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Surgical Experience of Primary Cardiac Tumor: Single-Institution 23-Year Report

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Background: Primary cardiac tumors are rare but have favorable surgical prognosis. Previous studies have been small series studies with limited surgical approaches. To date, few studies have examined the clinical features associated with different surgical procedures.

Material/Methods: In a search of the cardiovascular surgery database of our institution, we retrospectively identified 225 patients who had cardiac tumor resection from January 1993 to May 2016. The patients' clinical characteristics and operation information were reviewed, and the operation parameters, postoperative complications, and short-term prognosis among robotic, mini-thoracotomy, and conventional procedures in our center were compared.

Results: A total of 228 operations were performed, including 156 traditional open surgeries (68.4%), 60 robotically assisted neoplasm resections (26.3%), and 12 mini-thoracotomy procedures (5.3%). Among 232 lesions, myxoma (94.8%) was the most common neoplasm, and the remainders were fibroma (1.3%) and lipoma (0.9%). Operative complications occurred in 36 patients (15.8%). Arrhythmia (8.8%) was the first common complication, and delayed mechanical ventilation (4.8%) ranked second. The overall risk of recurrence of myxoma was 2.7%. The cardiopulmonary bypass (CPB) time in the mini-thoracotomy group was longer than in the robotic group (p=0.034) and the conventional group (p=0.002). There were no significant differences in cross clamp time (p=0.266) or complications (p=0.835) among the three groups. The in-hospital survival rate was 100% in all patients. There were no significant differences in main adverse events among the three groups at six-month follow-up (p=0.285).

Conclusions: Prognosis for cardiac neoplasm surgical resection is favorable for primary cardiac tumors. The minimally invasive surgery of cardiac tumor resection can be an alternative to conventional operations in selected patients.

MeSH Keywords: Carney Complex • Heart Neoplasms • Robotics

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Background

Primary cardiac tumors have low morbidity with autopsy frequency of 0.001% to 0.030%. Approximately 75% of cardiac tumors in adults are benign and nearly 25% of them are malignant [1]. More than half of the benign tumors are myxomas [2], and the rest are lipomas, papillary fibroelastoma, and rhabdomyomas. Sarcoma (including angiosarcoma, undifferentiated sarcoma, malignant fibrous histiocytoma, leiomyosarcoma, and osteosarcoma) is the most often reported neoplasm occupying 95% of malignant cardiac tumors [3]. Surgical resection is the most common and effective therapy for both benign and malignant tumors. Surgical approaches have varied as science and technology has advanced, and cardiac neoplasms can be excised using different procedures. Few articles have been published that summarize the surgical experience within a large population and the comprehensive surgical approaches used over two decades. In this study we reviewed the surgical experience at our center during a 23-year period.

Material and Methods

Patient selection

The cardiovascular surgery database at our center was searched for records of all patients who had cardiac tumor excision from January 1993 through to May 2016. Three operation approaches were included: 1) conventional procedure with median sternotomy; 2) robotically assisted procedure with da Vinci Surgical System (Intuitive Surgical, Sunnyvale, CA, USA); and 3) mini-thoracotomy procedure via right anterolateral approach. Both robotically assisted procedure and mini-thoracotomy procedure were minimally invasive surgeries where cardiopulmonary bypass was established via right internal jugular venous cannulation, right femoral arterial, and venous cannulation. And tumors were excised through a small working port, which were especially small in robotically assisted procedures which were performed between the ribs.

Data recording

Patient information, including demographics, cardiac comorbidities, symptoms, lesion characteristics, operation information, and in-hospital and six-month follow-up data were recorded.

Data analysis

Patient clinical characteristics and operation information were reviewed, and operation parameter, postoperative complications, and short-term prognosis among robotic, mini-thoracotomy, and conventional procedures were compared.

Statistical analysis

Categorical data were described as numbers and percentages and were compared using the Chi-square analysis. Continuous variables were presented as mean ±SD. Normally distributed data were compared using analysis of variance; data with nonconformity of normal distribution were compared by Mann-Whitney U test or Kruskal-Wallis test. All hypothesis tests had a two-sided significance level of 0.05. All statistical analyses were performed with SPSS, version 17 (SPSS, Inc., Chicago, IL, USA).

