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Article

Totally Thoracoscopic Treatment of Cardiac Myxoma: Experience from 29 Cases and Review of the Literature

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Abstract

Background: Cardiac myxoma, a rare benign tumor, can cause significant patient morbidity if left untreated. Traditionally, treatment has involved open sternotomy; however, recent advancements now enable minimally invasive resection using totally thoracoscopic techniques. **Methods**: This retrospective study reviewed 29 cases of totally thoracoscopic resections of cardiac myxomas performed at our department between January 2019 and October 2022. Perioperative data were analyzed, and the surgical outcomes of a single surgeon's clinical experience were evaluated. **Results**: The study included 20 men and nine women, with a mean age of 49 $\pm$ 10.38 years. All surgeries were uneventful, with an average tumor size of 34.46 mm $\times$ 25.07 mm. The mean operation time was 230.17 $\pm$ 59.67 min, and the average cardiopulmonary bypass time was 93.14 $\pm$ 28.15 min. No intraoperative complications or postoperative deaths were reported. Follow-up transthoracic echocardiography at 12 months showed no residual intracardiac tumors or other abnormalities. **Conclusion**: Totally thoracoscopic resection of cardiac myxomas was demonstrated to be a safe and effective procedure, offering rapid recovery and a low complication rate, aligning with modern trends in minimally invasive cardiac surgery.

Keywords

cardiac myxoma; totally thoracoscopic surgery; minimally invasive surgery

Introduction

Cardiac myxoma is a rare primary tumor of the endocardium, accounting for a significant proportion of primary cardiac tumors [1]. Despite its rarity, with a prevalence of 0.0017% in autopsy studies, untreated cases can lead to substantial morbidity [2]. Genetic predisposition and environmental factors are hypothesized to contribute to the abnormal proliferation of endocardial cells, resulting in the development of cardiac myxomas [3]. These tumors are frequently associated with severe cardiac manifestations, including pulmonary embolism and heart failure, significantly impairing patients' quality of life [4]. Although many cases are asymptomatic, symptomatic cardiac myxomas can present with disabling symptoms [5], such as dyspnea, chest pain, palpitations, and systemic embolization [6], making surgical excision the preferred treatment option.

Historically, open surgery with median sternotomy was the standard approach for removing cardiac myxomas [7]. However, this invasive procedure frequently results in prolonged hospital stay, increased postoperative pain, and a higher risk of complications such as wound infections and damage to surrounding tissues. The protracted recovery period can further impact the patient's quality of life during convalescence. Thoracoscopic techniques have gained popularity in recent years due to their reduced morbidity and improved outcomes [8]. Advances in surgical equipment and minimally invasive techniques have enabled excellent postoperative recovery with fewer complications [9].

The objective of this study was to review our experience with the totally thoracoscopic treatment of cardiac myxomas in 29 patients. This review aimed to highlight the benefits and challenges of this minimally invasive approach and contribute to the ongoing discussion regarding optimal management strategies for cardiac myxomas.

Materials and Methods

Data Collection

All patients who underwent totally thoracoscopic resection of the cardiac myxomas between January 2019 and October 2022, performed by a single surgeon, were retrospectively reviewed. The hospital granted ethical approval (No. K202406-05), and the study adhered to the principles of the Declaration of Helsinki. Data on intraoperative details, postoperative outcomes, and complications were collected. All patients were fully informed about the surgical procedure and provided consent. Follow-up data were also gathered.

