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Original Article

Videothoracoscopic First Rib Resection for Neurogenic Thoracic Outlet Syndrome: Results of 13 Patients

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Purpose: To present the clinical experience in video-assisted thoracic surgery (VATS) of first rib resection for patients with neurogenic thoracic outlet syndrome (NTOS).
Methods: The files of 13 patients (10 males, 3 females) having unilateral NTOS undergoing first rib resection via VATS were retrospectively investigated. The symptoms, operative times, durations of chest tube and hospital stay, complications, and postoperative courses were analyzed. All patients underwent VATS using a camera port and 3–5 cm utility incision.
Results: There was no morbidity. The average operation time was 81 ± 11 min (range 65–100 min). Chest tubes were removed in the first or second postoperative day (mean 1.23 ± 0.43 days). The mean postoperative length of hospital stay was 2.1 ± 0.9 days (range 1–3 days). The average duration of follow-up was 19 ± 13 months (range 2–38 months). Ten patients completed a follow-up during 6 months. One patient (10%) had minor residual symptoms, and the remaining patients (90%) were fully asymptomatic.
Conclusion: The VATS approach in the resection of the first rib for thoracic outlet syndrome is a safe method. It should be performed with acceptable risks under experienced hands. The magnified view and optimal visualization from the scope are beneficial. Avoiding neurovascular bundle retraction may seem to decrease the postoperative pain.

Keywords: neurogenic thoracic outlet syndrome, video-assisted thoracic surgery, first rib resection

Introduction

Thoracic outlet syndrome (TOS) is a disease that causes weakness, swelling, sensation of tingling, and/or pain of the upper extremities because of impingement of the brachial plexus and the subclavian vasculature, during their course between the neck and axilla.[1)] Neurogenic thoracic outlet syndrome (NTOS) is the most common manifestation of TOS in up to 95% patients, followed by venous thoracic outlet syndrome (VTOS) in 4% and arterial thoracic outlet syndrome (ATOS) in 1% of the patients.[2)]

The treatment of NTOS is mostly and primarily nonoperative, including physiotherapy and painkillers.[3)] Yet, surgical treatment including first rib resection combined with scalenotomy and resection of the cervical rib if it exists should be considered if there is no response to nonoperative treatment modalities.[1)] Various surgical techniques such as transaxillary and supraclavicular approaches have been performed.[1,4)] Ohtsuka et al.[5)]

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presented the video-assisted thoracic surgery (VATS) approach in 2 patients in 1999. Since then, several other reports on VATS in the treatment of TOS have been published.[6–12] Robotic resection of the first rib in patients with TOS has been described by Gharagozloo et al.[13] in 2012, and this approach has also gained importance in the surgical treatment of TOS.[14–16] In this study, we aimed to present our experience in VATS of first rib resection for patients with NTOS.

Materials and Methods

Thirteen consecutive patients with NTOS (including 10 males and 3 females; mean age 37.2 ± 5.7 years, range 28 to 46 years) undergoing first rib resection using the VATS approach between April 2020 and May 2023 were enrolled in the study. This study was reviewed and approved by the instutitional review board, and informed written consent was taken from all the participants. The files of the participants were investigated retrospectively. The symptoms, operative times, durations of chest tube and hospital stay, complications, and postoperative courses were analyzed.

All patients had unilateral NTOS (right/left: 9/4). They all complained of pain and numbness in ulnar nerve distribution. Three patients also had intrinsic hand muscle weakness. All patients received at least 6 months of physiotherapy and medical support with no improvement of the symptoms before the surgical treatment was offered. Each patient underwent nerve conduction test and had lowered results (mean 50.0 ± 6.5 m/sec, range 40 to 62 m/sec). A cervical magnetic resonance imaging was obtained for all patients demonstrating no other vertebral pathologies.

All operations were performed by a single experienced thoracic surgeon (O.D.). During the surgery, double-lumen intubation was used for single-lung ventilation. No carbon dioxide insufflation was used. The patients were placed in lateral decubitus position with the arm abducted to 90 degrees and held by a traction strap wrapped around the forearm and attached to an overhead bar. The tip of the scapula was used as a landmark for the fifth intercostal space. A 10-mm rigid 30-degree thoracoscope was introduced through the anterior axillary line in the 6th intercostal space. A 3 to 5 cm utility incision was made on the midaxillary line in the 4th intercostal space (**Fig. 1**). No rib spreader was used. The technical details of the operation (including how to define the margins of the resection of the first rib, how to free the first rib from neigbouring structures, and how to cut the first rib) were the same as previously decribed.[7,8] The planned resection margins of

