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Totally thoracoscopic surgery for atrial myxomas resection and atrial septal defect repair

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Abstract. – OBJECTIVE: The purpose of this study is to compare the effectiveness and safety of thoracoscopic surgery and traditional median sternotomy.

PATIENTS AND METHODS: 64 patients with atrial myxoma and 114 patients with atrial septal defect were collected from Mar 2012 to Aug 2015. 40 atrial myxoma and 77 atrial septal defect (ASD) patients underwent totally thoracoscopic surgery technique, while 24 atrial myxoma and 37 ASD patients underwent traditional median sternotomy. The baseline characteristics and perioperative data were recorded and analyzed from all cases. Follow-up data were obtained from outpatient clinics.

RESULTS: All patients had successful resections or repairs. Compared with the traditional median sternotomy, the patients with atrial myxoma who underwent thoracoscopic surgery had longer operation time (208.08 ± 23.98 *vs.* 170.00 ± 16.58 min) while shorter intensive care unit (ICU) stay time (17.67 ± 4.95 *vs.* 49.88 ± 3.21 h), less blood drainage (127.87 ± 48.84 *vs.* 275.00 ± 59.01 ml) and shorter hospitalization days (9.97 ± 3.54 *vs.* 15.13 ± 1.06 days). For patients underwent ASD repair, longer operation time (232.92 ± 61.02 *vs.* 183.40 ± 54.63 min), shorter mechanical assistant ventilation time (4.82 ± 2.10 *vs.* 6.02 ± 2.50 h) and shorter ICU stay time (18.54 ± 5.80 *vs.* 39.68 ± 18.44 h) were detected in the thoracoscopic surgery group. There was no postoperative embolism events or death in all participated patients. Neither residual shunt nor atrioventricular blocks were detected in all ASD patients.

CONCLUSIONS: Totally thoracoscopic surgery for atrial myxomas and atrial septal defect repair is more effective and safer. It provides another option to treat the patients with atrial myxoma and atrial septal defect.

Key Words

Thoracoscopy, Atrial myxoma, Cardiopulmonary bypass, Atrial septal defect.

Introduction

Atrial myxoma is one of the most common primary benign tumors of the heart, mostly located in the left atrium and then in the right atrium. However, the ventricular myxoma is rare to be found[1] The predilection and observation sites of myxoma were oval fossa. Most of the patients in whom had myxoma developed were adults (30-70 years, 70%), and women were over-represented[2]. It has different clinical manifestations according to the localization, size, length of the tumor pedicle, growth rate of the myxoma, whether occurred tumor tissue exfoliation hemorrhage, necrosis, etc. The most common clinical symptoms include obstruction since the myxoma goes into the ventricles, and usually it causes mitral stenosis or regurgitation. Also, fever, emaciation, anemia, joint pain, classic triad of embolic, cerebral infarction and even sudden death is accompanied[3,4]. All types of the myxoma are the indications for surgical resection after diagnosis.

Large atrial septal defect (ASD) is one of the most common types of the congenital heart disease. Traditionally, the resection of atrial myxomas and ASD repair have been performed by median sternotomy with conventional cardiopulmonary bypass (CPB). In recent years, minimally invasive surgical approaches have been applied to the resection of myxoma and ASD repair to minimize surgical trauma and improve cosmetic results[5-8]. Specially, the endoscopic techniques in total have also been developed for ASD closure and myxoma resection[9,10].

In this study, we reported our case load of 64 patients with atrial myxoma (40 undertook totally thoracoscopic operation, 24 under traditional median sternotomy) and 114 patients with atrial septal defect (77 with totally thoracoscopic

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operation and 37 with traditional median sternotomy). A comparison of effectiveness and safety of thoracoscopic surgery and traditional median sternotomy was further performed.