Results

Patient characteristics

We identified a total of 225 patients with mean age of 50.7±13.3 years (61.3% female and 38.7% male) (Table 1) and mean body mass index of 23.6±4.1 kg/m^2. Among the 225 patients, 31 patients had hypertension (13.8%), 15 patients had diabetes (6.7%), 19 patients had coronary artery disease (8.4%), nine patients had valvular heart disease (4.0%), and 30 patients had cerebral vascular disease (13.3%; 27 patients within three months, and three patients exceed three months). The cardiac function of most patients were fine according to New York Heart Association (NYHA) classification grading of cardiac function: 61 patients were NYHA I (27.1%), 129 patients were NYHA II (57.3%), 30 patients were NYHA III (13.3%), and five patients were NYHA IV (2.0%).

Patient symptom

Patients with heart neoplasm presented diverse symptom, and 42 patients (18.7%) were asymptomatic. Up to 164 patients (72.9%) complained of cardiac symptoms including dyspnea and orthopnea. Cerebral vascular symptoms occurred in 27 patients (12.0%) including the patients combined with cardiac symptom. Peripheral embolism happened in 18 patients (8.0%); and two patients (1.3%) had pulmonary embolism, both of whom had emergency operations.

Lesion characteristics

A total of 232 lesions were founded in 228 operations (Table 2). Up to 201 lesions occurred in the left atrium (LA), 23 lesions in the right atrium (RA), six in the left ventricle (LV), and two in the right ventricle (RV). Neoplasms that occurred in three chambers (LA, LV, and RV) were seen in one patient, biatrial lesions (LA and RA) occurred in two patients, and 225 patients had a tumor in a single chamber. The mean size of tumors was 4.8×3.4 cm according to echocardiogram measurements (product of maximum diameter). Among the tumors, 220 lesions (94.8%) were myxoma. About 5.2% of the neoplasms

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Table 1. Patients characteristics.

Variable	Conventional (n=153)		Robotic (n=60)		Minithoractomy (n=12)		No. of Patients (%) (n=225)		P Value
Sex									0.261
Male	60	(39.2)	25	(41.7)	2	(16.7)	87	(38.7)	
Female	93	(60.8)	35	(58.3)	10	(83.3)	138	(61.3)	
Age (year, 8–76)									0.992
8–20	5	(3.3)	2	(3.3)	0	(0.0)	7	(3.1)	
21–40	30	(19.6)	10	(16.7)	3	(25.0)	43	(19.1)	
41–60	77	(50.3)	36	(60.0)	5	(41.7)	118	(52.4)	
61–76	41	(26.8)	12	(20.0)	4	(33.3)	57	(25.3)	
Comorbidities									
CAD	16	(10.5)	3	(5.0)	0	(0.0)	19	(8.4)	0.347
VHD	9	(5.9)	0	(0.0)	0	(0.0)	9	(4.0)	0.150
DM	10	(6.5)	5	(8.3)	0	(0.0)	15	(6.7)	0.808
Hypertension	19	(12.4)	11	(18.3)	1	(8.3)	31	(13.8)	0.496
CVD	20	(13.1)	8	(13.3)	2	(16.7)	30	(13.3)	1.000
Cardiac function									0.000
NYHA I/II	119	(77.8)	59	(98.3)	12	(100.0)	190	(84.5)	
NYHA III/IV	34	(22.2)	1	(1.7)	0	(0.0)	35	(15.5)	
Symptom									
Asymptomatic	14	(9.2)	26	(43.3)	2	(16.7)	42	(18.7)	0.000
Symptomatic									
Cardiac symptom	130	(85.0)	28	(46.7)	6	(50.0)	164	(72.9)	0.000
Systemic embolism	30	(19.6)	9	(15.0)	6	(50.0)	45	(20.0)	0.020
Cerebral	17	(11.1)	8	(13.3)	2	(16.7)	27	(12.0)	0.822
Non-cerebral	13	(8.5)	1	(1.7)	4	(33.3)	18	(8.0)	0.003
Extremity artery	11	(7.2)	1	(1.7)	4	(33.3)	16	(7.1)	0.003
Pulmonary artery	2	(1.3)	0	(0.0)	0	(0.0)	2	(0.9)	1.000
Comorbidity operation	18	(11.8)	0	(0.0)	0	(0.0)	18	(8.0)	0.005
Valve surgery	9	(5.9)	0	(0.0)	0	(0.0)	9	(4.0)	
CABG	8	(5.2)	0	(0.0)	0	(0.0)	8	(3.6)	
Pericardiectomy	1	(0.7)	0	(0.0)	0	(0.0)	1	(0.4)	
Re-occurred operation	5	(3.3)	0	(0.0)	0	(0.0)	5	(2.2)	0.488
Second	4	(2.6)	0	(0.0)	0	(0.0)	4	(1.8)	
Third	1	(0.7)	0	(0.0)	0	(0.0)	1	(0.4)	

