

Thoracic outlet syndrome: single-center experience on the transaxillary approach with the aid of the TRIMANO Arthrex arm

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ABSTRACT

Thoracic outlet syndrome (TOS) is a pathology caused by compression on the neurovascular bundle by the first rib. The treatment of TOS is conservative management by analgesia and physiotherapy; however, if there is no response to conservative treatment, surgery is indicated through thoracic outlet decompression by first rib resection. Several surgical techniques are available, including supraclavicular, transaxillary, and transthoracic first rib resection approaches. The transaxillary approach provides better visualization on the neurovascular bundle and, thus, is sometimes the preferred method of treatment. The transaxillary approach has been criticized due to safety concerns regarding the neural bundle during surgical exposure. During surgery, hyperabduction of the arm is obtained by a surgical assistant, and the quality of exposure can decrease with time, or an iatrogenic injury to the neural bundle (brachial plexus) can occur from the hyperabduction. The use of the TRIMANO Arthrex arm can help in the exposure, instead of a surgical aide, because it provides stable exposure and visualization for the operating surgeon. We performed a retrospective review of patients undergoing transaxillary first rib resection using the TRIMANO Arthrex arm between June 2021 and December 2022. During installation, the patient is placed in the lateral decubitus position and the TRIMANO Arthrex arm is fixed at the operating table at the height of the patient's shoulder. Thus, the surgical aide can help the surgeon during the surgery, rather than placing the arm into and out of hyperabduction. The use of hyperabduction is limited to 15 minutes, followed by 5 minutes of rest, to decrease the tension on the neurovascular bundle. The surgeon then performs the transaxillary approach and systematically resects the first rib, scalene muscles, and subclavian muscles. By this approach, the inferior brachial plexus is also lysed. In our review, we found a total of 15 procedures of first rib resection for the treatment of TOS with the aid of the TRIMANO Arthrex arm that met our inclusion criteria. All procedures were performed by the same surgeon. None of the patients sustained an injury to the neurovascular bundle. All the patients had an uneventful hospital stay postoperatively, and none presented with a hematoma. The drain placed during surgery was removed on postoperative day 2. All patients had at least one radiograph taken during their hospitalization, with no pleural effusion or pneumothorax found. The use of the TRIMANO Arthrex arm is safe and can help in the positioning and installation of the patients undergoing transaxillary first rib resection. It decreases the number of surgical assistants and offers great comfort for the surgeon because it provides stable exposure for the operating surgeon. (J Vasc Surg Cases Innov Tech 2024;10:101400.)

Keywords: Thoracic outlet syndrome; First rib resection; Transaxillary first rib resection

Thoracic outlet syndrome (TOS) is a pathology in which there is compression on the neurovascular bundle by the first rib as it travels through the thoracic outlet.¹ Surgical management of TOS consists of first rib resection to decompress the thoracic bundle. However, surgery is reserved for patients for whom conservative treatment has failed.

Various surgical approaches have been described for first rib resection, including the transthoracic approach, transaxillary approach, and subclavian approach.^{2,3}

Many studies have described the differences between these approaches.⁴ The transaxillary approach provides better global visualization for three elements (venous, arterial, and neurological structures [ie, inferior branch of the brachial plexus]). However, when venous reconstruction is needed, the clavicular approach is preferred. The clavicular approach has also shown better outcomes postoperatively compared with other approaches.^{4,5} The transaxillary approach has been criticized due to safety concerns regarding the neural bundle and the need for hyperabduction of the arm that can result in neural injury.⁶ Injury to the neural bundle occurs either through direct injury to the nerve or extensive hyperabduction to the arm, resulting in a traction type injury to the nerve.⁷

The transaxillary approach usually requires a human aide to place the arm into hyperabduction. However, as

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the procedure progresses, the quality of exposure decreases, which results in a decrease in quality throughout the intervention. Vuoncino and Humphries⁸ presented the transaxillary approach using the Machleder retractor and explained their surgical approach.