Patients and Methods

Patients

This was a single center study. 64 patients with atrial myxoma and 114 ASD patients were collected from Mar 2012 to Aug 2015 in our center (Cardiovascular Surgical Department, The First Affiliated Hospital Harbin Medical University). 40 atrial myxoma and 77 ASD patients underwent thoracoscopic surgery, 24 atrial myxoma and 37 ASD patients underwent traditional median sternotomy. The baseline characteristics and perioperative data were recorded and analyzed from these cases, including the medical history, presenting symptoms, intra-operative and postoperative situations.

Anesthesia and Surgical Operation

All patients received induction of general anesthesia, and a left-sided double-lumen endotracheal tube was inserted. During the operation, the single left lung ventilation was allowed to support the patient. Blood pressure, electrocardiogram, transcutaneous oxygen saturation and end-tidal carbon dioxide were monitored.

The patient was positioned in the supine position with the right hemithorax slightly elevated to 15° to 30° angle. We made 3 small incision ports in the right chest, each one of about 2-3 cm in length (Figure 1). The position of port 1 is sixth intercostal space on the right side of the sternum, which was used for placement of thoracoscopy light source. Port 2, which was used for surgical instruments procedures, such as: electro-coagulation, shear, suture and knot tying, located at the fourth intercostal space on the right side of the sternum. Port 3, which was used for surgery instruments, occlusion of the superior vena cava and cold perfusion needle, aorta clamps, left heart drainage tube, located at the third intercostal space on the right midaxillary line. Carbon dioxide (1-2 l/min) was used for remove air embolism of heart and made the heart re-beat smoothly.

A 3 cm longitudinal incision was made in the right groin, and then femoral artery and femoral vein were separated and measured. The appropriate cannulas were chosen. Sternal angel was marked for estimate the depth of insertion of the venous cannulas. After systemic heparinization, the aortic cannula was inserted through the right femoral artery. Then the vein catheter was inserted through the right femoral vein into the inferior and superior vena cava, if the pressure of the femoral arterial cannula was normal. When the CPB started, we adjusted the position of the cannulas according to femoral arterial pressure and venous drainage. It is necessary to keep normal femoral arterial cannulas pressure and enough venous drainage for the CPB. The femoral artery cannulas contained 16 F to 24

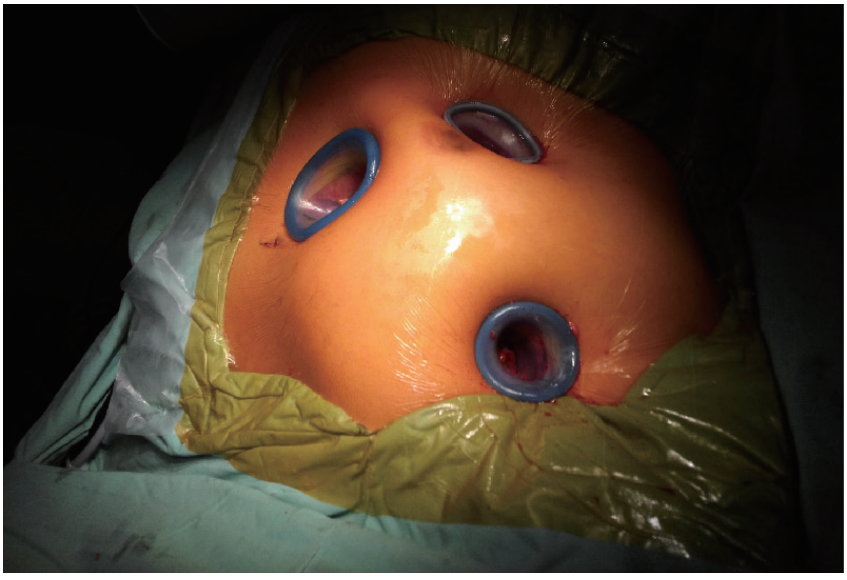

Figure 1. Location of the 3 minimal incisions on the right chest wall. Port 1, the sixth intercostal space on the right side of the sternum. Port 2, the fourth intercostal space on the right side of the sternum. Port 3, the third intercostal space on the right midaxillary line.

