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ORIGINAL ARTICLE

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THORACIC

Subxiphoid Thoracoscopic Surgery Is Safe and Feasible for the Treatment of Anterior Mediastinal Teratomas: A Multicentre Retrospective Study

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Graphical abstract

Subxiphoid Thoracoscopic Surgery is Safe and Feasible for the Treatment of Anterior Mediastinal Teratomas: a multicenter retrospective study

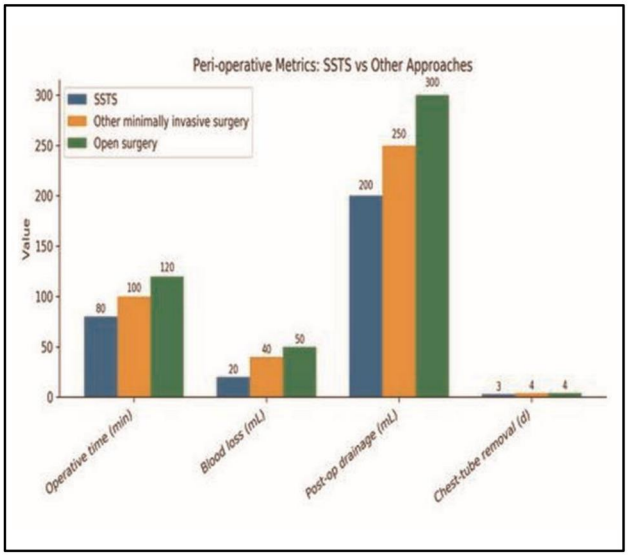
Summary

Population: 159 patients with benign anterior mediastinal teratoma from 5 medical centers.

Intervention: SSTS (n = 26).

Comparison: Other minimally invasive (n = 93) and open (n = 40).

Outcome:
- 100% R0
- Median : 80 vs 120 min
- Blood loss: 20 vs 50 mL
- Drainage: 200 vs 300 mL
- Chest-tube : 3 vs 4 days



Legend: SSTS = Subxiphoid-Subcostal Thoracoscopic SurgeryR0 = complete (margin-free) resectionmin = minutesmL = millilitresd = days

Author Contributions: Y. Liu and E. Xu are co-first authors of this work.

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Abstract

Background: Mediastinal benign teratoma is rare, with surgery being the only effective treatment. Few studies reported the surgical outcomes of resecting mediastinal benign teratomas via the subxiphoid approach by thoracoscopy. This study retrospectively compares the subxiphoid with other surgical approaches, aiming to assess the safety and feasibility of this technique.

Methods: We retrospectively analysed the clinical data of 159 patients with pathologically confirmed mediastinal benign teratomas who underwent surgery in 5 hospitals from July 2014 to June 2024. Various parameters of the subxiphoid approach were compared with those of other surgical methods.

Results: The surgical approaches included median sternotomy in 26 cases, lateral thoracotomy in 14 cases, lateral thoracoscopic surgery in 80 cases, subxiphoid thoracoscopic surgery in 26 cases, and robotic surgery in 13 cases. For patients who underwent the subxiphoid approach, the median surgery time was 80 min (70, 90), the median intraoperative blood loss was 20 mL (10, 20), the median postoperative drainage volume was 200 mL (0, 350), and the median time to drain removal was 3 days (0, 3). Complete tumour resection was achieved in all 26 patients (100%). The subxiphoid approach showed advantages in the aforementioned aspects compared to other surgical methods.

Conclusions: The subxiphoid and subcostal arch approach is a safe and feasible surgical technique for benign anterior mediastinal teratoma, with a potentially faster postoperative recovery and less cost. It is a valuable alternative to conventional median sternotomy, lateral thoracotomy, and lateral thoracoscopic surgery in resection of anterior mediastinal teratoma.

Keywords: anterior mediastinal tumour; teratoma; thoracoscopic surgery; subxiphoid.

