

ANTICOAGULANT THERAPY FOLLOWED BY THORACOSCOPIC THORACIC OUTLET DECOMPRESSION IN PAGET-SCHROETTER SYNDROME

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Abstract

Introduction: Paget-Schroetter syndrome (PSS) lacks a standardized treatment strategy. Anticoagulation alone carries a high risk of recurrent thrombosis due to mechanical injury to the venous endothelium from costoclavicular space narrowing. This study evaluated the mid- to long-term outcomes of combined anticoagulation and thoracoscopic first rib resection for thoracic outlet decompression in patients with PSS.

Materials and methods: A descriptive observational study was conducted in patients treated between January 2017 and April 2026. Patients with PSS initially treated with anticoagulation followed by thoracoscopic first rib resection for thoracic outlet decompression were included. PSS was diagnosed based on acute thrombosis, exclusion of thrombophilia, and imaging evidence of extrinsic subclavian vein compression at the costoclavicular space.

Results: During the study period, 41 patients were diagnosed with PSS, and 45 first rib resections were performed. Four patients underwent bilateral surgery due to symptomatic intermittent venous compression without thrombosis on the contralateral side of the thrombotic event. All patients received anticoagulation at diagnosis for at least three months, and thrombophilia was ruled out. Thrombosis resolved in all patients after initial medical treatment, without hemorrhagic complications. Thoracic outlet decompression was achieved through thoracoscopic first rib resection.

The median follow-up was 34 months (interquartile range [IQR], 11–56), and the mean follow-up was 37 ± 27 months. No recurrences were observed during mid- to long-term follow-up.

Conclusion: In our series, the combined treatment strategy for PSS showed encouraging mid- to long-term outcomes, with discontinuation of anticoagulant therapy and avoidance of the risks and quality-of-life limitations associated with prolonged anticoagulation.

Key words: Paget-Schroetter syndrome, venous thoracic outlet syndrome, anticoagulation therapy, first rib resection, video-assisted thoracoscopic surgery (VATS)

Resumen

Terapia anticoagulante seguida de descompresión del opérculo torácico por toracoscopia en síndrome de Paget-Schroetter

Introducción: El síndrome de Paget-Schroetter (SPS) no cuenta con una estrategia terapéutica estandarizada. La anticoagulación aislada se asocia con alto riesgo de recurrencia trombótica debido a lesión mecánica persistente del endotelio venoso causada por el estrechamiento del espacio costoclavicular. El objetivo fue evaluar los resultados a mediano y largo plazo de una estrategia combinada de anticoagulación seguida de resección toracoscópica de la primera costilla para descompresión del opérculo torácico.

Materiales y métodos: Estudio observacional descriptivo de pacientes tratados entre enero de 2017 y abril de 2026. El diagnóstico de SPS se estableció por trombosis aguda, exclusión de trombofilia y evidencia por imágenes de compresión extrínseca de la vena subclavia a nivel costoclavicular.

Resultados: Se diagnosticaron 41 pacientes y se realizaron 45 resecciones de primera costilla. Cuatro pacientes fueron sometidos a cirugía bilateral por compresión venosa intermitente sintomática sin trombosis contralateral. Todos recibieron anticoagulación al momento del diagnóstico durante al menos tres meses, y se descartó trombofilia. La trombosis se resolvió tras el tratamiento inicial, sin complicaciones hemorrágicas. La descompresión del opérculo torácico se realizó mediante resección toracoscópica de la primera costilla. La mediana de seguimiento fue de 34 meses (RIC: 11-56). No se observaron recurrencias durante el seguimiento.

Conclusión: La estrategia combinada mostró resultados favorables a mediano y largo plazo, evitando los riesgos y las limitaciones en la calidad de vida asociadas al uso prolongado de anticoagulantes.

Palabras clave: síndrome de Paget–Schroetter, síndrome de opérculo torácico venoso, terapia anticoagulante, resección de la primera costilla, cirugía toracoscópica videoasistida (VATS)

KEY POINTS

Current knowledge

- Paget–Schroetter syndrome is an uncommon form of upper-extremity deep vein thrombosis caused by extrinsic compression of the subclavian vein at the thoracic outlet. Combined treatment strategies including anticoagulation, thrombolysis, and thoracic outlet decompression have shown better functional and patency outcomes than anticoagulation alone.