Perioperative Evaluation

A comprehensive preoperative evaluation was conducted of all patients, including a detailed medical history and physical examination. Arrhythmias were assessed using 12-lead electrocardiograms (ECGs), with ambulatory ECG monitoring as needed for intermittent dysrhythmias. Transthoracic echocardiography (TTE) confirmed the presence of intracardiac myxomas. Patient histories were reviewed to identify any previous embolic events and imaging studies such as computed tomographic (CT) or magnetic resonance imaging (MRI) of the head were conducted when clinically indicated. Chest CT scans were used to determine the feasibility of the thoracoscopic approach, and femoral vessel ultrasonography was performed to verify vascular access patency. Echocardiographic evidence of myxomas was a prerequisite for all patients, and those with significant coronary stenosis, severe lung disease, or thoracic adhesions were excluded. Diabetes mellitus was diagnosed based on clinical findings and laboratory tests, including fasting blood glucose and glycated hemoglobin (HbA1c) measurements. Hypertension was diagnosed following international guidelines based on patient history and repeated blood pressure measurements. For patients over 50 years of age, coronary angiography was performed to assess coronary artery status and identify significant coronary artery disease preoperatively. Patients were included in the study if echocardiography confirmed a cardiac mass and there was a clear indication for surgery. Exclusion criteria included: (1) prior right thoracic surgery; (2) severe thoracic deformity; (3) severe pleural adhesions as seen on chest CT; (4) concurrent severe coronary atherosclerosis, valvular disease, or complex congenital cardiac anomalies; (5) contraindications to conventional thoracotomy; (6) the requirement for reoperation; and (7) significant calcification or deformity of the femoral vessels precluding extracorporeal circulation. This protocol ensured that only patients eligible for thoracoscopic myxoma resection were included. Intraoperatively, TEE was utilized to assess for residual tumors or other cardiac abnormalities and to confirm the complete resection of the tumor.

In the intensive care unit (ICU), patients were closely monitored for neurological status, myocardial markers, and potential complications. TTE and ECG were used to detect arrhythmias or structural abnormalities. Routine bedside chest radiography and pleural ultrasound were performed to identify pulmonary complications such as infections, edema, or embolism. Myocardial markers were regularly checked, and ST-segment changes on ECGs were carefully monitored for signs of coronary embolism. Fluid management was optimized with the judicious use of furosemide, and intravenous methylprednisolone was administered to improve pulmonary function. Mechanical ventilation was discontinued once patients demonstrated stable hemodynamics, satisfactory arterial blood gases, and robust spontaneous respiration. Postoperative care included aggressive chest physiotherapy, respiratory function training, and early ambulation to promote recovery. Early removal of thoracic drains was prioritized to further expedite recovery.

Anesthesia Strategy

A fast-track cardiac anesthesia protocol was implemented, using short-acting agents, including opioids and muscle relaxants. Intraoperative monitoring included TEE for real-time cardiac assessment; bispectral Index (BIS) monitoring was employed to optimize anesthesia depth, facilitating early tracheal extubation. Single-lung ventilation was achieved using a double-lumen endotracheal tube or a bronchial blocker. During mechanical ventilation, volume-controlled ventilation (VCV) or pressure-controlled ventilation (PCV) was used, with a tidal volume of 6 mL/kg and a respiratory rate of 12 breaths/min for bilateral lung ventilation and 14–16 breaths/min for single-lung ventilation. The goal was to maintain an end-tidal carbon dioxide pressure ($ETCO_2$) between 35–45 mmHg and to keep peak airway pressure (PAP) below 30 cm H_2O, with adjustments made as necessary to ensure optimal gas exchange and hemodynamic stability.

Operative Technique

The patient was positioned supine with the right side elevated by approximately 30° and slightly abducted to expose the anterior axillary line. Three 2-cm incisions were made: the first in the third intercostal space along the right parasternal line for the right-hand port, the second in the fourth intercostal space along the anterior axillary line for the left-hand port, and the third in the fifth intercostal space along the midclavicular line for the camera port. Incision protectors were utilized. Peripheral cardiopulmonary bypass (CPB) was established via the right femoral artery and vein. The pericardium was incised from the inferior vena cava to the ascending aorta, approximately 2–3 cm above the phrenic nerve, and retracted to expose the surgical field. The superior and inferior vena cava were occluded, and a purse-string suture was placed in the aortic root to insert the cardioplegia catheter. The ascending aorta was cross-clamped using a Chitwood clamp, and cold cardioplegia was administered antegrade. Carbon dioxide insufflation was used during the procedure. Right heart myxomas were excised via direct incision of the right atrium, including those located beneath the septal leaflet of the tricuspid valve. Left atrial myxomas were resected through right atrial and interatrial septum incisions, with a drainage tube inserted into the septum for left heart suction. The tumor and adherent tissue were excised, retrieved in a bag, or morcellated, followed by thoroughly irrigating the left heart chambers with saline. The tumor attachment site was cauterized and closed with Prolene sutures. The interatrial