INTRODUCTION

Mediastinal mature teratoma (MMT) is a relatively rare anterior mediastinal neoplasm that often presents without specific symptoms, accounting for 15% of all mediastinal tumours.[1-3] Clinical manifestations are predominantly due to mass effect, most commonly chest pain, chest tightness, and cough.[4,5] The majority of cases are incidentally detected on imaging and are frequently misdiagnosed as thymoma or thymic cyst.[6] Surgical resection remains the only effective treatment, and the choice of surgical approach depends on tumour size, nature, and location.[7-10] These tumours grow slowly and exhibit low malignant potential; mature teratomas consist of fully differentiated ectodermal, mesodermal, and endodermal elements and generally follow a benign course. Rarely, mature teratomas may contain immature components and behave aggressively, but surgical treatment is associated with favourable prognosis.[11-13] Common surgical approaches include median sternotomy, lateral thoracotomy, and video-assisted thoracoscopic surgery (VATS).[14-16] Compared with conventional open surgery, VATS offers significant advantages such as reduced blood loss, shorter drainage duration, lower complication rates, and shortened hospital stay.[17] However, lateral VATS is limited by intercostal nerve injury and inadequate tumour boundary exposure, particularly for midline tumours involving the brachiocephalic veins.[18,19] In recent years, the subxiphoid approach has gained increasing attention in anterior mediastinal surgery; subxiphoid thoracoscopic thymectomy (SATT) and thymoma resection via this route have been successfully performed at multiple medical centres.[20-22] Several studies report that this approach provides excellent surgical safety and reduced postoperative pain in thymoma patients.[23-25] As early as 1977,[26] it was shown that subxiphoid endoscopic procedures could accomplish exploration and biopsy; with advances in equipment and technique, this approach has been widely applied to various diseases. In 1999, Japanese scholar Kido first described 3 cases of anterior mediastinal tumour resection via a sternal-lifted subxiphoid incision.[27] To date, however, no studies have specifically addressed subxiphoid resection of benign mediastinal teratomas. Compared with other mediastinal tumours, teratomas contain more complex internal elements, are often multiloculated and cystic, and tend to be larger in diameter, all of which increase operative difficulty.[28] The aim of this study was to evaluate the preliminary outcomes of combined subxiphoid-subcostal thoracoscopic resection of benign mediastinal teratomas to confirm its safety and efficacy.

METHODS

Patient data

A retrospective analysis was conducted on the clinical data of all patients with benign mediastinal teratomas who underwent surgery at the Thoracic Surgery Department of 5 medical centres: the First Medical Center of the Chinese People's Liberation Army General Hospital, the Hainan Hospital of the Chinese People's Liberation Army General Hospital, the Southern Theater Command General Hospital of the Chinese People's Liberation Army, Henan Provincial People's Hospital, and Cangzhou Central Hospital, from July 2014 to June 2024. All patients successfully underwent tumour resection with a definitive pathological diagnosis. To control for potential technical variability, each surgeon had experience with at least 50 anterior mediastinal tumour resections and had performed 10 cases of Masaoka stage III thymoma resections. Exclusion criteria comprised non-anterior mediastinal teratomas, incomplete clinical records, patients who did not undergo surgery for any reason, and cases operated on by surgeons who did not meet the above-specified experience requirements. The data were collected retrospectively through each centre's electronic medical record system and entered by at least 2 independent physicians using standardized case report forms. All included patients had complete data; the detailed inclusion flowchart is shown in **Figure 1**. All centres employed the same evaluation criteria to ensure comparability and consistency across sites. To minimize potential sources of bias, we included all consecutive eligible cases to reduce selection bias; data abstraction was performed independently by at least 2 physicians using standardized forms to minimize measurement and observer bias. Patients with substantial missing clinical data were excluded to ensure standardized and