CABG – coronary artery bypass graft; CAD – coronary artery disease; CVD – cerebral vascular disease; DM – diabetes mellitus; VHD – valvular heart disease.

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Table 2. Lesion characteristics.

Variable (228 operations)	No. of Lesion (%)
Solitary Lesion	225 (98.7)
Biatrial Lesion (RA and LA)	2 (0.9)
Trilocular Lesion (LA, LV and RV)	1 (0.4)
Total Lesions	232
Location	
LA	201 (86.7)
RA	23 (9.9)
LV	6 (2.6)
RV	2 (0.9)
Pathology	
Myxoma	220 (94.8)
Non-myxoma	12 (5.2)
Fibroma	3 (1.3)
Lipoma	2 (0.9)
Thrombus tumor	2 (0.9)
Atrial hemangioma	1 (0.4)
Parasites tumor	1 (0.4)
Papillary fibroelastoma	1 (0.4)
Inflammatory myofibroblastic tumor	1 (0.4)
Sarcoma	1 (0.4)

LA – left atrium; LV – left ventricle; RA – right atrium; RV – right ventricle.

Table 3. Comparison between minimally invasive surgery and conventional procedure in patients with LA myxoma ressection.

Variable	Conventional (n=84)	Robotic (n=53)	Minithoractomy (n=10)	P Value
CPB time (min)	65.1±21.9	72.9±26.7	87.4±23.2	0.008
Crossclamp time (min)	37.1±16.2	37.9±15.1	45.3±17.5	0.266
Approach				0.000
Left atrium approach	7	51	1	
Atrial septum approach	77	2	9	
Complication	11	7	2	0.835
Arrhythmia	5	4	2	0.212
DMV	5	1	0	0.614
Thoracic complication	1	2	0	0.645

CPB – cardiopulmonary bypass; DMV – delayed mechanical ventilation; LA – left atrium; Value – Number (%).

were non-myxoma, including three fibromas (1.3%), two cardiac lipomas (0.9%), two thrombus tumors (0.9%), one atrial hemangioma (0.4%), one parasites tumor (0.4%), one papillary fibroelastoma (0.4%), one sarcoma (0.4%), and one inflammatory myofibroblastic tumor (0.4%).

Operation information

For the 225 patients, a total of 228 operations were performed in our center, 68.4% of which were conventional procedures via a median sternotomy approach. Concomitant procedures for cardiac comorbidities were performed on 18 patients, including nine valve surgery, eight coronary artery bypass graft and one pericardiectomy. Robotically assisted procedure was performed in 60 patients (26.3%) without other concomitant procedures. Mini-thoracotomy procedures using the right anterolateral approach were completed on 12 patients (5.3%). Redo-operations for recurrent cardiac neoplasms were performed on five patients (2.2%) through a conventional approach, four patients had the operation for a second time, and one patient for a third time. The patient who had three operations was found to have neoplasm re-occurrence in January 2016 and had not yet returned for an operation. Conventional procedures were the preferred approach in patients who had complex cardiac comorbidities (p=0.000), poor heart function (p=0.005), emergency status, and re-do operation. All 228 operations were successfully completed and no surgical mortality was found. Operative complication rate after operation was 15.8% (36/228); 20 patients (8.8%) had complications with arrhythmia; 17 patients (7.5%) had atrial fibrillation (AF), two

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Table 4. Patient characteristics of minimally invasive surgery versus conventional surgery after screening.

