



Original

Clinical and functional evaluation of patients with first rib resection for venous thoracic outlet syndrome

Evaluación clínica y funcional en pacientes con resección de primera costilla por síndrome de estrecho torácico venoso

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Abstract

Introduction and objectives: to analyze primary patency and clinical functionality scales (pre- and postoperative Villalta test and QuickDASH), as well as risk factors and complications related to venous thoracic outlet syndrome (VTOS) treated by first rib resection.

Methods: retrospective observational study of patients operated on between 1997 and 2024.

Results: a total of 54 patients (51.9% women) were analyzed, with a mean age of 34 years (SD 12.5). The dominant arm was affected in 55.6% of cases. Repetitive upper limb movements due to occupational activity or sport were reported in 55.6% of patients. One patient had a cervical rib, and two had antiphospholipid syndrome. A family history was observed in 7.4% of cases. Paget-Schroetter syndrome was the initial presentation in 83.3% of patients; all of them (100%) underwent catheter-directed thrombolysis (CDT). In 25 patients, CDT was combined with venous angioplasty, and three required venous *stent* implantations. Symptomatic subclavian vein stenosis was observed in 16.7% of cases, with 22.2% undergoing venous angioplasty. There was no surgery-related mortality. The postoperative complication rate was 7.4% (two pneumothoraces, one case of Horner's syndrome, and one subclavian vein injury). The mean follow-up time was 149 months (SD 78). All venous *stents* (100%) experienced structural failure. The Villalta test showed a mean reduction of 17.45 points from the preoperative score, with a mean postoperative score of 2.75 (mild; SD 3.5; paired Wilcoxon test, $p < 0.0001$, $r = 0.92$). The mean postoperative QuickDASH score was 9.45 (SD 15). The primary patency rate was 100%. During follow-up, 71% of patients showed no difference in arm circumference between limbs. Residual edema $< 5\%$ was observed in 12.9% and between 5-10% in 16.1% of patients.

Keywords:

Venous thoracic outlet syndrome. First rib resection. Villalta test. QuickDASH. Paget-Schröter.

Conclusions: first rib resection in patients with VTOS is an effective technique for symptom reduction, as assessed by functionality scales (Villalta and QuickDASH), with a high long-term patency rate.

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Resumen

Introducción y objetivos: analizar la permeabilidad primaria, las escalas clínicas de funcionalidad (test de Villalta pre- y posquirúrgico y QuickDASH), los factores de riesgo y las complicaciones relacionados con el síndrome de estrecho torácico venoso (SETV) tratados mediante resección de primera costilla.

Metodología: estudio observacional retrospectivo de pacientes intervenidos entre 1997 y 2024.

Resultados: se analizaron 54 pacientes (51,9 % mujeres), con una media de edad de 34 años (DE: 12,5). El 55,6 % se diagnosticó en el brazo dominante. El 55,6 % realizaba movimientos repetitivos por actividad laboral o por deporte. Un paciente presentó costilla cervical y dos, síndrome antifosfolípido. Se objetivó asociación familiar en el 7,4 % de los casos. El 83,3 % debutó con síndrome de Paget-Schrötter, de los cuales al 100 % se le realizó fibrinólisis dirigida por catéter (FDC). En 25 pacientes se asoció ATP venosa y en 3 de ellos se implantó un *stent*. El 16,7 % presentaba estenosis sintomática de vena subclavia, de los que el 22,2 % se trató con ATP venosa. No hubo mortalidad asociada. La tasa de complicaciones posquirúrgica fue del 7,4 % (dos neumotórax, un síndrome de Horner y una lesión de vena subclavia). El tiempo medio de seguimiento fue de 149 meses (DE: 78). Se observó un 100 % de fracturas de *stents*. El test de Villalta mostró una reducción media de 17,45 puntos con respecto al valor preoperatorio, con un valor medio posoperatorio de 2,75 puntos (leve; DE: 3,5; prueba de Wilcoxon pareada, $p < 0,0001$, $r = 0,92$). El QuickDASH tuvo un resultado medio posoperatorio de 9,45 (DE: 15). La tasa de permeabilidad primaria fue del 100 %. El 71 % no presentó variación en el diámetro del brazo entre ambas extremidades en el seguimiento. El 12,9 % tuvo edema residual < 5 % y el 16,1 %, entre el 5 y el 10 %.