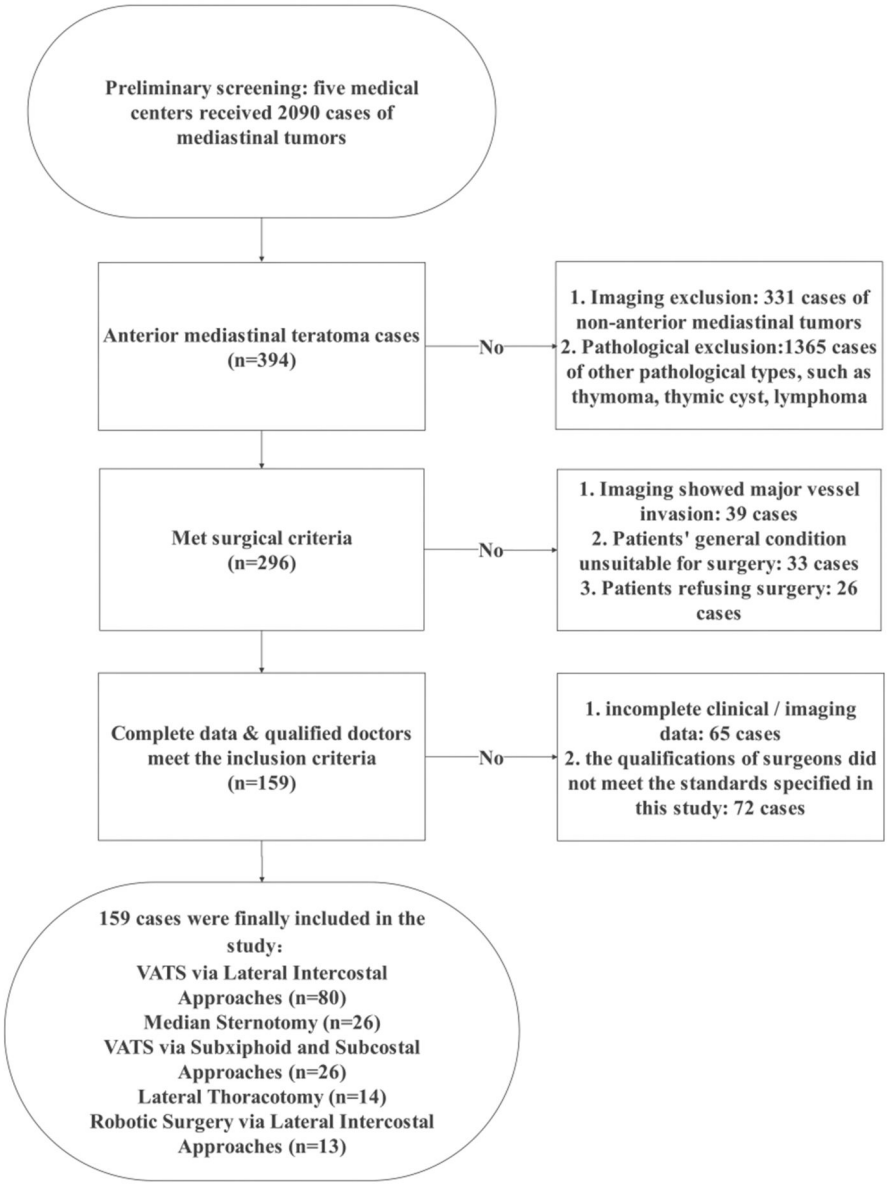

Figure 1. Flowchart of the Patients Screened

comprehensive data collection, whereas cases with only minor missing values underwent multiple imputation using the SPSS 21.0 (IBM Corp., www.ibm.com) Multiple Imputation module. The clinical characteristics, imaging findings, surgical methods, and prognosis of all patients were analysed. Depending on tumour location, size, and invasion, 5 surgical approaches were employed: median sternotomy, lateral thoracotomy, thoracic VATS via a lateral intercostal approach (main incision < 5 cm), VATS via subxiphoid and bilateral subcostal incisions, and robotic-assisted surgery via a lateral intercostal approach. We compared the subxiphoid approach with other open and thoracoscopic surgeries. One of the objectives of this study was to compare open versus minimally invasive surgery in terms of intraoperative outcomes (blood loss, operative duration) and short-term recovery (postoperative drainage, chest-tube removal time), and to further assess the safety of subxiphoid thoracoscopic surgery (SSTS) relative to all other surgical approaches. Although this was a retrospective study, the subxiphoid approach was applied on an intention-to-treat basis, and all procedures were performed by lead surgeons who had completed more than 100 anterior mediastinal resections via this technique. Data were statistically analysed using SPSS and Python 3.7.0 (Python Software Foundation, www.python.org). Normality of continuous variables was assessed using the Shapiro-Wilk test. Normally distributed continuous variables were presented as mean (standard deviation, SD) and compared using independent sample t-tests for normally distributed variables or the Mann-Whitney *U*-test for non-normally distributed variables. Non-normally distributed continuous variables were presented as median (25th percentile, 75th percentile). Categorical variables were reported as frequency or percentage and analysed using the Chi-square test or Fisher's exact test for

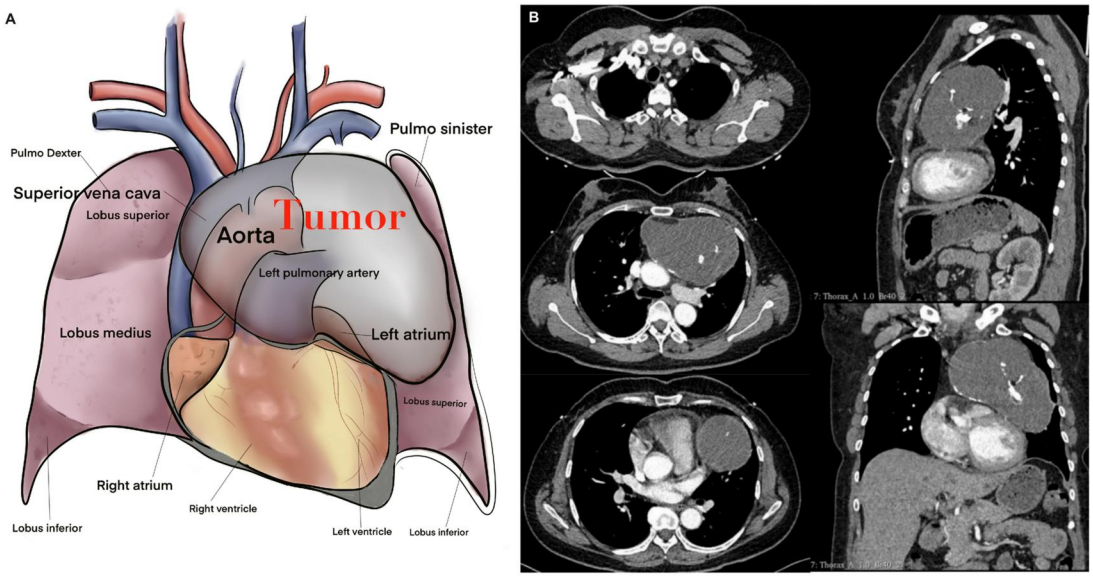

Figure 2. Tumour Location. (A) Tumour anatomical location diagram. (B) Preoperative CT, mediastinal window (width: 400, level: 50)

expected cell counts <5. A significance level of $P < .05$ was set. The research has been approved by the Ethics Committee of the General Hospital of the People's Liberation Army, with reference number S2023-388-01.

