



Case Report

Technical Adaptation of First Rib Resection by Vats for the Thoracic Outlet Syndrome

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Citation: Macedo JPCD., et al. Technical Adaptation of First Rib Resection by Vats for the Thoracic Outlet Syndrome. J Surg Res Prac. 2024;5(3):1-5.

<https://doi.org/10.46889/JSRP.2024.5301>

Received Date: 12-09-2024

Accepted Date: 26-09-2024

Published Date: 04-10-2024



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Abstract

Thoracic Outlet Syndrome (TOS) is not common in the thoracic surgeon's routine. However, when it is encountered, it is important that the correct diagnosis and treatment is carried out, especially as surgery can be indicated in cases of non-clinical improvement. The goal of the surgery is to release the thoracic outlet constriction structures, which can be performed by several approaches. The innovative VATS surgical technique described here allows better rib exposure, the use of blunt digital dissection, as well as a new device for rib cutting. The technique described here has proven to be feasible, safe and reproducible.

Keywords: Thoracic Outlet Syndrome; Venous Thrombosis; Computed Tomography

Introduction

Thoracic Outlet Syndrome (TOS) was introduced by Peet, et al., in 1956 as compression of the subclavian vessels and brachial plexus in the superior thoracic aperture, the thoracic outlet [1]. The incidence is still uncertain, but ranges from 3-80 cases per 1000 [2,3]. The syndrome is mainly divided into neurogenic TOS(nTOS), in cases of compression of the brachial plexus, arterial TOS(aTOS), in cases of compression of the subclavian artery and venous TOS(vTOS), in cases of compression of the subclavian vein.

Etiologies can vary, for example cervical ribs, transverse mega-apophysis, compression of the costoclavicular ligament, muscle hypertrophy or fibrous bands [3]. The symptoms depend on which structure is affected and can include pain, edema, cyanosis, phlebitis paresthesia, hand atrophy, pseudoaneurysm and venous thrombosis (Paget-Schroetter Syndrome).

Diagnosis begins with clinical suspicion and is reinforced by maneuvers such as the Ross maneuver, in which the affected limb is in 90° abduction and 90° elbow flexion while the patient slowly opens and closes the hands for three minutes and the Adson test, which involves for palpation of the radial pulse, elbow extension, lifting of the upper limb and ipsilateral head rotation while the patient performs a deep inspiration [4]. These tests can be performed in addition to Dynamic Doppler associated with static view. A chest tomography can be useful, especially as abnormalities are found in 30 to 60%, depending on the author. Magnetic Resonance Imaging (MRI), when performed in three stages, (dynamically, in neutral and in hyperabduction position, in addition to the position that deflagrates the symptoms), makes it possible to assess the scalene triangle and the costoclavicular space [4]. Electromyoneurography (EMNG) is recommended in cases of nerve conduction assessment due to differential diagnosis.

Surgical treatment is required for vascular TOS and the most severe symptoms of neurogenic TOS. Several techniques are used to complete the resection of the former. The pros and cons are as follows:

- Supraclavicular: provides a good exploration of cervical rib and subclavian vessels, makes vascular repair possible, as well allowing intraoperative provocative maneuvers before and after the decompression. The disadvantage is the cosmetic scar.
- Transaxillary: as the first rib is the common denominator for most causes of nerve and artery compression, removal generally improves symptoms [5]. Advisable in cases of rib resection, even if it is not easy to perform because of insufficient exposure [6]. It is not considered a minimally-invasive approach
- VATS: better exposure for rib resection compared to the trans-axillary approach, even less traumatic. Rib dissection can be very difficult and requires special material
- Robotic: this platform adds 3D vision and also improves the handling and exposure of structures. The use of bipolar reduces the chance of brachial plexus and stellate ganglion injury [6]. However, it is not widely available yet and still lacks standardization, as a variety of different techniques are currently used

The TOS surgical approach may vary according to the surgeon's necessity, surgical ability or practice. The objective is to introduce technical modifications to Ghefter, et al. [6]. The VATS approach involves a work incision, hydrodissection and the use of an ultrasonic bone cutter (Piezosurgery®, Mectron Medical Technology, Carasco, Italy). These modifications can facilitate rib dissection and increase the safety of the procedure.

Case Description

The procedure was performed on 5 patients with TOS. The median age was 42 and the most frequent gender was male. The surgery was indicated in two cases of arterial TOS (2,3) and three of neurogenic TOS (1,4,5) after clinical worsening despite treatment.