Variable	Conventional (n=84)	Robotic (n=53)	Minithoractomy (n=10)	P Value
Sex				0.130
Male	36	22	1	
Female	48	31	9	
Age (year, mean ±SD)	50.6±13.6	20.4±12.7	52.6±15.2	0.890
BMI (kg/m²; mean ±SD)	24.0±4.7	23.9±3.6	25.3±3.1	0.628
Comorbidities				
CAD	5	3	0	1.000
DM	4	3	0	1.000
Hypertension	12	8	1	0.915
CVD	15	8	2	0.885

BMI – body mass index; CAD – coronary artery disease; CVD – cerebral vascular disease; DM – diabetes mellitus; VHD – valvular heart disease. Value – Number (%).

patients (0.9%) had supraventricular tachycardia, (SVT), one patient (0.4%) had AF combined with ventricular premature beat (VPB), 11 patients (4.8%) had delayed mechanical ventilation (DMV) with ventilation time >24 hours, one patient (0.4%) had complications with cerebral infarction, one patient (0.4%) had pleural effusion (PF), one patient (0.4%) had complications with pneumothorax, one patient (0.4%) suffered from subcutaneous emphysema, and one patient (0.4%) presented with DMV and PF.

Conventional versus minimally invasive procedure

Patients with NYHA III/IV, recurrent neoplasm excision, comorbidity operation, and other chamber lesions were excluded. A total of 156 patients accepted the conventional procedure, and 84 patients received the left atrial tumor resection after excluding. Robotic procedure and mini-thoracotomy procedure were performed on 60 and 12 patients respectively, 53 and 10 patients had left atrial neoplasm resection after screening respectively (Table 3). Baseline characteristics among the three groups were not significantly different (Table 4). Cross clamp time was not significantly different among the three groups. Cardiopulmonary bypass (CPB) time was not significantly different between the robotic group and the conventional group (p=0.196). However, CPB time in the mini-thoracotomy group was longer than the robotic group (p=0.034) and the conventional group (p=0.002). Tumors were more often removed via left atriotomy using the robotic procedure and more frequently resected via the right atrium when using the mini-thoracotomy and the conventional procedure group (p=0.000). Differences were not noted in operative complications (p=0.835) including arrhythmia (p=0.212), DMV (p=0.614), and thoracic complication (p=0.645) among the three groups. In six-month follow-up, main adverse events (MAEs), including arrhythmia, cardiac death, stroke, and non-cerebral systemic embolism were seen in 11 patients (13.1%) in the conventional group, six patients (11.3%) in the robotic group and three patients (30%) in the mini-thoracotomy group, which was not statistically significantly different among the groups (p=0.285, with 4.7% lost to follow-up). The Kaplan-Meier curve for MAEs is presented in Figure 1.

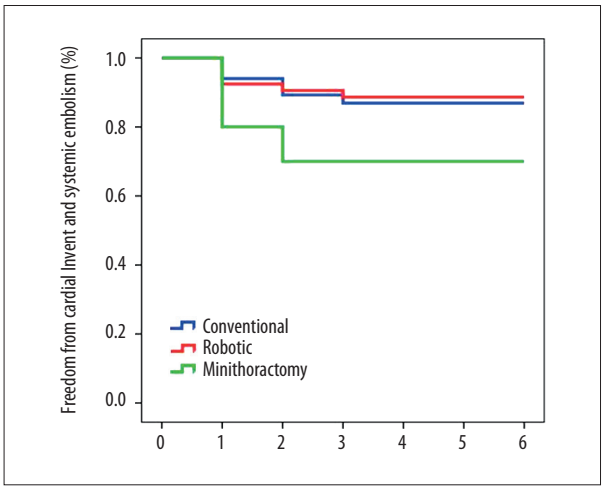

Figure 1. The Kaplan-Meier curve for MAEs.