Perioperative management and surgical procedure

We designate this surgical technique as Subxiphoid-Subcostal Thoracoscopic Surgery (SSTS). The patient was placed in the supine position, and general anaesthesia was typically administered via single-lumen endotracheal intubation.[29] A 1.5-cm longitudinal skin incision was made 0.5 cm lateral to the subxiphoid margin, through which a 12-mm trocar was inserted for thoracoscopic observation. Two 5-mm incisions were made at the intersection of the bilateral subcostal margins and midclavicular lines, with a 5-mm trocar placed in each; the left trocar held the grasper, and the right trocar held the ultrasonic scalpel. CO_2 was insufflated through the subxiphoid trocar at a pressure of 8-10 cm H_2O, with close intraoperative monitoring of end-tidal CO_2 levels. Using the ultrasonic scalpel, the retrosternal plane is dissected and both mediastinal pleurae are opened to expand the operative field—fully exposing the bilateral phrenic nerves and the venous angles of the brachiocephalic veins, improving safety during upper-pole dissection, and avoiding the spatial constraints of a unilateral thoracic approach. For small, well-demarcated teratomas, one side of the pleura may be preserved, preferably the right. Dissection continued posteriorly along the sternum up to the mediastinal pleura on both sides, and further upward to the thyroid-thymic ligament. Depending on the degree of tumour invasion, wedge resection of the lung or partial pericardiectomy was performed. Dissection proceeded upward along the tumour's inferior margin, with careful identification and preservation of the bilateral phrenic nerves. At the level of the left innominate vein, meticulous dissection was performed, and if separation from the tumour was not possible, the vein could be ligated. When the use of a stapler was required, the right-sided 5 mm trocar was replaced with a 12 mm trocar. If the tumour had cystic components, cyst fluid was aspirated to aid exposure. For larger/giant solid tumours, an additional 5 mm trocar could be placed at the right sternal border in the second intercostal space to assist exposure. The resected specimen was placed in the right thoracic cavity, retrieved via the subxiphoid trocar using a specimen bag; if the specimen was too large, the subxiphoid incision was enlarged as needed. The decision to place a drainage tube was made based on intraoperative findings, residual CO_2 was evacuated, and the incision was closed in layers. We also captured the anatomical localization diagram and imaging data of the tumour (**Figure 2**), the patient's surgical position and the surgeon's stance (**Figure 3**), as well as intraoperative stills from a representative patient to illustrate the surgical field (**Figure 4**). Additionally, operative videos were recorded to demonstrate the SSTS approach in cases of severe tumour-tissue adhesion and emergency management of intraoperative bleeding (**Videos S1 and S2**).

Perioperative management was consistent with other surgical approaches. Postoperative criteria for chest tube removal were the absence of significant abnormalities on chest X-ray, no fever, and chest fluid output of less than 200 mL per 24 hours. Patients were allowed to be discharged within 24 hours of chest tube removal if they experienced no significant discomfort and could resume normal activities.

RESULTS

Clinical data

From July 2014 to June 2024, according to the inclusion criteria, a total of 159 patients with pathologically confirmed benign mediastinal teratoma underwent surgical treatment in 5 medical centres. All patients underwent chest computed tomography (CT) scans, which confirmed that the tumours were located in the anterior mediastinum; 21 patients received chest magnetic resonance imaging (MRI) scan. The demographic and clinical characteristics of the tumours, including gender, age, maximum tumour diameter, and symptoms, are given in **Table 1**. Postoperative pathological examination confirmed that no immature elements were present in any of the patients.