The patient was under general anesthesia, double-lumen orotracheal intubation and lateral decubitus. The patient was placed in the lateral decubitus with the affected side up. The affected limb was extended anteriorly at 90° to 120°, improving exposure and avoiding hyperabduction or hyperextension (Fig. 1). As an alternative, the affected side arm can be placed at a 90° abduction angle to the chest wall, which also prevents hyperabduction (Fig. 1). The optical trocar (used for the scope) was inserted at the seventh/eighth intercostal space at the midaxillary line. The rear port was positioned near or anterior to the tip of the scapula. The third port/work incision was located in the axillary region as close to the first rib as possible (guided by thoracoscope) (Fig. 1). Use subpleural needle positioning and infusion of diluted epinephrine in saline, guided by pleuroscopy to ensure hydrodissection, from the second to first intercostal space. This separates the parietal pleura from the endothoracic fascia, optimizing the apical pleurectomy, as described by Araujo, et al., and improves the identification of the T1 root [6]. The extraperiosteal dissection started at the inferior border of the first rib. The intercostal muscles were detached from the bone by blunt dissection, finger plus periosteal elevators and scission by an ultrasonic device (HARMONIC ACE+® Johnson & Johnson Medical NV, Belgium).

The rib section was done in the middle portion (Fig. 2), anterior to the subclavian artery in the costoclavicular passage, like a "swing door". We used Piezosurgery® as a substitute for a traditional rib cutter. This made the step easier and safer because the device cuts bones but does not damage soft tissues. The anterior half of the rib was down-mobilized and the sternocostal joint was cut by an energy device or scissors. It was possible to identify the subclavian structures (vein, artery and plexus), the costoclavicular ligament and the subclavius muscle. After sectioning this ligament and muscle, the first half remained fixed superiorly by the anterior scalene muscle, which is pulled together with the bone and sectioned after a 3-4 cm extension of its rib insertion.

The subclavian artery and the lower brachial plexus roots were identified and the second half of the first rib was pushed down, revealing the cervical rib attachment. The posterior cut was performed with an ultrasonic bone cutter near the spine, in the rib neck between the costotransverse and costovertebral joints. The middle scalene muscle was identified and sectioned near the edge of the rib, preventing injury to the long thoracic nerve. The cervical rib was dissected as high as possible and then disarticulated. The articulation with the spine was more fragile than commonly found. A hemostasis review was performed. The air inside the pleura space can be aspirated or drained by chest tube placement. Hospital discharge generally occurs on the

second or third day after surgery, with chest tube removal when the surgeon finds it necessary, maintaining good pain control. A postoperative X-ray is performed and the chest drainage is removed when there is less than 200 ml/24h in the absence of an air leak.

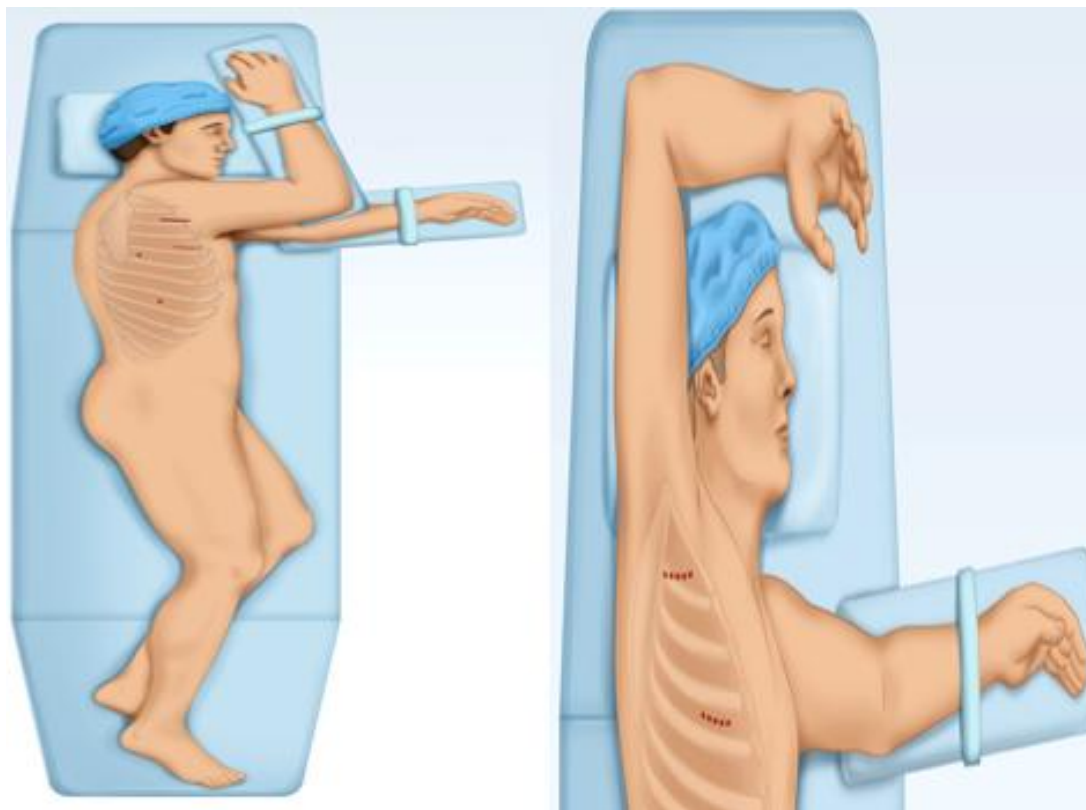


Figure 1: a: The red line represents the novel approach and the dashed line represents the standard incision. The dots represent the accessory ports; b: The alternative positioning where the upper dashed line represents the new approach and the lower line represents the normal technique.