Article's contribution to current knowledge

- This study reports mid- to long-term outcomes of patients with Paget–Schroetter syndrome treated with anticoagulation followed by thoracoscopic first rib resection. Despite delayed referral and limited use of thrombolysis, no recurrences were observed, anticoagulation was discontinued in all patients, and all resumed their previous physical activity.

Paget–Schroetter syndrome (PSS), also known as effort thrombosis of the axillosubclavian vein, is an uncommon cause of upper extremity deep vein thrombosis that typically affects young and otherwise healthy individuals. The condition is associated with extrinsic compression of the subclavian vein in the costoclavicular space, leading to endothelial injury and thrombosis. Anticoagulation alone has been associated with suboptimal outcomes and a high risk of recurrent thrombosis due to persistent mechanical compression within the costoclavicular space. Consequently, thoracic outlet decompression through first rib resection has been increasingly advocated as part of a combined treatment strategy¹⁻³. However, evidence regarding the long-term outcomes of combined treatment strategies using minimally invasive approaches remains limited. The aim of this study was to evaluate the mid- to long-term outcomes of patients with PSS treated with oral anticoagulation for at least three months followed by thoracic outlet decompression through video-assisted thoracoscopic first rib resection.

Materials and methods

This descriptive observational study was conducted as a retrospective single-center analysis of a prospectively maintained database from January 2017 to January 2026. The study was approved by the institutional review board (IRB), and the requirement for written informed consent was waived due to the retrospective design of the study. Patients with Paget–Schroetter syndrome (PSS) who initially received anticoagulation followed by thoracoscopic first rib resection for thoracic outlet decompression (VATS) were included.

The diagnosis of PSS was established in accordance with the criteria defined by the American Society for Vascular Surgery for thoracic outlet syndrome and was based on a history of acute thrombosis documented by Doppler ultrasound and frequently triggered by a precipitating factor, after exclusion of thrombophilia, together with demonstration of extrinsic compression of the subclavian vein on dynamic venous Doppler ultrasound and dynamic chest CT angiography after restoration of venous patency⁴. The use of venography was reserved for patients in whom the diagnosis remained inconclusive after the aforementioned methods or when catheter-directed thrombolysis (fibrinolytic therapy) was planned. After diagnosis, all patients received anticoagulation therapy followed by thoracic outlet decompression with first rib

resection performed by video-assisted thoracoscopic surgery (VATS). Preoperative medical management consisted of anticoagulation therapy with either oral agents or low-molecular-weight heparin, as well as catheter-directed fibrinolytic therapy or mechanical thrombectomy in selected cases. These catheter-based interventions were indicated when the diagnosis was established within 14 days of symptom onset. The anticoagulation regimen was determined by the Hematology Department. The agents used included vitamin K antagonists like, direct oral anticoagulants (DOACs), and low-molecular-weight heparin. Surgical decompression of the thoracic outlet consisted of first rib resection using a video-assisted thoracoscopic (VATS) approach. Patients with active cancer disease, trauma or catheter related thrombosis were excluded. Thrombophilia workup consists of the rule out of antithrombin, protein C and S deficiency, the prothrombin 20210 and factor V Leiden gene mutation and the antiphospholipid antibodies. The institutional diagnostic and treatment algorithm for patients with Paget–Schroetter syndrome is summarized in Fig. 1. Postoperative follow-up included a Doppler ultrasound performed between 1 and 3 months after surgical decompression, at the discretion of the treating hematologist. In the absence of signs of thrombosis, the need for continued oral anticoagulation was reassessed in conjunction with the treating hematologist. For the purposes of this study, mid-term follow-up was defined as 12 to 24 months and long-term follow-up as ≥ 24 months after surgical treatment, enabling assessment of late venous patency, recurrence, and post-thrombotic sequelae.