Conclusiones: la resección de la primera costilla en pacientes con SETV es una técnica eficaz para la reducción de la sintomatología evaluada a través de las escalas de funcionalidad (Villalta y QuickDASH), con una tasa de permeabilidad elevada en el seguimiento.

Palabras clave:

Síndrome de estrecho torácico venoso. Resección de primera costilla. Test de Villalta. QuickDASH. Paget-Schrötter.

INTRODUCTION

Thoracic outlet syndrome (TOS) is a rare but potentially disabling condition that predominantly affects young adults (20-50 years) (1). Its incidence rate is approximately 8% in the general population and is more common in women (70%) (2). The most frequent subtype is neurogenic (95%), followed by venous (3-5%) and arterial (1-2%) (3).

Venous thoracic outlet syndrome (VTOS) represents a significant cause of primary subclavian-axillary deep vein thrombosis (SA-DVT), known as Paget-Schroetter syndrome. The estimated incidence rate is 1 to 2 cases per 100,000 inhabitants per year. Although rare, it may lead to permanent functional sequelae, such as post thrombotic syndrome (up to 46% of cases), limitation in daily activities, and reduced quality of life (4,5). Its pathophysiology involves extrinsic compression of the subclavian vein along its course through the thoracic outlet by the costoclavicular space and, less frequently, by the insertion of the pectoralis minor tendon (1).

Early diagnosis and appropriate treatment are essential to prevent long-term complications. However, management remains challenging due to the lack of consensus. Although fibrinolysis fol-

lowed by first rib resection is a widely used strategy, controversies remain regarding long-term outcomes and associated complications. In addition, available studies are limited and often focus on small case series (6,7).

Given the impact of VTOS on an active population and the limited evidence regarding its surgical treatment, this study analyzes clinical and functional outcomes, as well as primary patency, in patients undergoing first rib resection, providing data to optimize management of this condition.

ENDPOINTS

The primary endpoints of this study were to evaluate primary patency and functional recovery in patients with VTOS treated with first rib resection. Clinical functional scales, including the Villalta score in the preoperative and postoperative periods, as well as the QuickDASH questionnaire, were analyzed.

Secondary endpoints included the analysis of risk factors associated with VTOS development and postoperative complications related to the procedure.

MATERIALS AND METHODS

We conducted a retrospective review of patients with VTOS who underwent first rib resection from January 1997 through December 2024. All patients underwent transaxillary first rib resection associated with scalenectomy (Fig. 1). In 1 case, cervical rib resection was also performed.

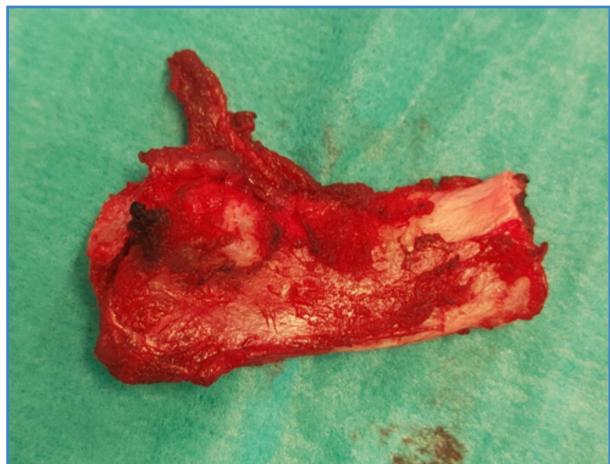


Figure 1. Intraoperative fragment of the first rib after surgical resection.

