without compromising complete tumor resection and without significant increases in operative times or serious adverse events. In addition, measures of recovery time in this study suggest faster recovery among the MI group, which is consistent with the proposed advantages by proponents of minimally invasive surgery.

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INTRODUCTION

Minimally invasive cardiac surgical procedures have become ubiquitous over the past decade. In previous generations, where long, highly invasive operations of significant risk were viewed as heroic, it was said that surgeons were judged by the size of their incision. However, with the advent of minimally invasive technologies—including laparoscopy, endoscopy, robotics, and endovascular treatments—the pendulum has swung in the opposite direction. In fact, in other surgical fields, the minimally invasive approach for many common procedures is preferred, even in cases where efficacy is yet to be clinically established. These include laparoscopic appendectomy, laparoscopic colon resection for cancer, and carotid stenting for carotid stenosis.

Advances in surgical instruments and visualization tools, as well as more adaptable perfusion systems, have enabled cardiac surgeons to perform an increasing spectrum of procedures through smaller incisions. In many cases, these techniques have been associated with decreased morbidity, shorter hospitalization, decreased pain, faster recovery, and superior cosmetic results [Frazier 1998; Glower 1998; Gillinov 1999; Ravikumar 2000; Grossi 2001]. Moreover, these less invasive approaches are associated with a higher level of patient satisfaction [Cohn 1997; Grossi 1999; Morgan 2004].

It is reasonable to expect that minimally invasive approaches to the removal of atrial masses may offer similar advantages. Currently, there are few reports of a minimally invasive approach for the excision of atrial masses, likely due to concerns of restricted access and inadequate excision margins [Cooley 1998; Shennib 1998; Verrier 1998].

The purpose of this study is to compare outcomes using a minimally invasive (mini-thoracotomy) versus standard (sternotomy) approach to the surgical resection of atrial masses. This study is the largest published series describing experience with excision of atrial masses via a minimally invasive approach, and it is the first to compare it with the standard approach.

MATERIALS AND METHODS

Study Population and Setting

Analysis was based on 40 consecutive patients who underwent atrial mass resection at the New York-Presbyterian Hospital/Columbia in New York, New York. The reference (REF) group included 18 patients who underwent excision of an atrial mass via a standard approach (sternotomy). The study or minimally invasive (MI) group included 16 patients who had an excision of an atrial mass via a mini-thoracotomy.

The remaining 6 patients who underwent atrial mass resection required another major cardiac procedure, including mitral value replacement (3) or coronary artery bypass grafting (3), and were excluded from analysis. Patients were not randomized; the surgical approach was determined by the preferences of the patient and surgeon.

Medical Record Reviews

Detailed clinical information for each patient was obtained from the patient's computerized medical record; this included demographics, past medical history, and perioperative information. Operative information was obtained from the operative and perfusion records. Pathology reports of excised tissue were interpreted by attending pathologists at our institution.

Information regarding tumor recurrence and long-term survival was obtained through medical record and telephone follow-up. Among the 34 patients, 26 (76.4%) are at least 2 years postoperative from their resection, with 2-year follow-up available on all 26 patients. All of the remaining 8 patients were at least 1-year postoperative, with 1-year follow-up available on all 8 of these patients.

Minimally Invasive Surgical Technique

After induction of general anesthesia, the endotracheal tube is replaced with a double lumen tube, the position of which is confirmed by bronchoscopy. Next, a venous cannula is placed in the superior vena cava via percutaneous internal jugular vein puncture. After placement of the cordis and Swan-Ganz catheter, the patient is positioned in a modified left lateral decubitus position, with the hips flat and the right arm tucked at the side. A 6-cm incision is then made along the fourth or fifth rib, lateral to the midclavicular line. In women, this is made at the infra-mammary fold. After establishment of single (left) lung ventilation, the chest is entered and the intercostal muscles divided with cautery in the third or fourth intercostal space. A small chest retractor is inserted, and the pericardium opened laterally (anterior to the phrenic nerve). After automated computed tomography–guided heparinization, the aorta is cannulated under direct vision, and a second venous cannula inserted percutaneously through the right femoral vein and advanced to the inferior vena cava–right atrium junction. Alternatively, in many patients the superior vena cava and inferior vena cava are cannulated directly with angled metal cannulas through the mini-thoracotomy incision. Following cannulation, bypass is begun with bicaval venous drainage, and the patient is cooled to 32°C. A Chitwood aortic cross clamp is inserted through a separate stab wound in the anterior walls. The cross clamp is applied to the aorta under direct vision, and 4:1 blood cardioplegia is given antegrade to arrest the heart. Subsequent doses are given antegrade and retrograde at 20-minute intervals. The location of the mass determines whether a transseptal or biatrial approach is utilized. The atrium is examined to assess the site of tumor attachment by direct vision and transesophageal echocardiogram. After the tumor is excised, the septum is closed primarily or with a pericardial patch, the heart closed in standard fashion, and the patient weaned from cardiopulmonary bypass. Once satisfactory hemostasis is confirmed, drains are placed in the pericardial space and right pleural space, and the thoracotomy closed in layers.

