

Surgical Outcomes of Cardiac Myxoma: Right Minithoracotomy Approach versus Median Sternotomy Approach

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Background: The standard approach in treating cardiac myxoma is the median full sternotomy. With the evolution of surgical techniques, the right minithoracotomy approach has emerged as an alternative method. Since few studies have been published assessing the right minithoracotomy approach, we performed a retrospective study to compare the clinical outcomes of the right minithoracotomy approach with those of the sternotomy approach. **Methods:** From January 2005 to December 2014, 203 patients underwent resection of a cardiac myxoma. Patients with preexisting cardiac problems were excluded from this study. 146 patients were enrolled in this study; 83 patients were treated using a median sternotomy and 63 patients were treated using a right minithoracotomy. **Results:** No early mortalities were recorded in either group. Although the cardiopulmonary bypass time and aorta cross-clamp time were significantly shorter in the sternotomy group ($p < 0.001$ and $p = 0.005$), postoperative blood transfusions and arrhythmia events were significantly less common in the thoracotomy group ($p = 0.004$ and $p = 0.025$, respectively). No significant differences were found in the duration of the hospital stay, postoperative intubation time, the duration of the intensive care unit stay, and recurrence. **Conclusion:** The minimally invasive right minithoracotomy approach is a good alternative method for treating cardiac myxoma because it was found to be associated with a lower incidence of postoperative complications and a shorter postoperative recovery period.

Key words: 1. Myxoma
2. Minimally invasive surgery
3. Tumor, benign

Introduction

Myxoma is the most common benign cardiac tumor. With recent developments in diagnostic and surgical techniques, the prognosis of cardiac myxoma is favorable [1,2]. The conventional approach used in treating cardiac myxoma has been the median sternotomy. Recently, as surgical techniques have evolved, the minimally invasive approach for cardiac surgery

has emerged as a promising alternative. Some studies have reported favorable results for valve surgery in which a right thoracotomy was used [3,4]. However, due to the rarity of cardiac masses, few studies on cardiac myxoma have been published. In the present study, we report the clinical results of a single-center comparison between the median sternotomy approach and the right minithoracotomy approach in treating cardiac myxoma.

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Table 1. Patient characteristics

Characteristic	Sternotomy (n=83)	Thoracotomy (n=63)	p-value
Age (yr)	54.82±13.96	51.53±14.67	0.193
Sex (female)	51 (61)	54 (86)	0.001
Body mass index (kg/m ²)	23.16±2.74	23.02±2.97	0.770
History of			
Diabetes mellitus	9 (11)	4 (6)	0.261
Hypertension	24 (29)	15 (24)	0.490
Cerebrovascular accident	9 (11)	7 (11)	0.959
Malignancy	4 (5)	10 (16)	0.025
Arrhythmia	1 (1)	0	0.568
Preoperative stroke	12 (14)	7 (11)	0.552
Preoperative ejection fraction (%)	61.14±5.67	62.47±4.23	0.125

Values are presented as mean±standard deviation or number (%).

Methods

From January 2005 to December 2014, 203 patients underwent surgery for the resection of a cardiac myxoma. 21 patients underwent a concomitant coronary artery bypass or a maze operation, or another valve operation (except for mitral valve operations, which were excluded). 33 patients who underwent myxoma removal using a da Vinci apparatus were excluded in order to ensure a uniform dataset. One patient was excluded due to the absence of medical records for analysis. Two patients were excluded because their pathologic diagnosis was not myxoma. Therefore, a total of 146 patients were included in the final dataset. We retrospectively reviewed the medical records of these patients. The patients' characteristics are summarized in Table 1. No definitive indication was used when choosing between the right minithoracotomy approach and the median sternotomy approach. In cases of emergency or urgent surgery, median sternotomy was preferred. In almost all cases, the surgical technique was chosen according to the operating surgeon's preference.

1) Operative techniques

(1) Median sternotomy: Median sternotomy was performed under general anesthesia. We used cardiopulmonary bypass (CPB) through aortic and bicaval cannulation. Cardiac arrest was induced by cardioplegic agents. Cardiac incisions were individualized to appropriately remove the mass. After being weaned

Table 2. Cardiac incisions for the removal of myxoma

Approach	Sternotomy	Thoracotomy
Direct approaches	22 (26)	39 (62)
Left atriotomy	15 (18)	36 (57)
Right atriotomy	5 (6)	3 (5)
Left ventriculotomy	1 (1)	0
Right ventriculotomy	1 (1)	0
Biaxial approaches	34 (41)	9 (14)
Dubost incision ^{a)}	27 (33)	15 (24)

Values are presented as number (%).

^{a)}Transverse right atriotomy extended to the right upper pulmonary vein and septal incisions through the fossa ovalis [5].

from CPB, all patients underwent transesophageal echocardiography to confirm that the tumor had been removed.