Inclusion criteria were patients with SA-DVT or symptomatic subclavian vein stenosis due to VTOS treated with first rib resection. Patients with arterial or neurogenic TOS, asymptomatic VTOS, and those treated exclusively with anticoagulation or fibrinolysis due to high surgical risk (advanced age or significant medical-surgical comorbidities) or refusal of surgery were excluded.

SA-DVT was diagnosed by Doppler ultrasound and subsequently confirmed by phlebography. Symptomatic subclavian vein stenosis was defined by clinical symptoms of upper limb venous obstruction (edema, pain, heaviness, or collateral circulation) along with radiologic evidence of significant compression (stenosis $\geq 50\%$ or flow delay) on CCTA, phlebography, or Doppler ultrasound.

According to our protocol, patients diagnosed with SA-DVT were initially treated with catheter-directed thrombolysis (CDT) using IV urokinase at a dose of 100,000 units per hour until complete thrombus dissolution (Fig. 2). After thrombolysis, anticoagulation with low-molecular-weight hepa-

rin was maintained for 3 to 4 months. Subsequently, after discontinuation of anticoagulation, surgical intervention with first rib resection was performed. In cases where residual stenosis was detected during thrombolysis, balloon angioplasty was performed (Figs. 3 and 4).

Venous stent placement was indicated in cases with significant residual stenosis after multiple balloon angioplasties when satisfactory restoration of venous flow was not achieved. This procedure was performed only in the initial cases of the series and was later abandoned due to a high rate of stent fracture and restenosis during follow-up (15,16) (Fig. 5).

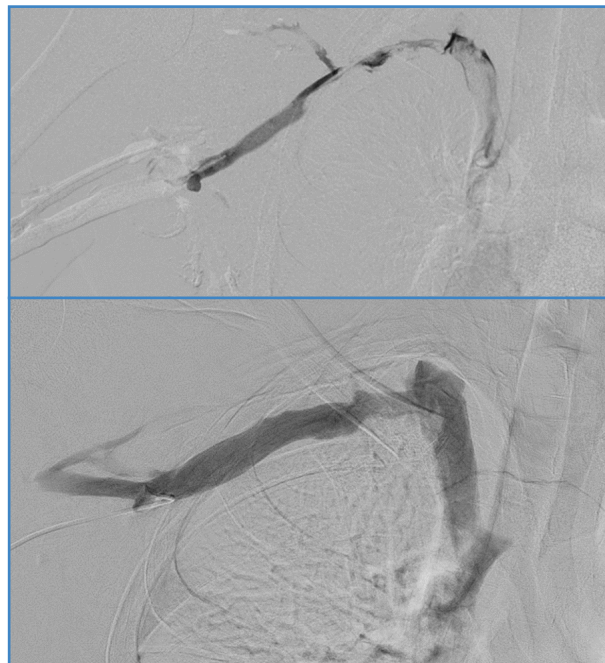


Figure 2. Phlebography showing thrombosis of the right subclavian-axillary venous territory with subsequent recanalization after fibrinolytic treatment.

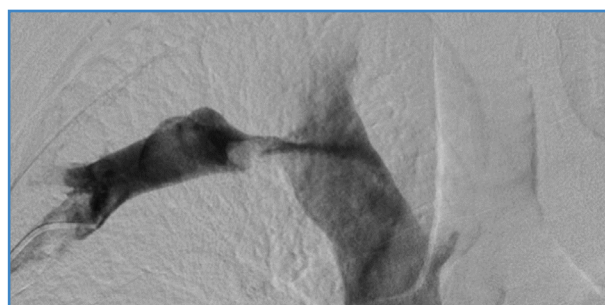


Figure 3. Phlebography showing $> 50\%$ stenosis and a filling defect between the clavicle and the first rib, consistent with chronic extrinsic compression of the thoracic outlet.