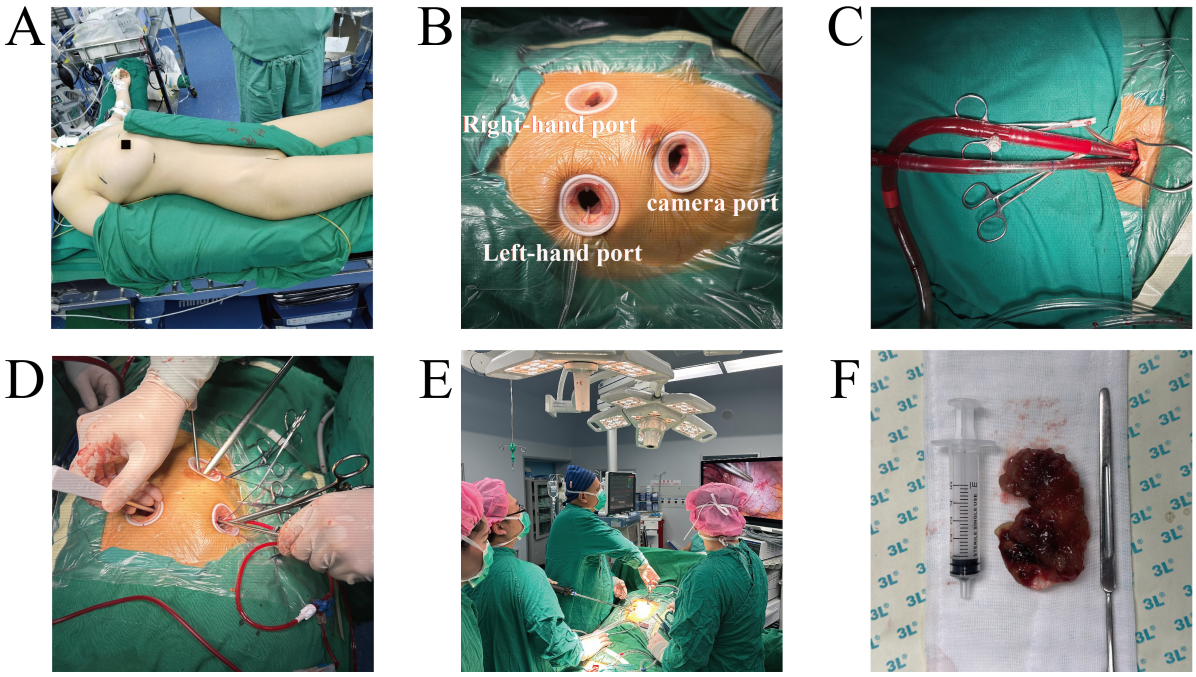

Fig. 1. The illustrations in Fig. 1 A–F show key steps in totally thoracoscopic cardiac surgery. (A) Patient positioning schema. (B) Schematic diagram of the thoracic wall incision. (C) Schematic diagram of the cannula placement in the inguinal area for peripheral cardiopulmonary bypass. (D) Schematic diagram of two sets of surgical instruments inserted through the thoracic wall incisions. (E) Schematic diagram of the surgical team setup during the operation. (F) Gross specimen of the resected cardiac myxoma.

septum was repaired using direct suturing or a bovine pericardial patch. The right atrium incision was meticulously sutured after examining the right ventricle. Residual gases were expelled from the cardiac chambers before the aortic cross-clamp (ACC) was released. The patient was gradually rewarmed and weaned from CPB. Autonomic resuscitation or external defibrillation was performed as needed, and extracorporeal circulation was successfully terminated. Each incision was carefully inspected for hemostasis, and all skin incisions were meticulously sutured. A 24F chest tube was inserted into the sixth intercostal space along the midaxillary line. The single-lumen endotracheal tube was repositioned, and the lungs were fully re-inflated to ensure optimal postoperative respiratory function. Surgical details are shown in Fig. 1A and **Supplementary Video 1** further demonstrates the described surgical technique.