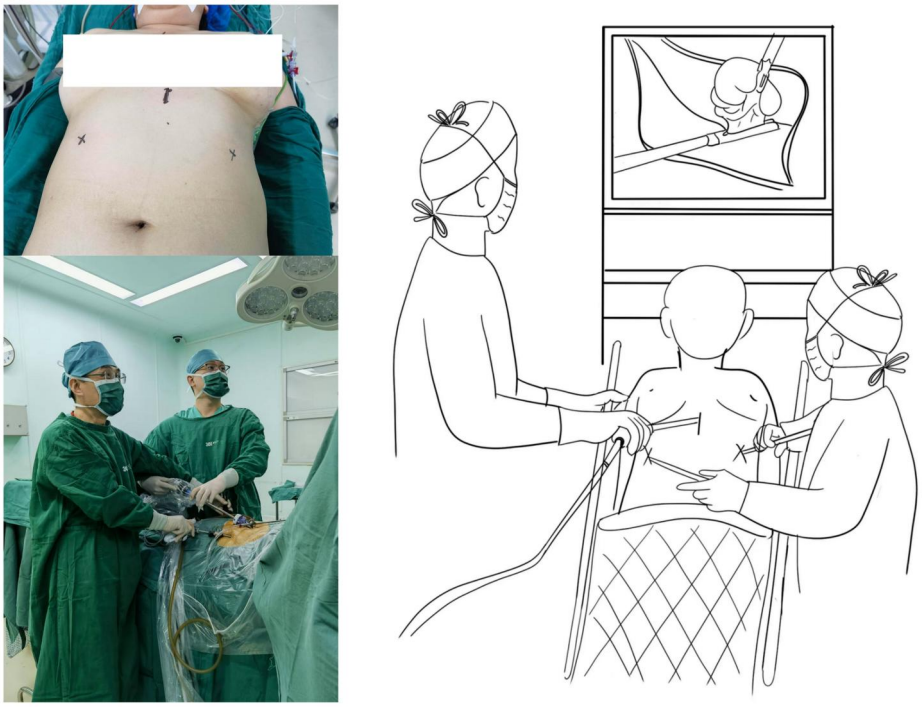

Figure 3. Schematic Diagram of Surgical Incision and Position

Surgical results

The median duration of surgery was 120 min (80.5-155), with a median intraoperative blood loss of 50 mL (20-100). Complete (R0) resection was achieved in 147 patients (92.5%), while 12 patients had microscopically suspicious margins due to tight tumour adherence to the pericardium or phrenic nerve, or scarring at the lung apex. Simultaneous resection of adjacent structures (phrenic nerve, pericardium, or lung) was performed in 48 patients (30.2%). The median maximum tumour diameter was 6.5 cm (5.0-8.5). Two patients (1.3%) required transfusion for major bleeding during tumour-pericardial dissection caused by a tear in a small pleural branch of the left innominate vein; haemostasis was achieved by small-gauze compression followed by continuous 4-0 Prolene suturing of the vessel defect. No patients required a change in the surgical approach due to intraoperative complications, and none were admitted to the intensive care unit (ICU) postoperatively for surgical reasons. There were no perioperative deaths. The median postoperative drainage was 300 mL (150-485), and the median time to chest tube removal was 4 days (3-5). No patients experienced severe postoperative complications, and there were no deaths within 6 months of follow-up.

We first compared open surgery with minimally invasive approaches and found that minimally invasive techniques offered significant advantages in intraoperative blood loss [20.00 mL (10.00, 50.00) vs 100.00 mL (50.00, 200.00), $P < .001$], operative time [90.00 min (70.00, 120.00) vs 150.00 min (123.00, 200.00), $P < .001$], postoperative drainage [245.00 mL (125.00, 435.00) vs 470.00 mL (288.00, 836.00), $P < .001$], and time to chest-tube removal [3.00 days (3.00, 4.00) vs 5.00 days (4.00, 6.00), $P < .001$] (**Table S1**). Further comparison of SSTS with other approaches revealed that the SSTS group demonstrated shorter operative times [80.00 min (70.00, 90.00) vs 110.00 min (90.00, 120.00), $P = .004$], lower intraoperative blood loss [20.00 mL (10.00, 20.00) vs 50.00 min (20.00, 50.00), $P = .007$], earlier chest-tube removal, and earlier discharge compared to the other surgical modalities [3.00 days (0.00, 3.00) vs 4.00 days (3.00, 4.00), $P < .001$]. The number of cases for different surgical procedures is shown in **Table 2**. Detailed comparative data are provided in **Supplementary Tables**. Comparative data for subxiphoid thoracoscopic surgery versus other surgical approaches are provided in **Table S2**. Comparisons between subxiphoid thoracoscopic surgery and other thoracoscopic approaches are shown in **Table S3**, while data comparing subxiphoid thoracoscopic surgery with robotic surgery are in **Table S4**. To mitigate bias from tumour size, SSTS patients were matched 1:2 to other thoracoscopic cases by tumour diameter (±1 cm), with balance assessed using standardized differences (<10%); post-matching analyses yielded conclusions consistent with the unmatched results (**Table S5**).

DISCUSSION

Mature mediastinal teratomas are rare and lack specific symptoms. Multiple studies, including the present one, have shown that minimally invasive surgery offers clear advantages over open approaches, yet the optimal minimally invasive route remains controversial.[30,31] Based on retrospective data from 5 medical centres and an analysis of 159 patients, this study compared the short-term efficacy of SSTS with other approaches. We found that subxiphoid resection of teratomas was associated with less intraoperative blood loss, shorter operative time, reduced postoperative drainage, and earlier chest-tube removal and discharge compared with other surgical modalities. When compared specifically with other thoracoscopic approaches and robotic surgery, the subxiphoid approach still showed significant advantages in terms of less postoperative drainage and quicker tube removal and discharge. There were no cases of residual tumour tissue with the subxiphoid approach, and there were no