Fig. 1 All the operations were performed through one camera port and 3 to 5 cm utility incision.

the first rib were anteriorly from nearby to the costochondral junction where the subclavian vein runs across the rib, and posteriorly from nearby to the costovertebral junction of the rib close to where the subclavian artery runs across the rib. After the margins of the first rib were identifed, the parietal pleura and the periosteum overlying it were opened with the help of a 5-mm endoscopic grasper and a hook-type electrocautery probe. Intercostal muscles were separated from the rib **(Fig. 2A)**. Then, scalene muscles were dissected off the rib. A long clamp was used to retract the rib and a blunt dissection was made using a peanut to dissect the neurovascular bundle from the superior aspect of the first rib. When the clear space was confirmed, the first rib was cut anteriorly near the costochondral junction using either an endoscopic rib cutter or a rongeur **(Fig. 2B)**. Then, blunt dissection was continued carefully through the posterior part of the rib **(Fig. 2C)**. Neurovascular bundles were identified by down-retracting the first rib. The neurovascular bundles were taken away from the rib using a peanut. The first rib were freed from the nearby structures posteriorly and then cut either by an endoscopic rib cutter as a single piece or resected as fragments using a rongeur. In order to trim the stumps to the costochonral junction anteriorly and the transverse process posteriorly, the rongeur was used, resulting in the neurovascular bundle descended into the pleural space **(Fig. 2D)**. At the end of operation, a chest tube was placed through the camera port and the axess incision was closed appropriately. The

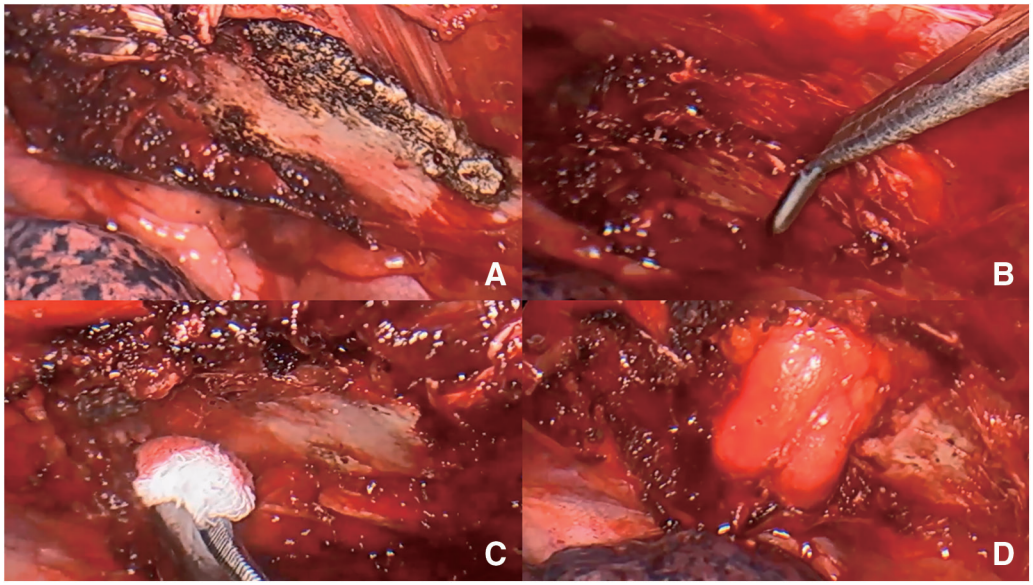

Fig. 2 (**A**) After the parietal pleura and the periosteum of the first rib were opened using a 5-mm endoscopic grasper and a hook-type electrocautery probe, intercostal muscles were separated from the rib by cautery. (**B**) The first rib was cut anteriorly near the costochondral junction using an endoscopic rib cutter. (**C**) Blunt dissection was continued through the posterior part of the rib using a peanut and other instruments. (**D**) The neurovascular bundle and nearby fatty tissue descended into the thoracic cavity at the end of the operation.

patients were extubated in the operating room and transferred to a recovery unit.

Each patient received the same pain management including intravenous nonsteroidal antiinflammatory drugs for 24 h every 8 h after the operation, and then oral form was introduced 3 times per day on the first postoperative day and continued at least 1 week. The chest tube was removed when there was no air leak, and the amount of the drainage was less than 150 mL/day. The patients were discharged on the chest tube removal day or the following day, according to their health conditions. Every patients were examined by their physiotherapist each week for the first postoperative month starting from 1 week after the operation and monthly up to 6 months if needed, in order to decide further need of physiotherapy.