Results

During the study period, a total of 50 first rib resections were performed using a video-assisted thoracoscopic surgery (VATS) approach in 45 patients. Of these, 41 patients were diagnosed with Paget–Schroetter syndrome, accounting for 45 rib resections. The remaining patients underwent first rib resection for other forms of thoracic outlet syndrome, including neurogenic thoracic outlet syndrome ($n = 3$) and arterial thoracic outlet syndrome ($n = 1$). In four cases, bilateral procedures were performed due to symptomatic intermittent venous compression on the contralateral side without thrombosis, consistent with McCleery syndrome. The 58% of the cohort were female, and the mean age was 30 ± 10 years.

All patients underwent Doppler ultrasound to confirm acute thrombosis. Subsequently, repeat

Doppler ultrasound and computed tomography angiography were performed in all cases, both with dynamic maneuvers (arm adduction and abduction), to assess venous compression at the costoclavicular space. In 7 patients, venography was required to confirm the diagnosis due to inconclusive findings on prior imaging, despite the presence of symptoms consistent with thrombosis and Doppler-confirmed thrombosis. Thrombophilia was ruled out after the initial anticoagulant treatment in all cases.

Preoperative anticoagulation and endovascular management are summarized in Table 1. All patients received anticoagulation therapy at the time of diagnosis: 33 received factor Xa inhibitors (21 rivaroxaban and 12 apixaban), 5 acenocoumarol, 2 low-molecular-weight heparin (LMWH), and 1 a direct thrombin inhibitor after one week of LMWH. One patient underwent catheter-directed thrombolysis with alteplase (1 mg/hour; total dose: 15 mg) using a multi-perforated catheter combined with ultrasonic waves (EkoSonic Endovascular System, BTG Interventional Medicine), while mechanical thrombectomy was performed in two patients. The mean duration of anticoagulation prior to surgery was 14.4 ± 16.4 months. Most patients had been initially diagnosed and managed at outside health-care centers, which likely explains the prolonged preoperative anticoagulation period observed in our cohort. Initial medical management resulted in complete thrombus resolution in all patients, without hemorrhagic complications. Two patients developed residual venous stenosis following anticoagulation therapy.

The mean interval from diagnosis to surgery was 433 ± 497 days, while the interval from evaluation by the thoracic surgeon to surgery was 83 ± 61 days. For bilateral resection patients, the mean time between operations was 2.4 ± 1.2 months.

Thoracic outlet decompression was achieved through first rib resection using a VATS approach in all cases. All patients underwent partial resection of the first rib: from the sternum to the posterior end of the rib insertion of the middle scalene muscle.

The median follow-up was 34 months (interquartile range, 11–56 months), and the mean follow-up was 37 ± 27 months. No recurrences were observed during this period. All patients

Figure 1 | Diagnostic and therapeutic workflow for the evaluation and management of patients with Paget–Schroetter syndrome