Definition of Outcome Measures

Time to extubation was defined as hours between arrival in the intensive unit to extubation. Intensive care unit length of stay was defined as the number of days from date of surgery to the day of discharge to step down unit or patient care floor. Hospital length of stay was defined as the number of days of inpatient stay, beginning on the day of the surgery to the day of discharge home or to a rehabilitation facility. Intraoperative packed red blood cells transfusion requirement was defined as the units of packed red blood cells transfused during the operative procedure. Duration of cardiopulmonary bypass and cross-clamp time were obtained from the perfusion record.

Intraoperative transesophageal echocardiogram was performed in the operating room following chest closure in all patients; these studies were interpreted by an attending cardiac surgery anesthesiologist. Postoperative transthoracic echocardiogram was defined as any echocardiogram obtained following transfer to the intensive care unit; these may have occurred in the intensive care unit, on the patient care floor, or in the outpatient setting. These studies were interpreted by an attending cardiologist who specializes in echocardiogram interpretation.

Analysis

Data were analyzed using a standard statistical software package, Stata 9 (Stata Corp, College Station, TX, USA). Continuous variables were reported as means ± standard deviation and compared using the Student *t* test. To compare

Table 1. Patient Characteristics*

	Reference Group	Minimally Invasive Group	Total	P
Patients, n	18 (52.9%)	16 (47.1%)	34 (100.0%)	
Age, y	58.8 ± 16.1	52.9 ± 19.0	56.0 ± 17.5	.33
Male sex, n	7 (38.9%)	2 (12.5%)	9 (26.5%)	.08
Preoperative creatinine, dL/g	0.83 ± 0.16	0.86 ± 0.30	0.84 ± 0.23	.78
Past medical history				
COPD, n	1 (5.6%)	0 (0.0%)	1 (2.9%)	.34
DM, n	2 (11.1%)	1 (6.3%)	3 (8.8%)	.62
CVA/TIA, n	3 (16.7%)	3 (18.8%)	6 (17.6%)	.87
CAD, n	1 (5.6%)	3 (18.8%)	4 (11.8%)	.21
Previous cardiac surgery, n	1 (5.6%)	1 (6.3%)	2 (5.9%)	.93

*COPD indicates chronic obstructive pulmonary disease; DM, diabetes mellitus; CVA/TIA, cerebrovascular/transient ischemic accident; CAD, coronary artery disease.

categorical variables, the chi-square test was used. The conventional *P* value of .05 or less was used to determine level of statistical significance. All reported *P* values are 2-sided.

RESULTS

Preoperative Characteristics. There were 18 patients in the REF group and 16 patients in the MI group. As described in Table 1, there were no statistically significant differences between the REF and MI groups based on demographic or preoperative characteristics including sex (7 versus 2 men; *P* = .08), age (58.8 versus 52.9 years; *P* = .33), preoperative creatinine (0.83 versus 0.86 dL/g; *P* = .78), or history of chronic obstructive pulmonary disease, diabetes mellitus, coronary artery disease, cerebrovascular accident/transient ischemic accident, or previous cardiac surgery (Table 1).

Pathology. Tissue diagnosis of the masses resected included myxoma (n = 24), fibroblastoma (n = 3), B-cell lymphoma (n = 1), and other benign masses (n = 6). There were no statistically significant differences between the REF and MI groups in pathology of masses (Table 2).

Operative Approach. Of the masses, 9 (26.5%) were contained in the right atrium, and 25 (73.5%) were in the left atrium. All right atrial masses were approached via the right atrium. For left atrial masses resected in the REF group, the biatrial and transseptal approaches were used 3 and 8 times, respectively. For left atrial masses resected minimally invasively, left atrial, biatrial, and transseptal approaches were used in 5, 3, and 6 cases, respectively (Table 3).

Outcomes. Table 4 summarizes the clinical outcomes of the 2 groups. Cardiopulmonary bypass (70.5 ± 28.5 versus 76.5 ± 29.0 minutes; *P* = .57) and aortic cross-clamp times (32.7 ± 22.3 versus 47.3 ± 27.7 minutes; *P* = .14) did not differ significantly between the REF and MI groups, nor did intraoperative transfusion of packed red blood cells (0.35 versus 0.38 units; *P* = .93). As assessed by intraoperative transesophageal echocardiogram, no moderate to severe valvular abnormalities or insufficiencies were observed following chest closure (Table 4).