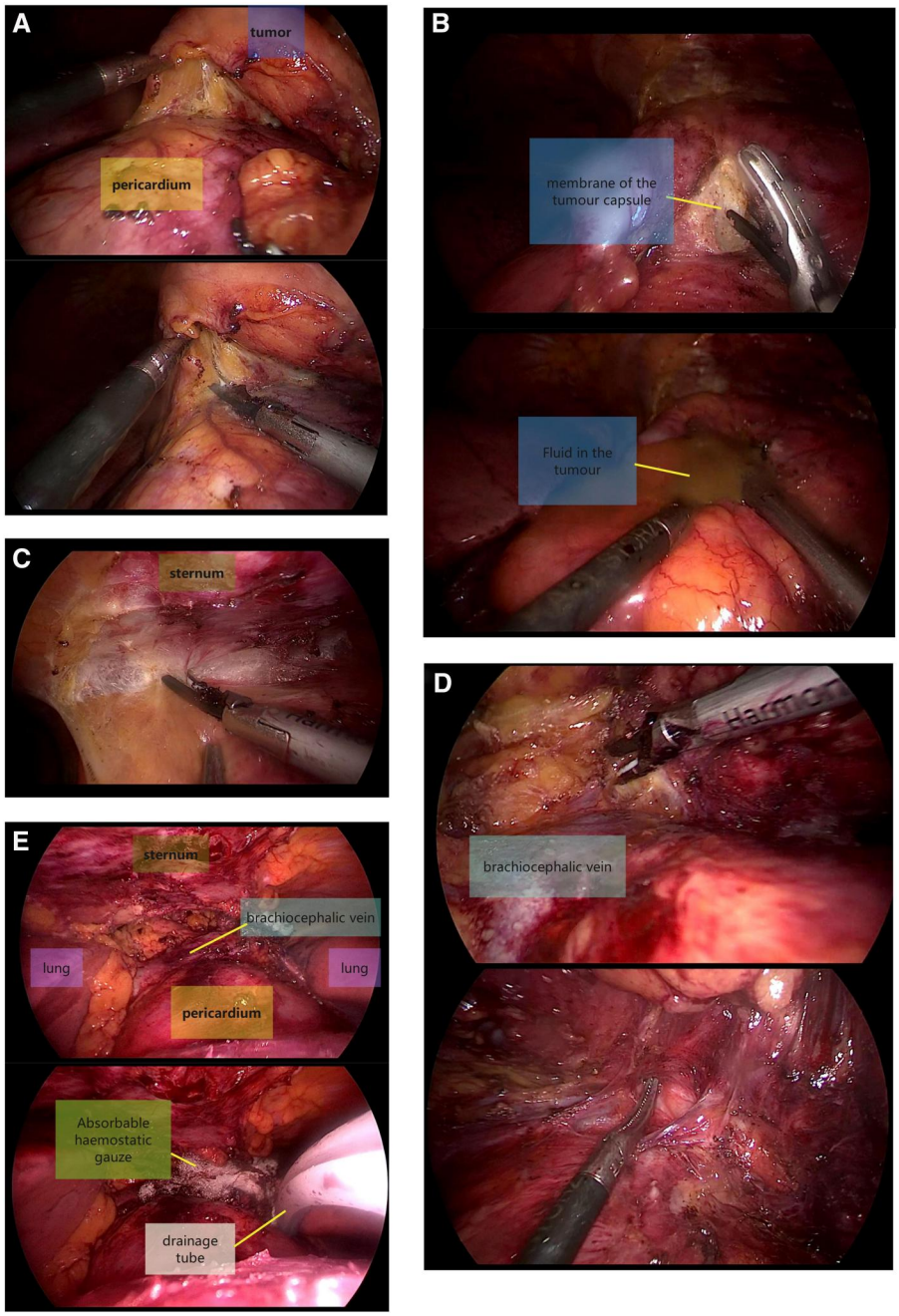

Figure 4. Schematic Diagram of Surgical Process. (A) Apply upward tension to the tumour using instruments, and use an ultrasonic knife to separate the gap between the tumour and the pericardium. If the pericardium is severely invaded, consider cutting the pericardium. (B) If the tumour is cystic or cystic-solid and too large, consider using an ultrasonic scalpel to open the tumour capsule. Quickly aspirate the internal fluid with a suction device. The process should be rapid and ensure complete suction of the liquid to avoid allergic reactions caused by liquid leakage. (C) Gently retract the tumour to expose the junction between the tumour and the upper part of the sternum. Gradually separate the tissues using an ultrasonic scalpel, with the dissection typically marked by the severing of the thyrothymic ligament. (D) The primary challenge of the surgery is the separation of the tumour from the brachiocephalic vein. The tumour is closely adherent to the vein, with almost no discernible space between them. Careful dissection with an ultrasonic scalpel is required. If the adhesion is too tight, consider blunt dissection with instruments instead of blindly using energy devices to avoid damaging the lateral wall of the brachiocephalic vein. Additionally, caution should be taken regarding the potential heat generated by the ultrasonic scalpel to prevent heat-induced injury. (E) The image below shows the surgical site after tumour resection. The tumour was completely removed with no residual tissue on the sternum or pericardium. The brachiocephalic vein was fully exposed and remained uninjured, with both phrenic nerves intact. The lungs were not adherent to the tumour; otherwise, a wedge resection of the lung would have been considered. Postoperatively, absorbable haemostatic gauze can be applied to the surgical site, and a drainage tube may be placed