F and the femoral vein contained bi-caval 22 F to 28 F cannula. All the cannulas are made in China (Changzhou Kangxin Medical company, Changzhou, China).

The pedunculated or sessile myxoma was excised when it was located by transthoracic echocardiography, along with its attachment part of the atrial septum, the resection of tissue was pulled out through the second incision with a soft tissue extractor or a sterile glove. Direct sutures were made, except in 21 cases, in which repair of the atrial septum was performed using an autologous pericardial patch (2% glutaraldehyde fixation for 15 min, 0.9% NaCl saline flush twice) because the base of the myxoma had a big size and a larger area of the adjacent atrial septum was excised. The mitral valve and tricuspid valve were checked by water pressure test (water was injected in ventricular).

For ASD repair, the right atrium was opened from a site parallel to the atrioventricular annulus after snaring of the superior and inferior vena cava, and 4 stay sutures were placed on the incision to expose the intra-atrial structure. The ASD was closed with direct 4-0 Prolene sutures. A bovine patch or autologous pericardial patch was used to repair larger ASD with running Prolene sutures. Stitching should be strict to avoid residual shunt and atrioventricular block. After ASD closure, the aortic cross-clamp was released. The patient was rewarmed and weaned from CPB. The integrity of the ASD closure was confirmed using transesophageal echocardiographic analysis.

After adequate hemostasis was achieved, all instruments were removed from the chest, and a 24 F chest tube was inserted into the right pleural space through port 2 for drainage after removal of the cannulas and reconstruction of the right femoral artery and femoral vein.

CPB Management

Middle-hypothermia (29°C-32°C), middle-hemodilution (HCT 0.21-0.25). The myocardium was protected by coronary perfusion with 4:1 cold (4°C-6°C) oxygenated blood (10-20 ml/kg). Flow rate: 60-80 ml/kg, MAP 50-80 mmHg. The electrolyte and internal environment were stable. Most of patients were under aortic cross-clamp.

Follow-up

Follow-up data were obtained from outpatient clinics for 12 months after patients discharged. All patients were voluntarily signed the informed consent and the study was approved by the Ethical Committee of our Hospital (The First Affiliated Hospital of Harbin Medical University, Harbin, Heilongjiang, China).

Statistical Analysis

Statistical software SPSS 13.0 (SPSS Inc., Chicago, IL, USA) was used for data analysis. All continuous variables are presented as mean ± standard deviation (SD) and median. Count data expressed in percentage. Continuous variables were compared by standard *t*-test if meet the normal distribution and homogeneity, otherwise, nonparametric-test was used. All statistical tests are two-tailed. A $p<0.05$ was considered statistically significant.

Results

Totally thoracoscopic surgery for myxomas resection

Baseline characteristics and perioperative data of patients underwent myxomas resections were found in Table I. For patients underwent thoracoscopic surgery, 13 males and 27 females were included. Five males and 19 females were included for median sternotomy. There was no difference in the age (48.35 ± 11.10 *vs.* 52.00 ± 4.24 years) and weight (61.66 ± 7.10 *vs.* 62.13 ± 3.31 kg) of the two groups of patients. Among all of 64 patients, myxoma located in left atria in 55 patients, and it concurred with mitral regurgitation in 21 patients, tricuspid regurgitation in 7 patients, respectively. Myxoma was located in the right atria in 9 patients, 2 patients concurred with tricuspid regurgitation. All patients had a history of heart disease (range, 11 months to 16 years). For patients underwent thoracoscopic surgery, 17 patients had post-exertional palpitation and 15 patients experienced chest tightness and shortness of breath. One patient had syncope, 2 patients had a history of stroke for 1 year and 3 years, respectively. Atrial fibrillation in 2 patients last for 2 years and 4 year, respectively; junctional escape rhythm in 1 patient, and right bundle branch block in 3 patients.