Discussion

Primary cardiac neoplasm is a disease with a low prevalence and favorable prognosis after operation [2]. Tumors occur more often in the middle-aged and elderly population [4], and the morbidity is higher in females [5]. Cardiac myxoma rarely

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occurs in young patients, and only 0.4% of patients were under the age of 10 years in our center study. In a previous study, young patients with cardiac myxoma were often in syndromic context of so-called Carney complex (CNC), which was first described as "the syndrome of myxomas, spotty pigmentation, and endocrine over activity" by Carney at the Mayo Clinic in 1985 [6] and has been found to be associated with germline mutation PRKAR1A [7].

Patients with cardiac tumors have diverse clinical presentations. According to our experience, about 18.7% of patients were asymptomatic. The majority of patients usually present with dyspnea and orthopnea, and some patients have other symptom such as syncope, presyncope, angina, and hemoptysis [1]. Systemic embolism is frequently seen and appeared on 20% of patients in our center and cerebral embolism was seen more often than peripheral artery. Pulmonary embolism was rare, and usually occurred in patients with right heart neoplasm, and regularly required emergency operation.

Echocardiography is an ideal imaging modality since it is simple, non-invasive, widely available, and of low cost [2]. Neoplasm can occur in any chamber of the heart. Most of tumors are solitarily arising from the left atrium. In our experience, only one patient had tumors arising from three chambers and the tumors re-occurred seven months after the operation. Tumors arising from right ventricle are rare and more likely to cause pulmonary embolism. Myxoma is the most common histological type with a ratio of 94.8% in our institution, which was higher than that of 78–89% in previous Japanese studies [8,9] and 42–50% in American studies [10]. Benign tumors such as fibroma, lipoma, hemangioma, and papillary fibroelastoma always have favorable prognosis after surgery operation. Sarcoma, which is a malignant neoplasm, is rarely seen and usually has a poor prognosis [11]. In a previous study, only 31.9% of patients with sarcoma underwent effective surgical resection because of advanced-stage tumors, metastatic extracardiac malignancy, and high comorbidity burdens [12].

Since the first excision of a left atrial myxoma was performed by Swedish cardiovascular surgeon Clarence Crafoord in 1954 [13], cardiac tumors resection gradually became a common operation and always had favorable prognosis [14]. The rate of complication after operation was 5.8% in our institution. Atrial arrhythmia, which occurred in 8.8% of patients in our center, was the most common complication. In one large series, transient atrial arrhythmias were seen in 26% of patients but only 2% of patients needed a permanent pacemaker [5]. Delayed mechanical ventilation may also occur in patients after tumor excision. The overall risk of recurrence of myxoma was 2.7% at our center. Andrew et al. [10] found the recurrence rate of myxoma after resection was 13%, but was much more common with familial myxomas than with sporadic tumors (22% versus 3%). Local recurrence of myxoma is uncommon but may be related to inadequate resection, multi-centricity, origin in chamber other than the left atrium, familial tumors, or disease complexes such as CNC [6].

Minimally invasive surgery (MIS) with a healing cosmetic incision has been applied to cardiac surgery more and more often due to advances in optics and instrumentations. The safety and efficacy of minimally invasive cardiac tumor resection has been confirmed in previous studies for select patients [15,16]. In our study, robotic-assisted procedures and mini-thoracotomy procedures of the left atrial myxoma resection had no significant differences in operative parameters such as cross clamp time and operative duration compared with a conventional procedure. But the CPB time in the mini-thoracotomy group was longer than the other two groups, which may have been due to the steep learning curve of the surgery. The in-hospital mortality, para-operative complications, and six-month MAEs of the three groups had no differences according to our experience. In our previous study [17], patients who accepted robotic-assisted myxoma resection had a better quality of life after their operation and went back to work much earlier compared with patients who had a conventional surgical procedure. However, we believe that it is more sensible to perform traditional open chest surgery on patients who have complex cardiac comorbidities, poor heart function, emergency status, and re-do operations.

Conclusions

Prognosis of cardiac neoplasm surgical resection is favorable for primary cardiac tumors. Minimally invasive surgery of cardiac tumor resection can be an alternative to conventional operation in select patients.

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