significant differences in the resection of surrounding tissues (eg, lung, pericardium) compared to other methods. The maximum tumour diameter resected via the subxiphoid approach was 10.5 cm, comparable to other techniques. While the study did not quantify postoperative pain, data from postoperative analgesic use, clinical follow-up, and previous reports indicate that the subxiphoid approach results in less postoperative pain than other approaches.[24,32,33]

Regarding preoperative biopsy strategy, we believe indications for biopsy should include: atypical imaging findings unable to

Table 1. Summary of Patient Statistical Data

	N (%)/mean (SD)/M (Q1, Q3)
Age (years)	33.07 (SD: 12.31)
Sex	
Male	57 (35.8%)
Female	102 (64.2%)
With symptoms	56 (35.2%)
Chest pain	34 (21.4%)
Cough	9 (5.7%)
Chest tightness	17 (10.8%)
Fever	5 (3.2%)
Fatigue	2 (1.3%)
With basic diseases	28 (17.6%)
CT diagnosis of benign teratoma	85 (53.5%)
CT shows the presence of adhesions	46 (29.6%)
Tumour nature	
Cystic tumour	33 (20.7%)
Cystic-solid tumour	113 (71.1%)
Solid tumour	13 (8.2%)
Surgical duration (min)	120 (80.5,155)
Surgical bleeding volume (mL)	50 (20, 100)
Postoperative drainage volume (mL)	300 (150, 485)
Time to remove drainage tube (day)	4 (3, 5)
Complete resection of tumour	147 (92.5%)
Remove the surrounding tissue	48 (30.2%)
Maximum diameter of tumour (cm)	6.5 (5.0, 8.5)

Abbreviation: CT, computed tomography.

Table 2. Statistical Table of Surgical Methods

Surgical methods	N (%)
VATS via lateral intercostal approaches	80 (50.3%)
Lateral thoracotomy	14 (8.8%)
Median sternotomy	26 (16.4%)
VATS via subxiphoid and subcostal approaches	26 (16.4%)
Robotic surgery via lateral intercostal approaches	13 (8.1%)

Abbreviation: VATS, video-assisted thoracoscopic surgery.

rule out malignant germ cell tumour, lymphoma, or metastasis; imaging evidence of invasion into major vessels, pericardium, or bronchi that may require multimodal or neoadjuvant therapy to improve resectability; elevated serum tumour markers suggesting malignant potential; and poor baseline patient status or severe comorbidities necessitating a pathologic diagnosis to guide individualized treatment planning.

Conversely, biopsy may be safely omitted and surgery performed directly when all of the following criteria are met: characteristic CT/MRI features of mature teratoma (mixed fat-soft-tissue density with coarse calcification or fat-fluid levels), clear tumour margins without signs of invasion into critical structures; absence of significant comorbidities and fitness for general anaesthesia; normal serum AFP, -HCG, and LDH levels; and no radiographic evidence of mediastinal or cervical lymphadenopathy.

The cystic-solid mixed nature of teratomas tends to place traction on vessels during dissection, leading traditionally to recommendations for open surgery to ensure exposure.[28] Based on our findings, we propose the following inclusion criteria for SSTS: (1) preoperative diagnosis of an anterior mediastinal mass; (2) complete CT (plain + contrast) and/or MRI (plain + contrast) imaging showing no obvious involvement of the left innominate vein or superior vena cava; (3) maximum diameter < 8 cm for purely solid tumours or < 10 cm for tumours with cystic components; and (4) routine preoperative evaluations (ECG, pulmonary function, etc) demonstrating no contraindications to surgery, Notably, 88.1% of 159 patients ($n = 140$) with all surgical options were eligible for inclusion, suggesting that there was no obvious case selection for the study.

Compared to traditional open thoracotomy, the subxiphoid approach, as a minimally invasive, thoracoscopic-assisted surgery, offers significant benefits in terms of reduced blood loss, shorter surgery duration, improved patient experience, and quicker tube removal and discharge. For surgeons, the subxiphoid resection of anterior mediastinal teratomas represents an expansion of their prior experience with subxiphoid thymectomy—particularly as an extension of techniques used for resecting locally invasive thymomas—and is therefore relatively straightforward to learn.