(2) Right minithoracotomy: Under general anesthesia and a double-lumen endotracheal tube insertion for single-lung ventilation, the patient's right chest was elevated at an angle of 30°. The right minithoracotomy incisions were made along the fourth intercostal space on the anterior axillary line to the mid-clavicular line. A port was made on the third intercostal space to insert the thoracoscope. After single-lung ventilation, pericardiostomy and CPB were performed. CPB was performed using arterial and venous cannulation. The arterial cannulation was on the ascending aorta and the venous cannulations were through the femoral and internal jugular veins. The aorta was cross-clamped and cardioplegia was infused through the aortic root cannula. Cardiac incisions were individualized due to variations in the tumor character (e.g., location, size, and surgical view). The cardiac incisions used to excise the myxomas are presented in Table 2 [5]. After weaning from CPB, all patients underwent transesophageal echocardiography to confirm that the tumor had been removed.

2) Statistical analysis

Categorical variables were expressed as frequencies and percentages and were compared between the two approaches using the chi-square test or Fisher exact test. Continuous variables were shown as means with standard deviations and were compared using a Student t-test. Statistical analyses were performed using PASW SPSS ver. 18.0 (SPSS Inc. Chicago, IL, USA). A value of $p < 0.05$ was considered to be statistically significant.

Table 3. Operative variables and tumor characteristics

Variable	Sternotomy	Thoracotomy	p-value
Cardiopulmonary bypass time (min)	73.41±31.73	94.43±33.14	<0.001
Aorta cross-clamp time (min)	39.67±22.31	50.87±24.58	0.005
Tumor size (cm)	3.79±1.84	3.50±1.55	0.308
Tumor type			0.430
Round	45 (54)	30 (48)	
Villous	38 (46)	33 (52)	
Tumor location			0.480
Left atrium	75 (90)	60 (95)	
Atrial septum	59 (71)	55 (87)	
Others	16 (19)	5 (8)	
Right atrium	5 (6)	3 (5)	
Atrial septum	4 (5)	2 (3)	
Others	1 (1)	1 (2)	
Left ventricle	2 (3)	0	
Right ventricle	1 (1)	0	

Values are presented as mean±standard deviation or number (%).

Results

Eighty-three patients underwent a median sternotomy and 63 underwent a right minithoracotomy. No patients were converted from right minithoracotomy to median sternotomy. The mean age of the patients was 53.47±14.31 years. Of the patients, 105 (72%) were female. No significant difference in age was found between the two groups ($p=0.193$). The thoracotomy group contained a greater percentage of female patients than the sternotomy group. The past medical histories of the patients showed no significant differences except for a history of malignancy ($p=0.025$). Preoperative strokes occurred in 19 patients, of whom 12 patients underwent a sternotomy and 9 underwent a thoracotomy ($p=0.552$). The overall mean preoperative ejection fraction of the left ventricle (LV) was 61.71%±5.13%, and this variable did not show a significant difference between the two groups ($p=0.067$). The operative variables and tumor characteristics are summarized in Table 3. The CPB time and aorta cross-clamp (ACC) time were significantly shorter in the sternotomy group than in the thoracotomy group ($p<0.001$ and $p=0.007$). No significant differences were found in tumor size and type ($p=0.307$ and $p=0.468$, respectively). The most common tumor site was the left atrium (LA) ($n=135$), followed by the right atrium (RA) ($n=8$), the inferior

Table 4. Comparison of clinical outcomes between the sternotomy approach and the right minithoracotomy approach

Variable	Sternotomy	Thoracotomy	p-value
Postoperative intubation time (hr)	10.68±18.08	6.68±3.26	0.053
Intensive care unit stay (hr)	67.47±219.20	26.13±10.27	0.168
Postoperative hospital stay (day)	11.67±24.64	7.13±6.62	0.156
Blood transfusion	42 (51)	17 (26)	0.004
Postoperative arrhythmia	25 (30)	9 (14)	0.025
Postoperative bleeding requiring reoperation	1 (1)	0	0.568
Postoperative stroke	1 (1)	0	0.568
Wound infection	1 (1)	0	0.568
Tumor recurrence	2 (2)	0	0.321
Mortality	0	0	-
Follow-up duration (day)	945.94±892.88	604.10±509.28	0.004

Values are presented as mean±standard deviation or number (%).

septum of the LV ($n=1$), the free wall of the LV ($n=1$), and the right ventricular outflow tract ($n=1$).

The clinical outcomes of myxoma removal are summarized in Table 4. The duration of the intensive care unit (ICU) stay, the postoperative intubation time, and the duration of the postoperative hospital stay were not significantly different between the two groups ($p=0.168$, $p=0.053$, and $p=0.156$, respectively). However, postoperative blood transfusions and arrhythmia were significantly less common in the thoracotomy group ($p=0.004$ and $p=0.025$, respectively). The most common arrhythmia was atrial fibrillation.