Follow up

Follow-up assessments were conducted postoperatively at 3, 6, and 12 months on an outpatient basis. These evaluations included a 12-lead ECG and TTE to assess the patients' clinical status and detect any signs of complications or adverse surgical outcomes.

Statistical Analysis

Data were analyzed using Statistical Package for the Statistical Product and Service Solutions (SPSS) (version 26.0 International Business Machines Corporation, NY, USA) software for Windows. Descriptive statistics were reported as means with standard deviations for normally distributed continuous variables, and paired *t*-tests were conducted. Medians (interquartile ranges) were reported for continuous variables with skewed distributions. Categorical data were expressed as frequencies and percentages.

Results

Patient Characteristics

The study included 29 patients, all of whom underwent totally thoracoscopic resection of cardiac myxomas performed by a single surgeon. Of these, 20 were men, and nine were women, with a mean age of 49 $\pm$ 10.38 years. None of the patients had preoperative comorbidities, and all operations succeeded without intraoperative complications. Tumor sizes ranged from 15 mm $\times$ 10 mm to 50 mm $\times$ 60 mm, with a mean size of 34.46 mm $\times$ 25.07 mm. Histopathological analysis confirmed the diagnosis of myxomas in all cases, with the left atrium being the most common tumor location. Additional data are illustrated in Table 1.

Table 1. Baseline Data.

Variables	Results
Sex	
Male (%, n)	69.0 (20)
Female (%, n)	31.0 (9)
Age (years)	49 ± 10.38
BMI (kg/m^2)	23.49 ± 3.14
Preoperative LVEF (%)	63.70 ± 3.47
Size	
Length (mm)	34.46 ± 12.87
Width (mm)	25.07 ± 8.58
Tumor Location	
Near mitral valve annulus	5
Ventricular side of the septal cusp of tricuspid valve	1
Anterior wall of the right atrium near the inferior vena cava	1
The left side of the atrial septum at the fossa ovalis	22

BMI, Body Mass Index; LVEF, left ventricular ejection fraction.

Operative and Postoperative Outcomes

The mean operative time was 230.17 ± 59.67 minutes, with a mean CPB duration of 93.14 ± 28.15 minutes and an ACC time of 41.90 ± 17.61 minutes. Estimated blood loss was 300 mL (interquartile range [IQR], 300–400 mL). Three patients required intraoperative blood transfusions. The median ICU stay was 39 hours (IQR, 22–63 hours), and the median duration of mechanical ventilation was 17 hours (IQR, 13–19 hours). The operative and postoperative periods were uneventful in all cases, with no instances of complications such as mortality, conversion to sternotomy, reoperation, infection, bleeding, thrombosis, coronary embolism, or pulmonary edema. For clarity, complications were defined as follows: death: any occurrence during the study period; conversion to sternotomy: intraoperative switch to a median sternotomy approach; reoperation: any unplanned surgical intervention; infection: diagnosed based on clinical signs and microbiological evidence; bleeding: hemorrhage at the thoracic incision or other sites; thrombosis: predominantly pulmonary embolism, confirmed through clinical assessment, respiratory status, blood gas analysis, and elevated D-dimer levels; coronary embolism: identified through new ECG changes or elevated cardiac enzymes indicative of ischemia; pulmonary edema: confirmed via radiographic infiltrates and clinical symptoms of respiratory distress. The median hospital stay was 6 days (IQR, 6–8 days). Pre-discharge echocardiography revealed no residual intracardiac masses or shunting. Perioperative data are provided in Table 2.