Categorical variables were presented as numbers and percentages of patients, as appropriate. Continuous variables were expressed as mean and standard deviation. The Fisher's exact test was used to compare categorical variables, and the results were considered statistically significant at p values <0.05.

Results

The summary of VATS first rib resection in NTOS patients is given in **Table 1**. No early and late complications developed after surgery. The average operation time was 81 ± 11 min (range 65 to 100 min). All chest tubes were removed in the first or second postoperative days (mean 1.23 ± 0.43 days). The mean postoperative length of hospital stay was 2.1 ± 0.9 days (range 1 to 3 days). The mean length of the stump of the first rib was 29.2 ± 5.4 mm. The average duration of follow-up was 19 ± 13 months (range 2 to 38 months). Patients 11, 12, and 13 did not complete a follow-up duration of 6 months, but they presented no complaints. Patient 6 had a mild sensational loss of hand that improved within 4 months with physiotherapy. The lenght of stump of the first rib of this patient was 29.2 mm. Among the 10 patients who completed a follow-up duration of 6 months, only one patient (10%) had minor residual symptoms and the remaining 9 patients (90%) were fully asymptomatic. The lenght of the stump of the first rib had no correlation with the symptoms during the follow-up (p >0.05).

Discussion

First rib resection for TOS has been performed for nearly 55 years through supraclavicular or transaxillary incisions.[17] The transaxillary approach is currently more popular since it causes smaller scars and reduces the risk

Table 1 Summary of VATS first rib resection in NTOS

Patient	Age	Sex	Side	OP time (min)	CTD (days)	HS (days)	C	Follow- up time (months)	Outcome at 6 months
1	36	M	Right	90	1	2	None	38	GO
2	33	M	Right	95	1	2	None	34	GO
3	42	F	Right	85	1	3	None	30	GO
4	42	M	Left	75	1	1	None	29	GO
5	39	M	Left	80	1	1	None	29	GO
6	45	F	Right	85	1	1	None	24	PHY
7	29	M	Right	70	1	1	None	20	GO
8	32	M	Right	70	1	2	None	19	GO
9	28	M	Left	75	2	2	None	12	GO
10	35	M	Right	70	2	3	None	10	GO
11	38	F	Right	60	1	3	None	3	N/A
12	39	M	Left	60	1	3	None	2	N/A
13	46	M	Right	75	2	3	none	2	N/A

VATS: video-assisted thoracic surgery; NTOS: neurogenic thoracic outlet syndrome; M: male; F: female; OP: operation; CTD: chest tube drainage; HS: hospital stay; C: complication; GO: good outcome; PHY: physiotherapy; N/A: not applicable

of muscle and nerve injury compared with the supraclavicular approach.[1] Difficulty in visualizing the surgical field is a disadvantage of the transaxillary approach.[7] VATS is accepted as a minimally invasive procedure in thoracic surgery, and it has been called as a beneficial technique over the open approaches in the resection of the first rib.[15] VATS increases the view along the full length of the rib with definite identification of all the neurovacular bundle, and since there is no 6 to 10 cm incision along the throacic wall, it avoids injury to intercostobrachial cutaneous nerve.[8] Therefore, since its first presentation in 1999 by Ohtsuka et al.,[5] endoscopic approaches to the first rib resection, including VATS and robotic-assisted thoracic surgery, have been used in cases of all kinds of TOS, and even for Paget-Schroetter Disease.[6–11,14,15]

Since April 2020, we adopted this technique in our clinics and operated on 13 patients. All surgeries were performed by a single experienced thoracic surgeon (O.D.). Contrary to similar reports using 3 ports technique that was called "totally thoracoscopic,"[7–9] we used a camera port and a 3 to 5 cm utility incision, as previously described.[6,10] However, there intrathoracic operational steps including identification of the first rib, freeing it from neighbouring structures, and cutting and removing it were similar as done by previous researchers mentioned above. We did not use a new technique, just aimed to present our clinical experience, and compare our results with similar studies.

Table 2 demonstrates comparison between VATS and robotic-assisted first rib resection. Our study consisted of only patients with NTOS (n = 13). Only Nuutinen et al.[9] reported such an homogenous patient population having NTOS. Our results are nearly similar with that study in terms of operation time, duration of chest tube, and hospital stay. However, compared with the other studies consisting of patients with ATOS or VTOS and Paget-Schroetter Syndrome, we had lesser duration of operation time, duration of chest tube, and hospital stay in our study.