All of the myxoma patients had a successful resection of atrial myxomas by either totally thoracoscopic surgery or traditional median sternotomy. Compared to patients underwent conventional median sternotomy, patients underwent thoracoscopic surgery had shorter ICU stay time (17.67 ± 4.95 *vs.* 49.88 ± 3.21 h, $p<0.001$) and hospitalization time (9.97 ± 3.54 *vs.* 15.13 ± 1.06

Table I. Baseline characteristics of patients with atrial myxomas.

Characteristics	Thoracoscopic surgery	Median sternotomy
Female (N)	27	19
Male (N)	13	5
Age (year, Mean ± SD (Median))	48.35 ± 11.10 (51.5)	52.00 ± 4.24 (52.5)
Weight (kg, Mean ± SD (Median))	61.66 ± 7.10 (59.5)	62.13 ± 3.31 (58.5)
Left atria (N)	38	17
Right atria (N)	2	7
Mitral regurgitation (N)	15	6
Tricuspid regurgitation (N)	7	0
Post-exertional palpitation	17	2
Chest tightness and shortness of breath (N)	15	2
Syncope (N)	1	0
Stroke (N)	2	0
Atrial fibrillation (N)	2	1
Junctional escape rhythm (N)	1	0
Right bundle branch block (N)	3	0

days, $p<0.01$), as well as less blood drainage (127.87 ± 48.84 *vs.* 275.00 ± 59.01ml, $p<0.001$). However, the longer CPB time (125.13 ± 29.33 *vs.* 59.13 ± 5.74 min, $p<0.001$), aortic cross-clamp time (52.02 ± 17.76, range 19.00 to 95.00 *vs.* 24.88 ± 3.08 min, range 0.00 to 71.00, $p<0.05$) and operation time (208.08 ± 23.98 *vs.* 170.00 ± 16.58 min, $p<0.001$) was found in patients underwent thoracoscopic surgery (Table II).

Totally thoracoscopic surgery for ASD repair

Baseline characteristics and perioperative data of patients underwent ASD repair were found in Table III. For patients underwent thoracoscopic surgery, 25 males and 52 females were included. Thirteen males and 24 females were included for median sternotomy. There was no difference in the age (30.19 ± 11.48 *vs.* 21.68 ± 20.11 years) and weight (55.47 ± 10.40 *vs.* 35.34 ± 23.51 kg) of the two groups of patients. Among all of 114 patients, 35 patients concurrent with tricuspid regurgitation and 8 patients had post-exertional palpitation.

ASD repair was successfully performed in all of the patients. Compared to patients underwent median sternotomy, patients underwent thoracoscopic surgery had shorter mechanical assistant ventilation time (4.82 ± 2.10 *vs.* 6.02 ± 2.50 h, $p<0.01$) and shorter ICU stay time (18.54 ± 5.80 *vs.* 39.68 ± 18.44 h, $p<0.001$). Similarly, the longer CPB time (114.95 ± 20.01 *vs.* 61.03 ± 29.60 min, $p<0.001$) and operation time (232.92 ± 61.02 *vs.* 183.40 ± 54.63 min, $p<0.001$) was found in patients underwent thoracoscopic surgery. The meantime of aortic cross-clamp were 37.39 ± 25.40 (range 0.00 to 168.00) and 12.95 ± 23.20 (range 0.00 to 86.00) in thoracoscopic surgery group and median sternotomy group respectively (Table IV). There were no statistic differences in blood drainage volume and hospitalization days for patients underwent median sternotomy and thoracoscopic surgery.

Table II. Perioperative data of patients with atrial myxomas.