DIAGNOSTIC AND TREATMENT WORKFLOW FOR PAGET–SCHROETTER SYNDROME

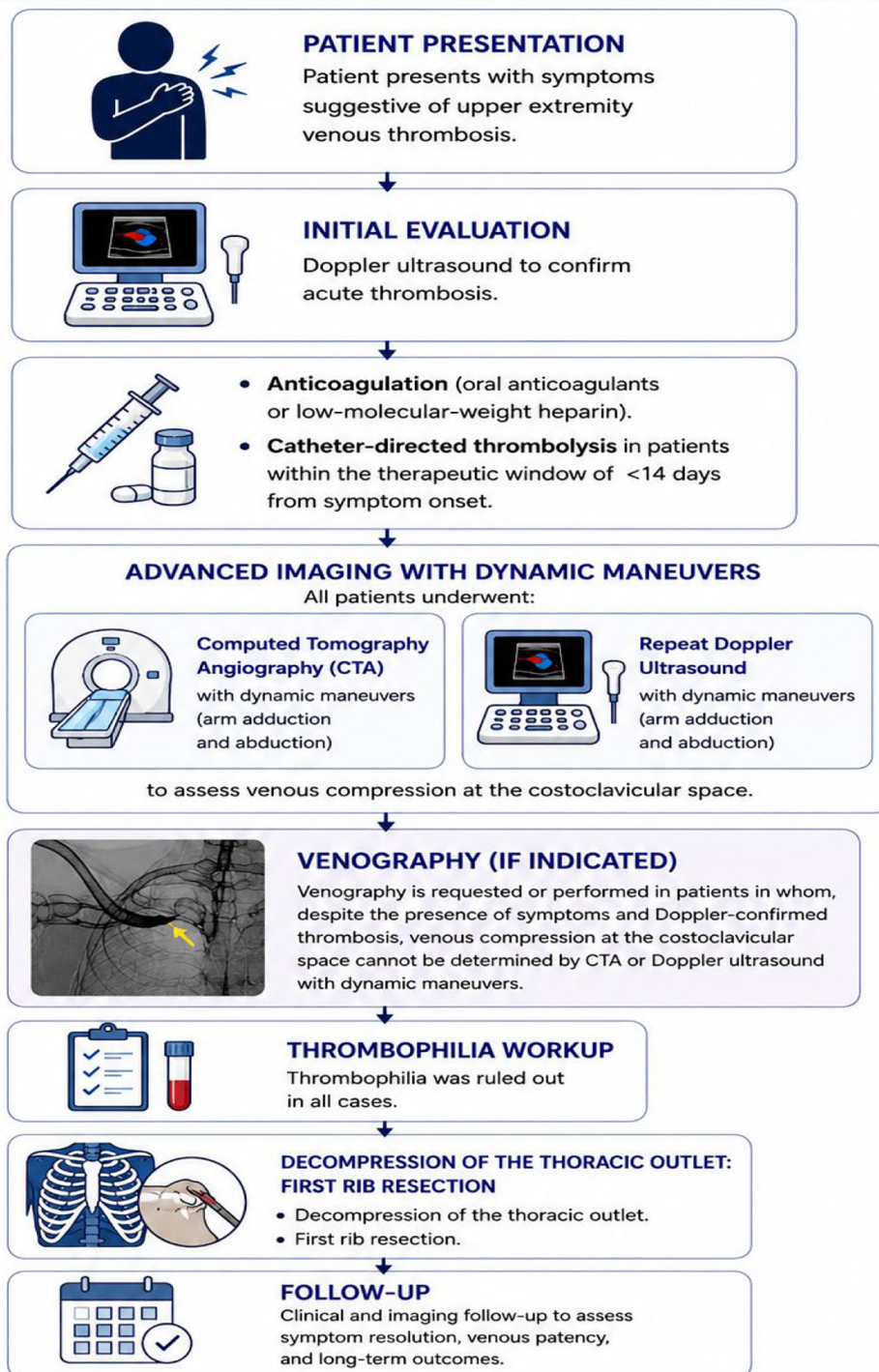


Table 1 | Preoperative anticoagulation and endovascular management

Variable	Value n (%)
Type of anticoagulation	
FXa inhibitors	33 (80)
Acenocoumarol	5 (12)
DTI	1 (2)
LMWH	2 (5)
Catheter-directed thrombolysis	1 (2)
Mechanical thrombectomy	2 (5)
Complete thrombus resolution	41 (100)
Hemorrhagic complications	0
Residual venous stenosis	2 (5)

Fxa: factor Xa inhibitors; DTI: direct thrombin inhibitor; LMWH: low-molecular-weight heparin

were able to resume the physical activity that had initially triggered the thrombosis and discontinue anticoagulation therapy. The mean time to anticoagulation discontinuation after surgery was 1.9 months.

Discussion

Paget-Schroetter syndrome is characterized as a primary thrombosis of the subclavian vein at the costoclavicular junction, typically occurring after strenuous upper-extremity activity. Its pathophysiology involves repetitive arm movements leading to endothelial microtrauma and subsequent activation of the coagulation cascade. Clinically, it presents abruptly in otherwise healthy young individuals with upper-extremity pain and swelling, often following vigorous physical exertion.