Compared to other thoracoscopic surgeries, in addition to the advantages of reduced postoperative drainage and shorter chest tube removal and discharge times, we also found in clinical practice that using a single-lumen endotracheal tube and selecting the supine position reduced preoperative preparation time, enhancing the simplicity of the surgery. Intraoperatively, the subxiphoid approach for teratoma resection offers improved surgical visualization compared to other thoracoscopic approaches, with clearer exposure of the bilateral phrenic nerves and the innominate vein, thereby reducing the risk of accidental injury. This is particularly beneficial for higher-positioned teratomas, as it allows easier exposure and protection of the left innominate vein. In previous practice, if the anterior tumour involves bilateral mediastinum, innominate vein, or the upper bound of the tumour is not clear, open median sternotomy was recommended. In addition, the surgical incision is smaller and more aesthetically pleasing. If intraoperative complications arise, conversion from the subxiphoid incision to a median sternotomy is straightforward. The subxiphoid combined with the clavicular midline and subcostal intersection incision that we propose is an improvement on the subxiphoid incision described by Zielinski et al[34] and Ding et al,[25] this improvement not only retains the advantages of the traditional subxiphoid incision but also further enhances the flexibility and safety of the procedure. It has been validated for the first time in the field of anterior mediastinal tumours, particularly for the relatively complex teratoma surgeries. Building on previous single-centre studies, this research involved collaboration with 4 additional medical centres, spanning over 2000 km geographically, with the participation of multiple surgeons. This provides more robust evidence that this surgical approach is clinically safe, feasible, and highly promotable in practice.

Previous reports on the subxiphoid-subcostal approach have mainly focused on thymoma resection, and it has gradually become a mainstream technique for thymoma removal. According to our study, this approach is also safe and feasible for the resection of anterior mediastinal teratomas. If preoperative evaluation suggests that the patient has suspected thoracic adhesion, hypersensitivity to pain, or poor baseline health, which could increase the risks associated with prolonged anaesthesia, the subxiphoid approach could offer significant benefits. For patients with tumours located near the midline and positioned relatively high, this approach offers a clearer exposure of the innominate

vein compared to lateral approaches. Additionally, in patients in whom thymoma cannot be excluded preoperatively and who require complete thymectomy with mediastinal fat dissection, the subxiphoid approach provides distinct advantages.

Postoperative drainage volume with SSTS is significantly reduced, and chest-tube removal and discharge occur earlier. We attribute these advantages to the following: (1) SSTS uses 3 sealed trocars with CO_2 insufflation entering the anterior mediastinum above the diaphragm, leveraging the natural retrosternal vascular-fat plane; the short path and minimal pleural disturbance allow complete CO_2 evacuation before closure, collapsing the vascular-fat plane and minimizing postoperative exudation. (2) The approach avoids intercostal muscle transection and nerve traction or injury, substantially reducing pain. (3) Routine omission of chest tubes in many cases reduces tube-related irritation; some patients also forego urinary catheterization, facilitating rapid recovery. (4) Supine positioning and single-lumen intubation simplify anaesthesia and intraoperative repositioning, shortening total operative time and thereby reducing stress-induced exudation. Other investigators studying this technique in thymoma have reached similar conclusions.[24,33,35]

Findings from high-volume tertiary centres may not generalize to low-resource settings; subxiphoid approach adoption requires local expertise assessment. The limitations of this study include the following: (1) The low incidence of this disease results in a limited sample size and potential selection bias due to intergroup tumour volume differences. We attempted diameter-based matching and calculations, which confirmed our conclusions; however, the small patient number precludes a rigorous PSM analysis based on comprehensive clinical parameters, and additional cases are needed for further comparison. (2) This study is a retrospective case-control study, and there may be some biases in data collection and follow-up; future prospective studies are needed for further comparison. (3) The follow-up period in this study is relatively short, so it is unclear whether the long-term benefits of this surgical approach will surpass those of other techniques. Currently, we can only conclude that the short-term outcomes are not inferior to those of other surgical methods.

CONCLUSION

The subxiphoid combined with subcostal arch approach is a safe and feasible surgical technique for benign anterior mediastinal teratoma, with a potentially faster postoperative recovery and less cost. It is a valuable alternative to conventional median sternotomy, lateral thoracotomy, and lateral thoracoscopic surgery in resection of anterior mediastinal teratoma.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *EJCTS* online.

FUNDING

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CONFLICTS OF INTEREST

J.G., Y.L., E.X., F.K., G.H., S.H., C.Lia., Y.L., C.Li., L.S., Y.P., and H.R. have no conflicts of interest or financial ties to disclose.

DATA AVAILABILITY

Due to concerns regarding patient privacy and confidentiality, the data supporting the findings of this study are not publicly available. However, these data can be shared by the corresponding author upon reasonable request.

PATIENT CONSENT CONFIRMATION STATEMENT

Because the data analysis posed minimal risk to participants, the Ethics Committee reviewed and approved the use of verbal rather than written informed consent for all patients. Prior to data collection, each participant was provided with a clear and comprehensive explanation of the study's purpose and procedures, and their verbal consent to participate was obtained.

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