Intensive care unit length of stay (46.1 versus 26.2 hours; *P* = .15), overall hospital length of stay (6.4 versus 5.1 days; *P* = .18), and time to extubation (0.78 versus 0.44 days; *P* = .44) all trended toward shorter duration in the MI group compared with the REF group, although none of these differences achieved statistical significance. Postoperative transthoracic echocardiograms were obtained in 14 of 34 patients (41.2%); none revealed any new significant abnormalities.

All patients survived to hospital discharged, but one patient in the REF group expired during the follow-up period. Three serious adverse events were encountered in total. One REF group patient suffered a spontaneous pneumothorax on postoperative day 2; this required a chest tube, which was later removed without incident. Within the MI group, 2 patients had significant complications. The first patient experienced postcardiotomy Dressler's syndrome, which subsequently resolved. The second patient suffered from atrial fibrillation complicated by hemodynamic compromise on postoperative day 2; this resolved, and the patient was in normal sinus rhythm at last follow-up.

Follow-Up. Of the 34 patients, 26 (76.4%) were at least 2 years postoperative from their resection; 25 of the 26 (96.1%) were alive at the 2-year follow-up. The remaining 8 were alive at 1-year follow-up. All patients were free of atrial mass recurrence at last follow-up.

DISCUSSION

This study was not designed to demonstrate superiority of the minimally invasive thoracotomy approach. Patients were not randomized, and patient and surgeon preference was the primary determinant of surgical approach. As a retrospective, nonrandomized study, these findings are limited. However, they do suggest that the minimally invasive approach is not inferior to the standard approach, and it may in fact offer important advantages.

Frequent criticisms of minimally invasive techniques include concerns regarding prolonged operative times and inadequate exposure. However, there were no significant differences between the 2 groups in cardiopulmonary bypass or cross-clamp times. In addition, with no recurrences in midterm follow-up, there is no evidence to suggest that surgical margins obtained via the minimally invasive approach were

Table 2. Pathology of Atrial Masses

	Reference Group	Minimally Invasive Group	Total	P
B-cell lymphoma	1 (2.0%)	0 (0.0%)	1 (2.9%)	.34
Myxoma	12 (66.7%)	12 (75.0%)	24 (70.6%)	.60
Fibroblastoma	3 (16.7%)	0 (0.0%)	3 (8.8%)	.09
Other benign masses	2 (11.1%)	4 (25.0%)	6 (17.6%)	.29
Total	18 (52.9%)	16 (47.1%)	34 (100%)	

Table 3. Operative Descriptives

	Reference Group	Minimally Invasive Group	Total
Distribution and surgical approach			
Right atrium			
Right atriotomy	7 (38.9%)	2 (12.5%)	9 (26.5%)
Left atrium			
Left atriotomy	0 (0.0%)	5 (31.3%)	5 (14.7%)
Left and right atriotomy	3 (16.7%)	3 (18.8%)	6 (17.6%)
Right atriotomy (transseptal)	8 (44.4%)	6 (37.5%)	14 (41.2%)
Total left atrium	11 (61.1%)	14 (87.5%)	25 (73.5%)
Total	18 (100.0%)	16 (100.0%)	34 (100.0%)
Concomitant procedures			
None	3 (16.7%)	7 (43.8%)	10 (29.4%)
Right atrial patch	1 (5.6%)	1 (6.3%)	2 (5.9%)
Left atrial patch	1 (5.6%)	0 (0.0%)	1 (2.9%)
Septal patch	5 (27.8%)	6 (37.5%)	11 (32.4%)
Septal and left atrial patch	0 (0.0%)	2 (12.5%)	2 (5.9%)
Pulmonary vein repair	0 (0.0%)	1 (6.3%)	1 (2.9%)
Mitral valve repair	1 (5.6%)	0 (0.0%)	1 (2.9%)
Tricuspid valve repair	2 (11.1%)	0 (0.0%)	2 (5.9%)
Atrial septal defect closure	5 (27.8%)	0 (0.0%)	5 (14.7%)
Total	18 (100.0%)	16 (100.0%)	34 (100.0%)

inadequate. Moreover, based on intraoperative and postoperative echocardiograms there were no significant valvular abnormalities in either group.

The proposed advantages of minimally invasive surgery are decreased morbidity and improved recovery times. No significant difference between MI and REF groups was found in either intraoperative transfusion of packed red blood cells or serious adverse events, and the only patient death occurred in the REF group.

Notably, when comparing both intensive care unit length of stay and overall length of stay, there were trends toward shorter time to extubation, intensive care unit stay, and overall hospital stay among the MI group. This suggests that patients undergoing a mini-thoracotomy may in fact recover more quickly.