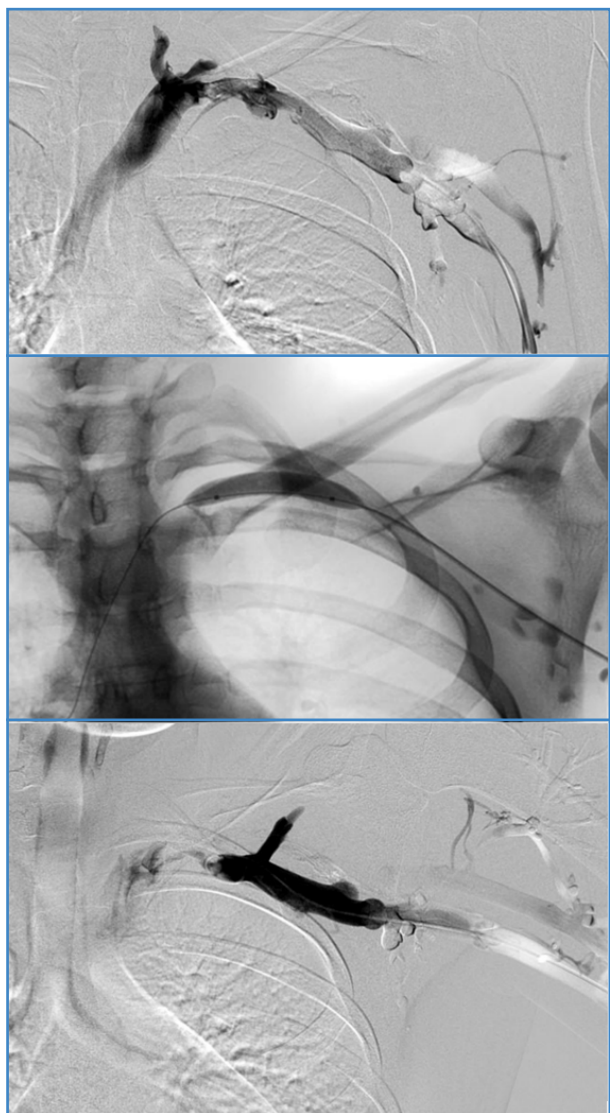


Figure 4. Severe residual venous stenosis after fibrinolysis. Venous angioplasty and result.

Preoperative variables included age, sex, affected limb, associated risk factors (repetitive movements related to occupational or sports activity), and Villalta score.

Treatment variables included the use of catheter-directed thrombolysis (CDT), venous angioplasty, and/or venous stent placement.

Postoperative outcomes included procedure-related complications, primary patency assessed by Doppler ultrasound during follow-up, mortality related to the disease, Villalta score (8) (to diagnose and classify postthrombotic syndrome: 5-9 mild, 10-14 moderate, and ≥ 15 or presence of venous ulcer severe), QuickDASH questionnaire (7,9) (0 indicates



Figure 5. Chest radiograph showing fracture of a venous stent in the right subclavian-axillary territory.

no disability and 100 indicates maximum functional limitation), and variation in diameter between the affected and contralateral arm. Association with hypercoagulability disorders was also evaluated.

The follow-up protocol consisted of outpatient visits at 1 month, 6 months, and 12 months after surgery. At each visit, a directed clinical history was obtained, including administration of the postoperative Villalta score, physical examination, and control ultrasound. In cases with favorable evolution at 1 year, patients were discharged from follow-up.

Subsequently, all patients included in the study were scheduled for an in-person evaluation between November 2024 and January 2025. During this assessment, a vascular surgeon performed upper limb venous ultrasound, measurement of both arm diameters, evaluation of associated risk factors, and collection of postoperative functional outcomes (Villalta score and QuickDASH questionnaire).

A database was created using Microsoft Excel, and data analysis was performed with the commercial package IBM SPSS Statistics version 22.0.

Measures of central tendency, dispersion, and distribution were calculated for all variables in the dataset. Descriptive summaries included mean, median, mode, variance, IQR, SD, minimum, and maximum values. Categorical data were presented in frequency tables and categorized according to absolute frequencies, relative frequencies, cumulative frequencies, and percentages.