To date, no universally accepted standard of care exists for the management of PSS, and optimal strategies for long-term venous patency and symptom resolution remain debated. Four principal approaches have been described: anticoagulation (AC) alone; catheter-directed thrombolysis (CDT) combined with anticoagulation; anticoagulation followed by thoracic outlet decompression; and CDT combined with anticoagulation followed by thoracic outlet decompression. Anticoagulation alone has been associated with higher recurrence rates and may require prolonged therapy, which is particularly undesirable in a young and otherwise

healthy population. Consequently, a multimodal strategy combining medical therapy with surgical decompression is generally advocated^{1, 2}. An earlier case series from our institution reflected the historical heterogeneity in PSS management, including patients treated with anticoagulation alone and others undergoing surgical decompression⁵. Recent systematic reviews and meta-analyses consistently support combined therapeutic approaches, particularly those incorporating thoracic outlet decompression. Karaolanis et al. reported venous patency rates of 88-98% and symptom resolution exceeding 93% in patients treated with thrombolysis followed by decompression, compared with substantially lower patency rates in patients managed with anticoagulation alone (~63%)⁶. Similarly, Hoexum et al. demonstrated that thrombolysis followed by surgical decompression yielded superior clinical outcomes, with up to 96% of patients reporting excellent symptomatic improvement, whereas conservative management achieved satisfactory results in only approximately half of cases⁷. In the same pooled analysis, catheter-based therapies were associated with low complication rates, with adverse events reported in approximately 4.5% of procedures, although specific rates of major bleeding were inconsistently described. Importantly, pooled data suggest that most patients remain symptom-free at mid- to long-term follow-up, with surgical decompression associated with high venous patency rates and favorable functional outcomes. However, some studies have still reported rethrombosis during follow-up, likely reflecting heterogeneity in treatment timing and use of adjunctive thrombolytic therapy^{6,7}. Despite these findings, direct comparisons between initial treatment strategies remain limited. In one of the few comparative studies, Chun et al. demonstrated that early thrombolysis combined with anticoagulation prior to first rib resection resulted in significantly higher preoperative and final venous patency rates compared with anticoagulation alone (98% vs. 78% preoperatively; 92% vs. 74% postoperatively), with a trend toward improved functional outcomes. These results suggest that early thrombus removal may enhance the effectiveness of subsequent surgical decompression⁸.

In this context, our cohort provides insight into real-world management challenges. Most patients were initially treated with anticoagulation alone, largely due to delayed or missed diagnosis and limited familiarity with the condition in the primary care settings where they were initially evaluated. As a result, only one patient underwent catheter-directed thrombolysis and two underwent catheter-directed mechanical thrombectomy, all within the optimal early treatment window. Additional barriers included referral delays and limited access to thrombolytic therapy. This is reflected in the prolonged interval between diagnosis and surgical decompression observed in our series. Nevertheless, despite delayed intervention and limited use of catheter-based therapies, the incidence of residual subclavian vein stenosis was low (4.4%), and most patients experienced substantial symptomatic improvement. These findings suggest that thoracic outlet decompression may still provide meaningful clinical benefit even when performed beyond the acute phase, likely through enhancement of collateral venous drainage. This observation is consistent with emerging evidence supporting the role of surgical decompression in chronic venous thoracic outlet syndrome. Mangiameli et al. reported significant symptom improvement in 83% of patients undergoing first rib resection for chronic disease, including those with persistent venous occlusion, further emphasizing the functional benefits of decompression even in delayed presentations⁹.

Follow-up durations reported in the literature typically range from 3 to 5 years, with some series extending up to two decades. Johansen reported a mean follow-up of 57 months, with over 90% of patients asymptomatic or mildly symptomatic, while Molina et al. dem-

onstrated excellent 5-year outcomes with complete venous patency and absence of significant symptoms following combined treatment^{10, 11}. Long-term data from Urschel et al. further support the durability of these results. Collectively, these findings reinforce the effectiveness of combined anticoagulation and thoracic outlet decompression in achieving sustained symptom relief and venous patency, while highlighting the importance of continued surveillance given the non-negligible risk of recurrence¹².