Follow-up

All patients were effectively followed for 12 months. During this period, no complications such as myxoma recurrence, residual interatrial septal shunts, arrhythmias, or valvular heart disease were observed.

Table 2. Intraoperative and Postoperative data.

Variables	Results
Intraoperative duration (min)	230.17 ± 59.67
CPB duration (min)	93.14 ± 28.15
ACC duration (min)	41.90 ± 17.61
Blood loss (mL)	300 (300, 400)
Blood transfusion (%, n)	10.4 (3)
Postoperative LVEF (%)	62.86 ± 3.45
Postoperative complications (n)	0
Mortality (n)	0
ICU stay duration (h)	39 (22, 63)
Ventilation time (h)	17 (13, 19)
Total hospital stay duration (days)	14 (11, 16)
Postoperative stay duration (days)	6 (6, 8)

CPB, cardiopulmonary bypass; ACC, aortic cross-clamp; ICU, intensive care unit; LVEF, left ventricular ejection fraction.

Discussion

Primary cardiac neoplasms are sporadic [10], with approximately 75% classified as benign and myxomas accounting for nearly 50% of these cases [11]. Determining the exact incidence of these tumors is challenging since many patients remain asymptomatic, with detection frequently incidental during evaluations for unrelated cardiac conditions. Myxomas are benign tumors originating from the endocardium that present with a diverse range of symptoms influenced by their position, size, and mobility. These symptoms frequently relate to intracardiac obstruction, embolic potential, or systemic effects [5].

Table 3. Case Series of Minimally Invasive Totally Thoracoscopic Myxoma Resection.

Ref	Year	N	Complications	CPB duration (min)	ACC duration (min)	Duration of postoperative stay (days)	Follow-up (months)
Tarcan *et al*. [22]	2011	1	0	121	57	3	3
Dang *et al*. [23]	2018	1	0	150	116	8	3
Xu *et al*. [24]	2023	2	0	Mean 111.5	Mean 54	Mean 8.5	1
Yu *et al*. [25]	2010	12	0	96–126	46–63	Mean ± SD 7 ± 1.2	-
Deng *et al*. [26]	2017	TTCS 40 MS 24	0	Mean ± SD TTCS 125.13 ± 29.33; MS 59.13 ± 5.74	Mean ± SD TTCS 52.02 ± 17.76; MS 24.88 ± 3.08	Mean ± SD TTCS 9.97 ± 3.54; MS 15.13 ± 1.06	12
Zhao *et al*. [27]	2021	15	*1/15	Mean ± SD 46.5 ± 18.6	Mean ± SD 20.6 ± 6.7	Mean ± SD 5.2 ± 1.2	3
Nam *et al*. [28]	2021	26	0	Mean ± SD 134 ± 39	Mean ± SD 81.4 ± 26.4	Mean ± SD 6.9 ± 5.4	-
Dang *et al*. [29]	2024	36	△2/36	Median (IQR) 127 (120–164)	Median (IQR) 49 (45–79)	Median (IQR) 7 (6–9)	Mean ± SD 27.5 ± 15.0

TTCS, totally thoracoscopic cardiac surgery; MS, median sternotomy; SD, standard deviation; IQR, Interquartile Range; *Represents one patient who developed postoperative coronary embolism; △Represents one case of sternotomy conversion for aortic bleeding and one case of postoperative pulmonary edema.