Statistical significance was set at $p < .05$. The Wilcoxon signed-rank test was used for paired samples in the analysis of preoperative and postoperative Villalta scores. Additionally, survival analysis was performed using Kaplan-Meier curves to evaluate primary patency, with group comparisons using the log-rank test.

RESULTS

A total of 75 patients underwent first rib resection between January 1997 and December 2024. Of these, 54 patients (72%) had VTOS, 15 (20%) neurogenic TOS, and 6 (8%) arterial TOS (Fig. 6).

The mean age in the VTOS group was 34 years (range, 13-66; SD, 12.5), with an equal sex distribution, as 51.9% were women. The dominant arm was affected in 55.6% of cases, with no significant differences in laterality.

Telephone contact was achieved in 44 patients (81.5%), in whom the Villalta score and QuickDASH questionnaire were administered. Of these, 31 patients subsequently attended an in-person visit, where venous ultrasound and bilateral upper limb diameter measurements were performed. Loss to follow-up was due to relocation to other regions and death from causes unrelated to the condition under study. Mean follow-up was 149 months (minimum, 6; maximum, 325; SD, 78).

Regarding associated risk factors, 55.6% of patients reported repetitive movements involving the affected limb (22.3% related to sports activity, 16.65% to occupational activity, and 16.65% to both). No cardiovascular risk factors were identified. Coagulation studies were performed in all patients, with antiphospholipid syndrome identified in 2 cases. Familial aggregation was observed in 7.4% (4 patients: 2 siblings and 2 mother-daughter pairs). No genetic studies were performed (Table I).