Figure 2: Ultrasonic bone cutting during surgery. The device. Source: Mectron.

Discussion

We had five cases with good outcomes and no complications. The mean operative time was 2 hours, half an hour shorter than the standard VATS approach. The mean thoracic drainage time and length of stay were two and four days respectively. All

patients at the 30 postoperative day had improved symptoms; patients 2, 3 and 4 were asymptomatic and patients 1 and 5 had diminished their pain medication usage from daily to occasional.

TOS symptoms may present from mild to severe, varying from thrombosis to muscle atrophy. Diagnosis is often challenging. In addition to classic maneuvers, some authors advocate the use of imaging studies, including 3D reconstructions of a computed tomography with a specific thoracic outlet protocol [6]. We agree that the diagnosis is a compound of clinical presentation, positive clinical maneuvers and positive findings in image exams. Ciampi P, et al., reported 50 patients treated for TOS [1]. The outcome was assessed by a questionnaire. The overall success rate was 95.9%, with the definition of success rated as excellent, good or fair. We witnessed similar positive outcomes, where most of the patients had their symptoms improved and some remained asymptomatic.

Laulan J, et al., highlight rehabilitation with good outcomes. It begins with initial analgesic and muscle relaxant [4]. The correctly conducted rehabilitation could provide prolonged relief of symptoms in about 2/3 of patients, especially in pain relief [4]. The nTOS can be classified in "true" neurological form associated with neurological deficits and painful neurological form. No matter the nTOS presentation, we always begin the treatment with rehabilitation. The surgery is considered when symptoms are considered refractory.

On the other hand, surgery is performed earlier in case of vascular findings. The vascular forms are very rare. The vTOS stands for 2 to 3% of TOS and aTOS represents about 1% [4]. In our cases, aTOS was responsible for 40% of the surgical indication, despite nTOS for 60%. probably because it is the most common type of the syndrome TOS.

Recent publications are focused on robotic access. In spite of all the advantages, we still do not have a standardization of the technique. The ports may vary like Burt BM or Wybaillie E1 regarding the height and placement [9,10]. Strother E1 advocates the use of VATS associated with the robot approach [11]. We believe that a robot is a good choice especially in challenging cases, those with cervical rib. Ghefter, et al., classified the cervical rib from complete to incomplete [6]. The cervical rib is an anomalous rib that originates on the transverse process of C7 or a supernumerary first rib. that originates from the transverse process of T1 [6]. The cervical rib has a total of four different types. The first type is complete and articulates with the first rib. The fourth type has a small bony portion slightly larger than the transverse process of C7. The incidence varies from 0,45 to 1,5% in population and the complete resection really ensure good outcomes during postoperative period [6]. The extra portion rib was presented in our five cases as we main performed surgical treatment to arterial and neurogenic TOS.

Conclusion

Modifications to the VATS first rib resection technique match the feasibility and good outcomes of the minimally-invasive approach. Ghefter, et al., suggested a work incision at the third intercostal space (Fig. 1), an apical pleurectomy that is not supported by hydrodissection, dissection of the rib with a Cobb and a cut with a Kerrison or an endoscopic rib cutter [6]. The new technical approach modifies the work incision position, now closer to the first rib location, introduces hydrodissection and uses an ultrasonic bone cutter. The following advantages have been observed:

- The apical pleurectomy, after a physiological saline injection, is easier due to hydrodissection. The association with vasoconstrictor agents results in a bloodless surgery
- The pleurectomy improves the visibility of the structures, such as the first rib, subclavian vein, artery and brachial plexus
- After the subperiosteal dissection, the rib is carefully divided into it's middle portion. Care should be taken with subclavian structures and the brachial plexus, as well as with the position of rib cutting. The second half, which is close to the spine, cannot remain too long
- The rib section can be performed with a thoracoscopic rib cutter, Kerrison or Piezosurgery®
- Piezosurgery® is a device used to perform an osteotomy. The cut is safer and less invasive because of the ultrasonic frequency, which does not cause injury in soft tissue (subclavian structures)
- As the incision is above the first rib (Fig. 1), a finger can be used for blunt digital dissection. This helps to detach the rib from the chest wall, sternum and spine
- In cases of vascular injury, this incision placement makes it possible to repair using the full VATS approach
- A more aesthetically-acceptable result; the small scar is covered by the patient's arm due to its axillary location
- Surgical access may differ according to the surgeon's preference, what they are most accustomed to or to the structure that

needs to be decompressed. We prefer our new proposal because it ensures the feasibility of first and cervical rib resection. In addition, we have been presenting good outcomes. The main limitations of this paper is the small number of cases, the heterogeneous presentation of TOS. Further publications are still necessary to consolidate the technique

Conflict of Interests

The authors have no conflict of interest to declare related to this article.

Funding

The research received no specific grants from any funding agency in the public, commercial or non-for-profit sectors.

Ethical Approval

The ethics committee approved this study.

Informed Consent

Written informed consent was obtained from all individual participants included in the study.

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