Surgical intervention remains the primary treatment modality for cardiac myxoma [9]. Historically, open sternotomy has been the standard approach, offering direct visualization and access to the heart [10]. However, in recent years, there has been a notable shift towards minimally invasive techniques driven by advancements in surgical specialties; these comprise mini-thoracotomy, video-assisted thoracoscopy (VATS), robotic surgery, and totally thoracoscopic surgery [12]. Minimally invasive methods offer advantages such as minimal postoperative pain and faster recovery [8]. Although robotic-assisted endoscopic surgery shows promise, the technique has been constrained by high costs and the significant space required for the equipment, restricting its broader adoption [13]. Subsequently, more cost-effective approaches, such as mini-thoracotomy and non-robotic thoracoscopic surgeries, are more commonly utilized. Over the past two decades, totally thoracoscopic cardiac surgery (TTCS) has been widely applied in the treatment of various cardiovascular conditions, including atrial and ventricular septal defects, mitral, tricuspid, and aortic valve diseases, with excellent clinical outcomes [14–16]. This technique has recently been successfully applied to complex conditions such as hypertrophic obstructive cardiomyopathy and coronary artery bypass grafting [17,18]. TTCS has proven effective in repeat surgeries and in managing iatrogenic cardiac injuries [19,20]. The primary advantages of this technology are its minimally invasive nature, rapid recovery, improved cosmetic outcomes, reduced risk of surgical complications, decreased likelihood of repeat surgeries, shortened hospital stays, and lower healthcare costs [21].

In this study, 29 cases of totally thoracoscopic resection of cardiac myxomas performed by a single surgeon were reviewed. Based on the findings, the following insights are offered: (1) Optimal candidates for thoracoscopic resection can be identified through accurate tumor localization and careful size assessment; (2) Preoperative evaluation with chest CT and cardiac ultrasound is crucial; operative port placement may need to be adjusted based on the patient's anatomy; (3) Proper positioning of the venous drain is essential for right atrial myxomas to avoid compressing the right atrium and causing tumor fragmentation; (4) The tumor pedicle and surrounding normal tissue should be excised as widely as possible to prevent recurrence; (5) Tumor extraction should be performed using an extraction bag to minimize the risk of contamination. For tumors lacking a peritoneal covering, particularly those larger and prone to fragmentation, removal should be done in stages using oval forceps. After excision, each cardiac chamber should be thoroughly rinsed with saline to eliminate residual tumor tissue; (6) The roughened area left after resecting the tumor's pedicle should be cauterized and sutured with Prolene to prevent thrombosis; (7) If the defect created by resection is substantial, the septum should be repaired with a Dacron or pericardial patch; (8) For atrial incisions, a double-layer closure technique is recommended, with precise hand-tying of knots due to the proximity of the incision to the chest wall; (9) Intraoperative evaluation of atrioventricular valve function is crucial; before closing the septal and right atrial incisions, the valves and subvalvular structures should be carefully examined to ensure no damage to the chordae tendineae. Adhering to these principles can effectively reduce the risk of intraoperative complications, ensuring medical safety and optimal surgical outcomes. Our study demonstrates that totally thoracoscopic resection is a safe and effective treatment for cardiac myxomas, with no complications or mortality observed in our patient cohort.

Several studies that utilized minimally invasive, totally thoracoscopic techniques for cardiac myxoma resection were reviewed, excluding those involving robotic assistance. The focus was on studies that provided precise data on patient outcomes and surgical procedures, ensuring their relevance to current practice. A summary table of primary outcome data from eight studies of totally thoracoscopic myxoma resection is presented in Table 3 (Ref. [22–29]). Given the limited number of published studies in this field, most consist of case reports, case series, and retrospective comparative studies.

Our analysis encompassed 91 cardiac myxoma resections performed over 13 years from 2011 to 2024, reflecting a diverse patient population and diverse surgical experiences. These studies consistently highlight the safety and efficacy of minimally invasive approaches, with a notably low incidence of postoperative complications. Furthermore, the shorter hospital stays reported in these studies emphasize the accelerated recovery enabled by thoracoscopic surgery, a hallmark of minimally invasive procedures. This exhaustive analysis of 29 cases treated using a totally thoracoscopic approach supports these established trends while adding robust evidence to the existing literature. Our findings, which align with the cumulative data from other studies, underscore the safety, efficacy, and rapid recovery associated with thoracoscopic surgery. This series demonstrated no postoperative complications or mortalities, highlighting the precision and care that have become standard in our practice. The outcomes from our 29 thoracoscopic myxoma resections closely align with those reported in recent literature, underscoring the reliability of minimally invasive techniques. With an average operative duration of 230.17 minutes, CPB time of 93.14 minutes, and ACC time of 41.90 minutes, our results reflect a high level of procedural efficiency. Reducing blood loss and the limited utilization of blood products lowers hospitalization costs and conserves healthcare resources. The patients experienced swift recovery, characterized by brief ventilation times, concise ICU stays, and an average postoperative stay of just 6 days, keeping with the principles of minimally invasive cardiac surgery.