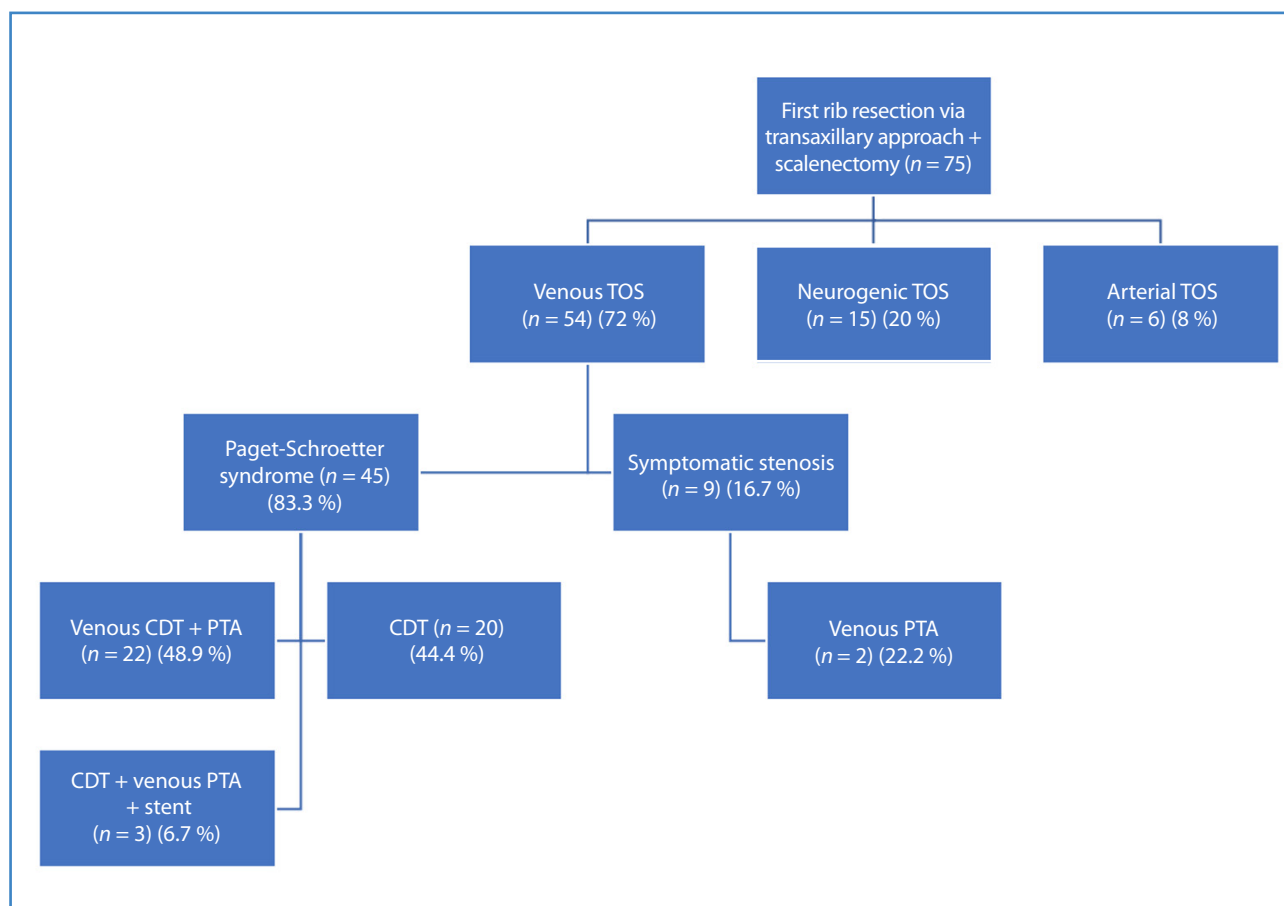


Figure 6. Inclusion and exclusion criteria for patients with venous TOS treated with transaxillary first rib resection associated with scalenectomy.

Table I. Demographic and clinical characteristics of patients with VTOS undergoing first rib resection ($n = 54$)

Variable	Value
Mean age	34 (range: 13-66; SD, 12.5)
Sex:	
Women	28 (51.9%)
Men	26 (48.1%)
Risk factors:	
Repetitive movements	30 (55.6%)
Sports activity (weightlifting, swimming, paddle tennis, basketball, handball)	12 (22.3%)
Occupational activity (waiters, plumbers, carpenters, supermarket stockers)	9 (16.65%)
Both (sports and occupational)	9 (16.65%)
Cardiovascular risk factors	0 (0%)
Hypercoagulability	2 (3.7%)
Family history	4 (7.4%)

A total of 83.3% of patients presented with upper limb deep vein thrombosis (Paget-Schroetter syndrome), whereas 16.7% were diagnosed with symptomatic subclavian vein stenosis. All patients underwent transaxillary first rib resection combined with scalenectomy. In addition, 1 patient underwent concomitant cervical rib resection.

In all patients with Paget-Schroetter syndrome, CDT was performed for a mean of 53 hours (SD, 24); venous angioplasty was associated in 48.9% of cases, and angioplasty with stent placement in 6.7%. The mean interval between CDT and surgery was 4.6 months (SD, 3.6), during which patients remained on anticoagulation, which was continued indefinitely in 5 patients (11.1%) due to underlying conditions: 2 with antiphospholipid syndrome, 2 with recurrent deep vein thrombosis or pulmonary embolism, and 1 with atrial fibrillation.

Among patients with symptomatic subclavian vein stenosis, 22.2% underwent venous angioplasty prior to surgical intervention (Fig. 6).

The postoperative complication rate was 7.4%. Two patients developed pneumothorax, which resolved after chest tube placement for 72 hours. One patient developed Horner syndrome due to stellate ganglion injury, manifested by ptosis and miosis, with complete resolution within 2 years without the need for reintervention. Additionally, 1 case of subclavian vein tear occurred following resection of a bony spur at the Lisfranc tubercle. The lesion, extending to the brachiocephalic trunk, was repaired

with venous patch angioplasty using the great saphenous vein via a supraclavicular approach. Mean length of stay was 88 hours (SD, 42).

During long-term follow-up, a 100% fracture rate was observed in implanted stents (Fig. 5). No disease-related mortality was recorded.