Characteristics	Thoracoscopic surgery	Median sternotomy
CPB (min)	125.13 ± 29.33 (115.50)***	59.13 ± 5.74 (75.00)
Aortic cross-clamp (min)	45.04 ± 16.82 (43.5)*	33.96 ± 16.35 (33.00)
Operation time (min)	208.08 ± 23.98 (210.00)***	170.00 ± 16.58 (197.50)
Mechanical assistant ventilation time (h)	6.50 ± 2.40 (4.90)	6.38 ± 0.46 (5.20)
ICU stay time (h)	17.67 ± 4.95 (18.00)***	49.88 ± 3.21 (45.00)
Blood drainage (ml)	127.87 ± 48.84 (150.0)***	275.00 ± 59.01 (300.00)
Hospitalization days (d)	9.97 ± 3.54 (10.00)**	15.13 ± 1.06 (14.00)

Variables are presented as mean ± SD (median).

Table III. Baseline characteristics of patients with a trail septal defect.

Characteristics	Thoracoscopic surgery	Median sternotomy
Female (N)	52	24
Male (N)	25	13
Age (year, Mean ± SD (Median))	30.19 ± 11.48 (28.00)	21.68 ± 20.11 (13.00)
Weight (kg, Mean ± SD (Median))	55.47 ± 10.4 (54.50)	35.34 ± 23.51 (34.00)
Tricuspid regurgitation (N)	28	7
Post-exertional palpitation (N)	6	2

Follow-up

Neither death nor embolism events caused by postoperative tumor off were detected. Also, there was no residual shunt or atrioventricular block in patients underwent ASD repair. There were no complications from the cannulation sites in the femoral vein or artery.

Discussion

Minimally invasive surgery begins in the 1990s[11]. In recent years, minimally invasive surgery has been widely used in the cardiac surgery[12]. Thoracoscopic surgery has been applied in many cardiac conditions, including the closure of congenital heart defects, resection of atrial myxoma, coronary artery bypass grafting as well as atrial fibrillation recently years[13]. It provided a better treatment with less trauma, less bleeding and faster recovery, compared with traditional cardiac heart surgery. Zhe et al[14] had reported several ASD cases were successfully repaired by totally thoracoscopic surgery. With thoracoscopic, we felt that the stalk of atrial myxomas was easily found and totally resected to prevent the recurrence of the myxoma after the operation. Especially some stalks of myxoma were loosely attached to the endocardium, which could be easily detached because of magnification. Besides, Yu et al[5] had reported that 12 cases underwent video-assisted cardiac surgery for removal of atrial myxoma successfully.

Despite these successful minimally invasive operations, the most of surgeons have not embraced endoscopic methods for more complex heart surgery due to several restrictions. Thoracoscopic vision is a two-dimensional image, which is different with the three-dimensional vision in traditional operation. Therefore, more training is needed to improve the spatial orientation ability and to prevent misoperation, adverse events and especially, bleeding for it is very hard to repair bleeding during the thoracic surgery process. Due to the small vision, surgeons must pay more attention to resect the tumor pedicle and to keep the integrity of the tumor to avoid embolism event. The mitral valve or tricuspid valve needs to be checked because of the regurgitation is often accompanied by myxoma. In this study, we treat atrial myxoma and ASD with totally thoracoscopic operation. All patients had successful myxomas resection or ASD repairs. Compared with traditional median sternotomy, the patients underwent thoracoscopic surgery had a shorter length of stay at ICU, less blood drainage and shorter hospitalization days. However, longer operation time, longer CPB time and aortic cross-clamp time were also detected for patients underwent thoracoscopic surgery. We did not meet the

Table IV. Perioperative data of patients with a trail septal defect.

Characteristics	Thoracoscopic surgery	Median sternotomy
CPB (min)	1 14.95 ± 20.01 (115.0)***	61.03 ± 29.60 (53.00)
Aortic cross-clamp (min)	37.39 ± 25.40 (45.00)***	12.95 ± 23.20 (0.00)
Operation time (min)	232.92 ± 61.02 (220.00)***	183.40 ± 54.63 (165.00)
Mechanical assistant ventilation time (h)	4.82 ± 2.10 (5.00)**	6.02 ± 2.50 (6.00)
ICU stay time (h)	18.54 ± 5.80 (18.00)***	39.68 ± 18.44 (44.00)
Blood drainage (ml)	179.48 ± 172.68 (150.00)	177.84 ± 139.13 (200.00)
Hospitalization days (d)	11.41 ± 4.24 (11.00)	11.68 ± 5.35 (9.00)