Potential complications related to the first rib resection for TOS include chylothorax, paresthesia, pneumothorax, and neurovascular injury.[8] Complication rate may be as high as 12.1%.[6] Pleural effusion and venous thrombosis necessitating thromboembolectomy have been reported.[7] Superficial wound infection and subcutaneous emphysema that did not influence postoperative hospital stay were also mentioned.[8,9] The development of pneumonia and pulmonary embolism was reported to increase the hospital stay duration.[6] In our study, we did not see any minor or major complication related to the surgery.

The use of VATS for the resection of the first rib provides better illumination and magnified operative view. Full visualization of the rib and the nearby neurovascular structures allows a more complete resection. Besides, since there is no retraction to the neurovascular bundle, the risk of brachial injury is potentially lower.[8] Postoperative pain is lower when the brachial injury is avoided and due to the fact that no major muscles of the neck and back are divided.[7] We did not measure the pain scoring in our study but observed that patients commonly

Table 2 Comparison between VATS and RATS first rib resection

Procedure	Studies	No. of cases	Pathology	OP time (min)	CTD (days)	HS (days)	Outcome
VATS	Soukiasian et al.[6]	58	58 TOS (no detail)	N/g	N/g	2.47	N/g
	Hwang et al.[7]	8	6 ATOS 1 VTOS 1 NTOS	193	6	9	100% (in 25 months)
	George et al.[8]	10	9 NTOS 1 ATOS	85	N/g	3	90% (in 9 months)
	Nuutinen et al.[9]	30	30 NTOS	83	1.27	1.93	67% (in 3 months)
	Buero et al.[10]	10	10 PSS	123	1.50	3.10	100% (in 12 months)
	This study	13	13 NTOS	81	1.23	2.10	90% (in 19 months)
RATS	Gharagozloo et al.[14]	79 83	79 NTOS 83 PSS	88 127	N/g N/g	34	97% (in 6 months) 100% (in 24 months)
	Zehnder et al.[15]	24	19 VTOS 5 ATOS	128	1	2	67% (in 12 months)

VATS: video-assisted thoracic surgery; RATS: robotic-assisted thoracic surgery; No.: number; TOS: thoracic outlet syndrome; ATOS: arterial thoracic outlet syndrome; VTOS: venous thoracic outlet syndrome; NTOS: neurogenic thoracic outlet syndrome; PSS: Paget-Schroetter disease; OP: operation; CTD: chest tube drainage; N/g: not given; HS: hospital stay

necessitated less painkiller treatment both in the hospital and in the follow-up.

Two studies compared VATS and transaxillary approaches for the resection of first rib. In the first study, short-term results were compared. Although the operation time was longer in the VATS arm, other parameters included pleural drainage and hospital stay durations. Besides, after a follow-up of 3 months, recovery rates in both approaches were similar, and there was no significant difference in "return to work" situation of the patients. Long-term outcomes were also compared in the second study. Although good or excellent outcome rate was higher in the transaxillary group, the difference was not significant (83% versus 77%). Encouraged by these two studies, the authors concluded that the VATS approach should be an acceptable alternative to the transaxillary approach.[9,11] No patient underwent transaxillary approach in our clinic; thus, although we agree with the abovementioned conclusion, we do not have our data to compare the results.

The rate of good recovery after the VATS approach in the resection of the first rib ranged from 67% to 100% in the literature, as given in **Table 2**. This high range may be due to different follow-up durations among the reports, and all studies, except one, consisted of all types of TOS and even Paget-Schroetter Syndrome. Good outcome of 67% was achieved in the study of Nuutinen et al.[9] consisting of only patients with NTOS after a follow-up of 3 months. We omitted our last 3 patients who did not complete a postoperative period of 3 months, and found out that our rate of good outcome was 90% for patients followed up more than 3 months.

Conclusion

In conclusion, our results demonstrate that the VATS approach in the resection of the first rib for TOS is a safe method. It should be performed with acceptable risks in patients with NTOS under experienced hands. The magnified view and optimal visualization from the scope are beneficial. Avoiding neurovascular bundle retraction may seem to decrease the postoperative pain. However, further randomized multicentered controlled trials comparing the VATS approach with alternative methods in order to validate the efficacy and safety of this technique are required.

Disclosure Statement

The authors report no conflicts of interest.

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