The preoperative Villalta score was calculated in all patients, with a mean of 20.2 points (severe post thrombotic syndrome) (minimum, 14; maximum, 26; SD, 2.7), with predominance of pain, edema, and venous ectasia.

The Villalta score was reassessed in all patients contacted by telephone ($n = 44$). The mean postoperative Villalta score was 2.75 points (mild; SD, 3.5), representing a mean reduction of 17.45 points. Villalta scores decreased significantly after surgery (median [IQR] preoperative = 20 [18-23] vs postoperative = 2 [0-5]; paired Wilcoxon test, $p < .0001$; $r = 0.92$). The most frequent findings were pain and paresthesia in the mild category ($n = 8$) and heaviness in the moderate category ($n = 6$). No patients presented severe symptoms. A total of 77.2% had no post thrombotic syndrome at follow-up, and 18.3% had mild post thrombotic syndrome. One case of moderate and one of severe post thrombotic syndrome were observed; in the latter, symptoms could not be clearly attributed to first rib resection due to a concomitant diagnosis of pectoralis minor hyperactivation syndrome, confirmed by traumatology, with surgical indication (tenotomy) and overlapping symptoms.

In addition, the mean postoperative QuickDASH score was 9.45 (minimum, 0; maximum, 75; SD, 15). A total of 47.7% of patients reported no functional limitation, whereas 50% had a limitation of less than 30%. Only 1 patient had a score of 75, corresponding to the previously mentioned case of pectoralis minor hyperactivation syndrome.

All patients who attended in-person follow-up ($n = 31$) underwent upper limb venous ultrasound, which demonstrated a primary patency rate of 100%. Kaplan-Meier survival analysis was performed to evaluate primary patency. As no loss of patency

occurred during follow-up, the curve remained constant, with a primary patency rate of 100% over time (Fig. 7).

Additionally, arm circumference was measured to assess residual edema. In 71% of patients, no significant difference was observed between the operated and contralateral arm, indicating absence of clinically relevant edema. A total of 12.9% had a diameter increase of $< 5\%$ (mild residual edema), whereas 16.1% showed a difference between 5% and 10% (moderate residual edema). No cases of edema greater than 10% were recorded (Table II).

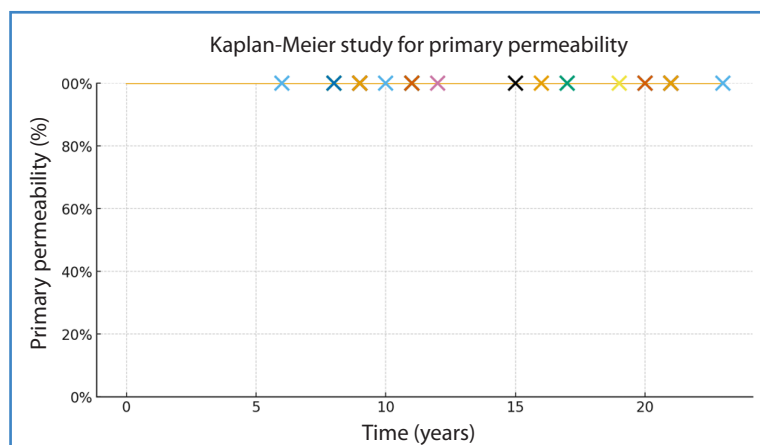


Figure 7. Kaplan-Meier curve for primary patency. At 9 and 11 years, 2 censoring marks were recorded corresponding to deaths unrelated to the studied condition. The remaining censoring marks represent loss to follow-up; primary patency remained 100% throughout the observation period.