Variables are presented as mean ± SD and median.

situation to perform mitral valvoplasty (MVP) or tricuspid valvoplasty (TVR) at the same time, most valvular regurgitation was gone after the tumor was removed, a few cases have a slight regurgitation, which needs no further treatment. Notably, there was no statistical difference in blood drainage and hospitalization days between patients underwent thoracoscopic surgery and median sternotomy. This is partially associated with the skilled surgical techniques for ASD repair either by thoracoscopic surgery or median sternotomy.

The other influence successful factors are good cannulas technology and good venous drainage. The position of cannulas affects the femoral arterial cannula pressure and the femoral vein drainage. If venous drainage is insufficient, blood retention in the systemic circulation, engorged heart influence operation, meanwhile decreasing body perfusion flows and directly affects the whole body of oxygen supply. There were only 3 patients in this study which cannot achieve enough body perfusion because of the high femoral cannula pressure. The reason was that the larger size cannula was causing the increase of the resistance since the female's femoral vessels were thins. Therefore, we added a small size cannula (14 F-16 F) on another femoral artery, which offered perfusion on both sides of the femoral artery. We had 1 patient who had a high femoral artery cannula pressure at beginning, but it turns into normal after a few minutes, we consider it may be existing vasospasm, we spray on the surface of artery vessels with papaverine diluent after that (30 mg papaverine diluted with 0.9% NaCl 500 ml). Most of the poor vein drainage will be improved by adjusting the position of the cannulas. But we failed in 1 case, the patient finally gets a better drainage by a rectangular cannula inserted into the superior vena cava through the Port-3. Pneumothorax and atelectasis have occurred after postoperation because of the lung tissue was damaged during the operation[15]. There was only 1 case with the occurrence of pneumothorax and atelectasis, closed thoracic drainage was applied after diagnosis, recovery smoothly. Procedures carefully, less lung tissue damage, good hemostasis, well expansion lung, unobstructed drainage may reduce the occurrence of pulmonary complications.

No death or postoperative embolism events caused by tumor off occurred among all of 64 myxoma patients underwent tumor resection. No increase of mitral regurgitation or tricuspid regurgitation, arrhythmia and recurrence were found during a 12-month follow-up. All the patients' tumors were resected successfully with satisfied results. The advantages of the totally thoracoscopic surgery are less pain, less trauma, no use of steel wire and avoiding the midline sternotomy that needed a long time to recover. This method can reduce the bleeding after operation, at the same time, we also reduce the allogeneic blood transfusion as well as blood transfusion complications. Patients got cosmetic incision and discharged very soon.

We observed longer operation time in thoracoscopic surgery group, and this was partial because of prolonged CPB and aortic cross-clamp times. The previous literature[16,17] had reported that the CPB time of minimally invasive mitral valve surgery was extended 25% due to the learning curve and complex technology, which directly increase the injury caused by CPB. However, the CPB technology has recently been developed very well[18,19]. Therefore, thoracoscopic surgery is still effective and safe for treatment of myxoma although the longer CPB time. Notably, we found that the cross-clamp time was related with the complicity of operation, the surgeon's operation skill and thoracoscopic proficiently.

Conclusions

We reported our single center study of 64 patients with atrial myxoma and 114 patients with atrial septal defect treat with myxoma compared with traditional median sternotomy surgery. Totally thoracoscopic surgery technique had better cosmetic results, less trauma and pain perception, less bleeding, a shorter intensive care or hospital stay time, as well as a more rapid recovery, compared with conventional sternotomy surgery. The totally thoracoscopic surgery technique is effective and safe for treatment of myxoma and ASD. Further researches are needed to assess this technique

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Conflict of Interests
The Authors declare that they have no conflict of interests.

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