In our transaxillary surgical approach, we use the TRIMANO Arthrex arm as the retractor. Because it is easy to manipulate, the TRIMANO Arthrex arm can help in the installation of the patient undergoing transaxillary first rib resection with better exposure and visualization for the operating surgeon. Also, we believe that using the four-angled arm can help and aid with positioning, especially as the surgeon is required to reposition the arm multiple times during the operation to limit the hyperabduction to 15-minute period to decrease the risk of injury to the neurovascular bundle. We describe our experience using the TRIMANO Arthrex arm in the aid of transaxillary first rib resection.

METHODS

A retrospective cohort study was performed at our vascular and endovascular surgical unit of patients who underwent first rib resection with the aid of the TRIMANO Arthrex arm between June 2021 and December 2022 as treatment of TOS. The institutional review ethics board approved the study with a waiver of informed consent because all data were de-identified. Only a descriptive analysis was performed rather than a prescriptive analysis due to the low number of cases.

Preoperative diagnosis and evaluation. As a regional referral center, many of the patients are referred with a differential diagnosis of TOS. During the clinic appointment, a thorough history is obtained, including a history of trauma and the specific history regarding each type of TOS (ie, arterial, venous, neurogenic). All the patients undergo a full physical examination focused on the diagnosis of TOS, including palpation of pulses, an upper arm stress test, an elevated limb tension test, and the Adson test. All the patients also undergo diagnostic imaging and investigations, including chest radiography searching for a cervical rib, duplex ultrasound with a compressibility test to determine the patency of the subclavian artery and vein and evaluate any aneurysmal changes after stenosis by the first rib, computed tomography, cervical magnetic resonance imaging, a nerve conduction study to evaluate nerve conduction and determine the presence of any sequelae due to compression on the brachial plexus.

Once TOS is diagnosed and while waiting for the results of the complementary diagnostic tests, the patients are referred to physiotherapy as the first line of treatment of TOS. All the patients undergo 10 to 12 sessions of physiotherapy. The physiotherapy sessions are specific for the treatment of TOS.

No consensus has been reached regarding the indications for surgical intervention in the management of TOS for the neurogenic and venous types. Thus, failure of conservative treatment after 3 to 6 months and the persistence of symptoms are the main indications for surgical decompression of the thoracic outlet.⁹ For the arterial subtype, the indication for operative management is guided by the Scher classification of surgical treatment for subclavian artery pathology.

Surgical installation and approach. Under general anesthesia, the patient is prepared and placed in the lateral decubitus position at 45°. The TRIMANO Arthrex is fixed at the operating table at the height of the patient's shoulder. During surgical preparation, the TRIMANO Arthrex arm is prepared with a disposable TRIMANO Arthrex cover.

Installation process. First, the affected arm is prepared and placed in a stockinette. The retractor is then attached to the operating table and covered with a sterile drape (Fig 1, A). Next, the arm is placed in the beach chair kit to prevent any pressure injuries (Fig 1, B). The arm is then wrapped with self-adhesive tape. The arm is then connected to the TRIMANO arm (Fig 1, C), and the retractor is ready to use. The arm in the resting position is shown in Fig 1, D, and the arm in the operating position is shown in Fig 1, E.

The use of hyperabduction (Fig 1, E) is limited to 15 minutes, followed by 5 minutes of rest to decrease tension on the neurovascular bundle and, thus, decrease the risk of injuring the neural bundle. The 15-minute period is calculated from the start of the surgery. During installation, the arm is placed in the resting position (Fig 1, D). Also, it is crucial to correctly install the beach chair kit and the stockinette to prevent any pressure injuries to the arm or dislodgment of the arm. The surgeon then uses the transaxillary approach to systematically resect the first rib, scalene muscle, and subclavian muscle. By this approach, the inferior brachial plexus is also lysed.