Although individual studies reported variations in incision design and surgical techniques, the consistency of positive outcomes highlights the adaptability and flexibility of the thoracoscopic approach. The case reports and series reviewed provide valuable insights into the nuances of thoracoscopic surgery, particularly in managing large or unusually positioned tumors. In this series, the patient selection based on tumor size and location was crucial for determining the feasibility and outcomes of totally thoracoscopic resection of cardiac myxomas. This program's initial phase focused on smaller atrial septum tumors to ensure quality and safety. With expertise gained, the criteria were expanded to include more challenging cases with no adverse effects on patient outcomes. Recent studies have explored the application of thoracoscopic techniques in specific populations. For instance, a compelling series by Liu *et al*. [30] demonstrated that totally thoracoscopic surgery is a safe and effective option for managing left atrial myxomas during pregnancy, benefiting both maternal and fetal outcomes.

Limitations

While these studies show promising results, the review must acknowledge the limitations of the available literature, which is predominantly based on case reports and small series. Most studies were retrospective, with variability in patient demographics and surgical protocols limiting definitive conclusions. Moreover, follow-up periods were generally short to moderate, lacking comprehensive long-term outcome data. Therefore, more extensive, well-designed prospective studies with extended follow-up periods are needed to strengthen the evidence for thoracoscopic myxoma resection. Future research should also include direct comparisons with the traditional sternotomy approach to better evaluate the advantages and limitations of minimally invasive techniques.

Conclusion

This series, representing a single surgeon's experience, supports the feasibility and safety of totally thoracoscopic resection of cardiac myxomas. While further studies with long-term follow-up are necessary to confirm these preliminary results, existing evidence suggests that thoracoscopic surgery is effective in selected patients. Ultimately, the approach and procedure should be tailored to the patient's condition, informed by thorough preoperative evaluation.

Availability of Data and Materials

The data supporting this study's findings are available from the corresponding author, Abudunaibi Maimaitiaili, upon reasonable request. For the literature review that informs the data used in this study, the sources can be accessed through PubMed.

Author Contributions

AM served as the principal investigator for the project, overseeing the entire process, including study conceptualization and design. AA and DM made a significant contribution to the collection of data and the initial drafting of the article. Played a pivotal role in organizing the clinical data and ensuring the accuracy and completeness of the patient's medical history. Reviewed the pertinent literature, reading a substantial volume of material, critically interpreted the clinical findings and provided significant intellectual input to the discussion section. ZXY provided valuable assistance in the data collection process and offered insightful comments during the drafting stages of the manuscript. AA and DM contributed equally to this work and should be considered co-first authors. All authors contributed to editoria changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

This retrospective study, which involved a case series from our institution, was approved by the Ethics Committee of the First Affiliated Hospital of Xinjiang Medical University (approval no. K202406-05) and was conducted in compliance with the Declaration of Helsinki and its subsequent revisions, or equivalent ethical criteria. Given the retrospective design of our study, the requirement for informed consent was waived by our Institutional Review Board.

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Conflict of Interest

The authors declare no conflict of interest.

Supplementary Material

A **Supplementary Video** (Video 1) provides a visual accompaniment to the technique described. Video 1: Intraoperative Footage of Thoracoscopic Myxoma Resection demonstrates the critical steps of the procedure and serves as a practical guide to the surgical approach presented in our study. Supplementary material associated with this article can be found, in the online version, at https://doi.org/10.59958/hsf.7777.

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