Tumor recurrence was observed in two patients in the sternotomy group. One patient had a primary tumor at the LA interatrial septum and a recurrent tumor at the RA posterior wall a year after the first operation. In the first operation, myxoma removal was performed with the interatrial septum connected to the myxoma stalk. Direct repair of the interatrial septum was performed. The second operation to excise the recurrent myxoma in the RA was successfully performed through sternotomy, and no further recurrence was observed. The other patient had a primary tumor in the LA roof and the tumor recurred at the same site. Although we planned a second operation for the recurrent myxoma, the patient was lost to follow up. Blood transfusion was required in 42 patients in the sternotomy group and in 17 patients in the right minithoracotomy group. Postopera-

tive bleeding that required surgery to control the bleeding occurred in one patient in the sternotomy group. This patient underwent two operations for bleeding control and recovered. A wound infection occurred in one patient in the sternotomy group. Wound dehiscence occurred at the sternotomy site and the patient recovered after irrigation of the wound. No mortalities occurred during the follow-up period.

Discussion

Median sternotomy has been the conventional approach for the resection of cardiac myxoma. Sternotomy has some advantages related to procedural convenience. However, surgical scars that are too long and postoperative infection or mediastinitis can occur relatively frequently [6]. Minimally invasive cardiac surgery involves a smaller surgical wound, a shorter hospital stay, a faster recovery from the operation, and cosmetic advantages [7].

Minimally invasive cardiac surgery was first proposed to treat atrial septal defects [8]. Subsequently, many reports comparing the sternotomy approach and the right minithoracotomy approach showed favorable results for the latter [7,9]. Ko et al. [10] reported the first removal of myxoma through a right minithoracotomy in 1998. Due to the rarity of cardiac myxoma, few reports regarding the minimally invasive approach have been published, and those that were available for our literature review included results from only a small number of patients.

In our series, the number of patients was over 100. Our study involved some differences compared to previous studies. Sawaki et al. [11] reported outcomes of the video-assisted minimally invasive approach in treating benign cardiac masses. The authors reported a shorter postoperative intubation time and an ICU stay for the minimally invasive group, although the only statistically significant finding was that the duration of the hospital stay was significantly shorter in the minimally invasive group. Our study showed similar results, with a shorter hospital stay, postoperative intubation time, and ICU stay in the right minithoracotomy group; however, these differences were not statistically significant.

Prolonged CPB time and ACC time were potential disadvantages of minimally invasive surgery. Our study showed similar results for the CPB time and

the ACC time as previous studies [2,12]. We expected that the CPB time and the ACC time would be shorter due to the evolution of surgical techniques. Blood transfusions and postoperative arrhythmia were significantly less common in the thoracotomy group, which suggests that clinical recovery may have been shorter in the thoracotomy group. This tendency has also been demonstrated in previous studies, in which blood transfusion was more occurred in the thoracotomy group than in the sternotomy group; however, the incidence of atrial fibrillation was not different between the thoracotomy group and sternotomy group [11]. The reason for this result was most likely the relatively small number of patients (n=23). Pineda et al. [13] reported clinical outcomes pertaining to the same question. They found no differences in postoperative blood transfusions, and a relatively lower incidence of postoperative arrhythmia in patients who underwent minimally invasive cardiac surgery. Mihos et al. [12] reported the incidence of postoperative atrial fibrillation in patients undergoing valve surgery, finding a significantly lower incidence of postoperative atrial fibrillation in patients who underwent the minimally invasive approach (odds ratio, 0.4; $p < 0.001$). It was assumed that minimally invasive surgery reduced surgical trauma and inflammation and improved postoperative recovery. However, longer CPB and ACC times were also risk factors for atrial fibrillation. Therefore, the data are insufficient to allow firm conclusions regarding the exact mechanism through which the incidence of atrial fibrillation was reduced [12]. No significant differences were found regarding bleeding requiring operation, the incidence of postoperative stroke, and tumor recurrence. These results suggest that myxoma removal surgery is safe and that favorable outcomes can be expected for both approaches. There were 2 cases of tumor recurrence in the median sternotomy group. Because of relatively shorter follow-up period in the thoracotomy group, tumor recurrence were not found in the thoracotomy group. However, the number of recurred patients is too small to analyze.

Cardiac myxoma is usually located in the atrium, and is especially common in the LA, meaning that the right minithoracotomy approach is possible in almost all patients. However, a careful preoperative examination of the tumor location is mandatory before performing minimally invasive cardiac surgery, be-

cause the right minithoracotomy approach results in a limited surgical field.

This study was retrospective, with an intermediate duration of follow-up. The advantages of the right minithoracotomy are that it involves less pain and enhances patients' quality of life. However, we were not able to gather data about patients' subjective outcomes. Although the size of the cohort was larger than those of previous studies, a larger study population would be necessary to analyze all surgical variables. Thus, further studies are needed to better characterize the relationships of the sternotomy approach and the minimally invasive approach with clinical and subjective outcomes in a larger multicenter study.

In conclusion, the minimally invasive right minithoracotomy approach was found to be a good alternative method in treating cardiac myxoma because it was associated with a lower incidence of postoperative complications and a shorter period of postoperative recovery. Further research with more patients and a longer follow-up period will be necessary to compare long-term variables, such as tumor recurrence.

Conflict of interest

No potential conflict of interest relevant to this article was reported.

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