TRIMANO Arthrex arm. The TRIMANO FORTIS is a four-angled retractor arm that is used mainly in orthopedic surgeries as a retractor. The retractor is easily maneuvered by a single handle (Fig 1, A). The device is used by orthopedic surgeons at our institute (different site). The retractor was first tested and shared with the orthopedics surgery team. Because our hospital is a regional referral center for the treatment of TOS, it was justifiable and cost-effective to obtain one for the vascular surgery team. The cost of the device is €9999; however, our experience and results have justified the cost of the retractor.

The TRIMANO FORTIS support arm (model no. AR-1740; Fig 2) was used in all operations. The arm is prepared in the surgical field using a disposable sterile drape (model no. AR-1648). The arm is placed in a beach chair kit to

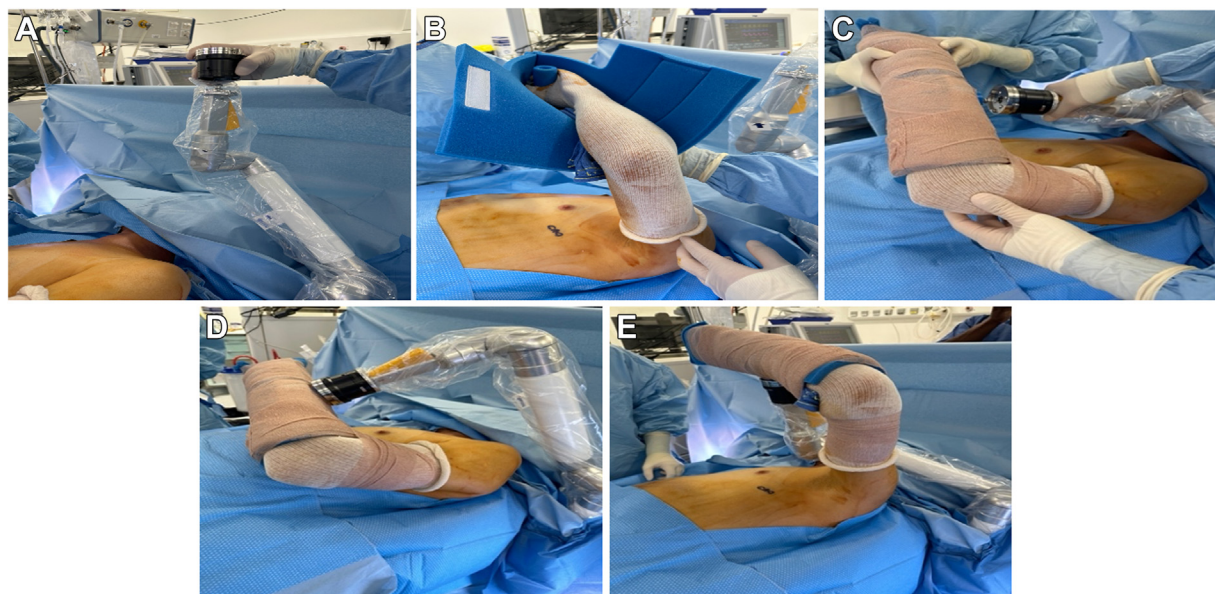


Fig 1. Installation process. **A**, Retractor attached to the operating table and covered with a sterile drape. **B**, Arm wrapped with self-adhesive tape. **C**, Arm connected to the TRIMANO arm. **D**, Arm in the resting position. **E**, Arm in operating position (hyperabduction).

ensure safety to the arm during manipulation. The beach chair kit is a disposable attachable sponge in which the arm is placed before it is connected to the TRIMANO arm (model no. AR-1644; Fig 1, B). The use of the retractor system is simple; thus, the operating surgeon will become familiarized with its functionality during surgery with no need for a learning curve to use the device.

RESULTS

In our review, we found a total of 15 procedures of first rib resection for the treatment of TOS with the aid of the TRIMANO Arthrex arm that met our inclusion criteria. All 15 procedures were performed by the same surgeon. All the patients underwent surgery after conservative medical therapy had failed.