For purposes of this study, patients requiring mitral valve surgery were dropped from analysis. By chance, all 3 patients were in the REF group; due to additional operative time needed to complete this concomitant procedure, inclusion of these patients would have skewed the cardiopulmonary bypass and cross-clamp times in favor of the MI group. However, the possibility of mitral valve surgery was not a contraindication to the minimally invasive approach. Our institution has compiled significant experience performing mitral valve surgery using the same incision and, in fact, it has become the most commonly performed minimally invasive cardiac procedure at our institution.

One obvious barrier to the implementation of a minimally invasive procedure is the lack of experience among surgeons. While an increasing number of surgeons are acquiring these skills, only select centers have adopted these techniques as standard treatment [Cooley 1998]. Training physicians to perform these procedures initially may increase operative times of tumor excision procedures. Previous studies note that a steep learning curve exists for these procedures, particularly in robotic approaches [Fann 1997; Cooley 1998; Cosgrove 1998; Shennib 1998; Verrier 1998]. This study suggests that once proficiency is acquired, minimally invasive procedures can be performed with the same speed and safety as standard procedures.

We perform the right thoracotomy via an anterior mini-thoracotomy through the fourth intercostal space. In women, the 6-cm incision is placed in the infra-mammary fold. In our experience, the described minimally invasive approach provides comparable exposure to the traditional sternotomy. And given the steeper learning curve for robotic methods as well as the required incision for removal of masses, it may be more widely applicable than robotic approaches.

While not statistically significant, our data showed a trend toward shorter lengths of stay, suggesting that patient recovery may be faster in the MI group. Although the minimally invasive approach described often utilized percutaneous femoral venous cannulation, we routinely cannulated the aorta centrally, avoiding potential complications of peripheral arterial cannulation [Cooley 1998]. There were no complications related to the femoral incision sites.

In this study, patients were followed for up to 2-years. Longer-term follow-up will be necessary to make more

Table 4. Outcome Measures*

	Reference Group	Minimally Invasive Group	Total	*P*
Patients, n	18 (100%)	16 (100%)	34 (100%)	
In-hospital mortality, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	NA
Long-term mortality, n	1 (5.6%)	0 (0.0%)	1 (2.9%)	.34
Recurrence of atrial mass, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	NA
Valve insufficiency†, n	0 (0.0%)	0 (0.0%)	0 (0.0%)	NA
IOPRBC, n	0.35 ± 0.79	0.38 ± 0.72	0.36 ± 0.7	.93
CPB, min	70.5 ± 28.5	76.5 ± 29.0	73.3 ± 28.5	.57
XCL, min	32.7 ± 22.3	47.3 ± 27.7	39.6 ± 25.3	.14
TE, d	0.78	0.44	0.6	.44
ILOS, h	46.1	26.2	36.7	.15
Discharge creatinine, dL/g	8.3 ± 2.6	7.5 ± 1.7	7.9 ± 2.2	.31
HLOS, d	6.4 ± 2.8	5.1 ± 2.8	5.8 ± 2.9	.18

*NA indicates not applicable; IOPRBC, intraoperative packed red blood cells; CPB, cardiopulmonary bypass duration; XCL, aortic cross-clamp duration; TE, time to extubation; ILOS, intensive care unit length of stay; HLOS, hospital length of stay.

†Moderate to severe valve insufficiency following resection.

definitive conclusions regarding recurrence. These future studies should also assess measures of health status and patient satisfaction associated with various approaches. Our center is aggressively collecting quality of life data, including the SF-36, from patients undergoing all cardiac procedures to better understand patients' preferences as well as to better describe patients' return of function [Ware 1995]. An earlier study resulting from this effort comparing atrial septal defect repair via a robotic versus conventional approach demonstrated more favorable quality of life among patients undergoing the robotic procedure [Morgan 2004]. Additional studies from this effort will provide important information for determining where benefits are achieved.

Despite limitations, findings in this study are important. First, this is the largest series describing a single center's experience with excision of atrial masses via a minimally invasive approach, and it is the first to compare it with the standard approach. Moreover, since atrial masses are rare, occurring in 0.001% to 0.003% of the population, it would be difficult to conduct a randomized trial with sufficient power to assess differences between these 2 approaches, therefore a cohort study may provide the best obtainable evidence [Reynen 1995].

In summary, minimally invasive atrial mass excisions can be accomplished reliably without compromising complete tumor resection, significant increases in operative times, or increases in serious adverse events. In addition, consistent with the proposed advantages by proponents of minimally invasive surgery, measures of recovery time in this study suggest faster recovery among the MI group.

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