Table II. Postoperative outcomes and follow-up of patients with VTOS undergoing first rib resection ($n = 54$)

Mean follow-up time (months)	149 (range: 6-325; SD: 78)
Mean length of stay (hours)	88 (SD: 42)
<i>Postoperative complications</i>	4 (7.4%)
Pneumothorax	2 (3.7%)
Horner syndrome	1 (1.85%)
Subclavian vein injury	1 (1.85%)
<i>Endovascular post-therapy complications</i>	
Stent fractures	3 (100 % of implanted stents)
<i>Villalta's test</i>	
Preoperative period	20,2 (DE: 2.7)
Postoperative period	2,75 (DE: 3.5)
Postoperative QuickDASH	9,45 (DE 15)
<i>Postoperative residual edema</i>	
Without edema	22 (71%)
Mild edema ($< 5\%$)	4 (12.9%)
Moderate edema (5-10%)	5 (16.1%)
Rate of primary patency	100%
Associated mortality rate	0%

DISCUSSION

First rib resection has been widely described as definitive treatment for VTOS, particularly in patients with SA-DVT or Paget-Schroetter syndrome. Several studies support that the combination of fibrinolysis and surgery significantly improves clinical and functional outcomes. Illig et al. reported symptomatic improvement and high venous patency rates when surgery is performed within the first 2 weeks after diagnosis (10). Similarly, Urschel and Razzuk reported a success rate > 95% in young athletes following first rib resection (11). Recent studies confirm these findings and support early surgical resection as the optimal management strategy, with favorable patency outcomes and low thrombotic recurrence (12-14).

In our series, we observed a primary venous patency rate of 100%, which is consistent with the optimal results reported in other series. However, all implanted venous stents fractured. These findings support the relative contraindication of stent use in the costoclavicular segment, even as a bridging strategy, given the lack of durable structural benefit due to persistent extrinsic compression and the dynamic mobility of the costoclavicular region (15,16). This reinforces bone resection as the preferred treatment, even in cases of venous stenosis without thrombosis.

The Villalta score, although originally designed for lower limbs, has been used to assess VTOS. Kayssi et al. demonstrated a good correlation between its score and clinical improvement in patients with Paget-Schroetter syndrome (17). In our study, we observed a significant reduction in the mean Villalta score (from 20.2 to 2.75 points), with 77.2% of patients showing no evidence of postthrombotic syndrome.

Regarding functional assessment, the Quick-DASH questionnaire identified mild residual limitations in most cases. Molina et al. applied this instrument in a cohort of young patients surgically treated for TOS and reported mean scores below 15 at follow-up, indicating good functional recovery (18). In our series, 97.7% of patients had a score < 30, and nearly half (47.7%) reported no functional limitation.

Regarding postoperative complications, the overall rate was 7.4%, comparable to that reported in the

literature (5-10%) (19,20). The case of extensive subclavian vein injury requiring repair with a saphenous vein patch was exceptional and highlights the importance of a multidisciplinary approach in centers with expertise in complex vascular surgery. Similarly, the occurrence of Horner syndrome, although rare, has been previously described as a complication related to sympathetic plexus manipulation during scalenectomy (21).

Of note, the relevance of occupational and sports-related factors in the etiology of VTOS in our cohort. More than 50% of patients performed activities involving repetitive upper limb movements, consistent with previous studies identifying these factors as common triggers in young, active populations (22).

As a limitation of this study, it should be noted that it is a retrospective analysis with a relatively small sample size and no control group. These factors limit the generalizability of the results and the ability to compare first rib resection with other therapeutic modalities, such as anticoagulation alone. However, despite these limitations, the results support the efficacy and safety of first rib resection as a valuable surgical intervention for VTOS, particularly when combined with initial endovascular and anticoagulant therapy.

Future prospective, multicenter studies with larger sample sizes will be required to validate these findings and provide more robust evidence regarding the efficacy and safety of first rib resection compared with other treatment options. Generating additional evidence will help define more precisely the role of first rib resection in VTOS management and its advantages over alternative therapies.

CONCLUSIONS

In conclusion, our results confirm that first rib resection, combined with initial endovascular treatment and anticoagulation therapy, is an effective and safe strategy for the management of VTOS. Long-term clinical, functional, and hemodynamic improvement is significant, with a low complication rate and excellent functional recovery in most patients.

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