All 15 procedures were performed for the treatment of TOS (6 arterial, 6 venous, and 3 neurogenic) on 14 patients. The laterality was on the right side for 10 procedures (66.6%) and the left for 5 procedures (33.3%), with one bilateral case. Of the 14 patients, 8 were women and 6 were men. Their mean age was 33.5 ± 10.8 years. The average surgery time was 119.06 ± 37.5 minutes. None of the patients experienced intraoperative complications, no patient died, and none sustained an injury to the neurovascular bundle. Also, none of the patients presented with a positioning injury, whether cutaneous such as pressure ulcers, or compressive such peripheral nerve compression.

All patients had an uneventful hospital stay postoperatively. None of the patients presented with a hematoma or thoracic duct injury, with the subcutaneous drain placed during surgery removed after 1.8 days postoperatively.

During their hospital stay, all the patients underwent at least one chest radiograph to ensure no pneumothorax or pleural effusion was present.

After discharge, all the patients were referred to physiotherapy to continue their rehabilitation process. All the patients were seen 1 month after surgery in the postoperative clinic and were assessed by a complete physical examination and symptom assessment. All the patients reported amelioration of their symptoms.

One of the patients presented with Horner syndrome (HS) as an early surgical complication. It was discovered the second day postoperatively. The mechanism of HS postoperatively is still unclear; however, the most applicable theory is the use of retractors in the surgical field and irritation of the cervical sympathetic trunk. Four patients presented with paresthesia on the median cutaneous nerve territory. The chest radiograph at 1 month postoperatively revealed no pneumothorax or pleural effusion. The outcomes and follow-up data are summarized in the Table.

DISCUSSION

Use of the TRIMANO Arthrex arm provides adequate exposure through its mobilization via its four joints. With the hyperabduction achieved using the TRIMANO arm, the surgical aide will be able to assist the surgeon rather than positioning the patient's arm into hyperabduction.

The transaxillary approach first, described by Roos,¹⁰ is a well-recognized method for first rib resection in the treatment of TOS. The technique has showed better postoperative results compared with other surgical



Fig 2. The TRIMANO FORTIS support arm.

techniques.⁴ The importance of the transaxillary approach lies its exposure to bony structures such as the first rib and, if found, the cervical rib.¹¹ However, it is not the preferred or recommended approach for vascular reconstruction, if needed. Due to the possibility of postoperative complications, it is sometimes under-used. Largescale studies showed that pneumothorax is the most serious complication with the classic transaxillary approach for first rib resection.^{12,13} This has led to the development of different surgical techniques to improve the transaxillary surgical approach, including robotic and endoscopic techniques.^{7,14}

As discussed, the transaxillary approach requires adequate visualization to avoid injury to the neurovascular bundle. This is usually provided by placing the patient's arm into hyperabduction. Visualization of the surgical field is usually achieved by retraction by the surgical assistant. However, the quality of exposure decreases during

Table. Summary of patient complications

Complication	Patients, No. (%)
Bleeding	0 (0)
Pneumothorax	0 (0)
Pleural effusion	0 (0)
Thromboembolic events	0 (0)
Paresthesia	5 (33.3)
Wound complication	1 (6.6)
Surgical site infection	0 (0)
Hypertrophic scar formation	1 (6.6)

the surgery due to either time or the fatigue of the surgical assistant.

To the best of our knowledge, this is the largest series describing the use of the TRIMANO Arthrex arm as an operative aid. In our series, we encountered only one major complication. One patient developed HS. The development of HS has not yet been described in the literature as a possible complication of the transaxillary approach for first rib resection. However, HS has been described as a complication of thoracic surgery, thyroidectomy, and minimally invasive thyroidectomy.^{15,16}

CONCLUSIONS

Our results show that the use of the TRIMANO Arthrex arm is safe. It provides help in positioning and the installation of patients undergoing transaxillary first rib resection. It also decreases the necessity of having multiple surgical aides and provides comfort for the operating surgeon.

DISCLOSURES

None.

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