Traditionally, first rib resection has been performed using supraclavicular, infraclavicular, or transaxillary approaches. The thoracoscopic technique, first described by Ohtsuka et al. in 1999, provides enhanced visualization of the thoracic outlet during rib resection. In addition, unlike open approaches, the extent of rib resection is not limited by the surgical access, allowing for complete resection of the first rib when necessary¹³. Compared with open approaches, this technique may reduce surgical morbidity and overcome anatomical limitations inherent to conventional exposures, potentially enhancing decompression effectiveness^{14–20}.

Finally, it is important to acknowledge that current evidence is largely derived from retrospective series and pooled analyses, given the rarity of the condition. The absence of randomized controlled trials limits the ability to establish definitive treatment algorithms. In this context, our study aims to contribute additional evidence regarding the mid- to long-term outcomes of initial anticoagulation followed by thoracoscopic first rib resection, supporting its role as a viable and effective strategy in the management of Paget–Schroetter syndrome.

Conflict of interest: None to declare

References

1. Illig KA, Doyle AJ. A comprehensive review of Paget-Schroetter syndrome. *J Vasc Surg* 2010; 51: 1538–47.
2. Cook JR, Thompson RW. Evaluation and management of venous thoracic outlet syndrome. *Thorac Surg Clin* 2021; 31: 27–44.
3. Cai TY, Rajendran S, Saha P, Dubenec S. Paget-Schroetter syndrome: A contemporary review of the controversies in management. *Phlebology* 2020; 35: 461–71.
4. Illig KA, Donahue D, Duncan A, et al. Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome. *J Vasc Surg* 2016; 64: e23–e35.
5. Ramírez JI, Gutiérrez V, Finn BC, et al. Síndrome

- de Paget-Schrötter: descripción de cuatro casos. *Medicina (B Aires)* 2018; 78: 372-5.
6. Karaolani G, Antonopoulos CN, Koutsias SG, et al. A systematic review and meta-analysis for the management of Paget-Schroetter syndrome. *J Vasc Surg Venous Lymphat Disord* 2021; 9: 801-10.
 7. Hoexum F, Hoebink M, Coveliers HME, Wisselink W, Jongkind V, Yeung KK. Management of Paget-Schroetter syndrome: a systematic review and meta-analysis. *Eur J Vasc Endovasc Surg* 2023; 66: 866-75.
 8. Chun TT, O'Connell JB, Rigberg DA, et al. Preoperative thrombolysis is associated with improved vein patency and functional outcomes after first rib resection in acute Paget-Schroetter syndrome. *J Vasc Surg* 2022; 76: 806-13.
 9. Mangiameli G, Italiani A, Rizzardi G, et al. Venous thoracic outlet syndrome (vTOS): May surgery be a solution in chronic form? *Ann Vasc Surg* 2025; 121: 1-13.
 10. Johansen KH. Does axillosubclavian vein ("effort") thrombosis oblige first rib resection. *Arch Surg* 2008; 58: 43-9.
 11. Molina JE. Reoperations after failed transaxillary first rib resection to treat Paget–Schroetter syndrome patients. *Ann Thorac Surg* 2011; 91: 1717-21.
 12. Urschel HC Jr, Razzuk MA. Paget-Schroetter syndrome: what is the best management? *Ann Thorac Surg* 2000; 69:1663-8.
 13. Ohtsuka T, Wolf RK, Dunsker SB. Port-access first-rib resection. *Surg Endosc* 1999; 13: 940-2.
 14. Buero A, Lopez SO, Lyons GA, Pankl LG, Young P, Chimondeguy DJ. First rib resection using videothoracoscopy in patients with vascular thoracic outlet syndrome. *EJVES Vasc Forum* 2024; 62: 15-20.
 15. Loscertales J, Congregado M, Jiménez Merchán R. Extirpación de la primera costilla por videotoracosopia para el tratamiento del síndrome del estrecho torácico. *Arch Bronconeumol* 2011; 47: 204e7.
 16. Soukiasian HJ, Shouhed D, Serna-Gallgos D, McKenna R 3rd, Bairamian VJ, McKenna Jr RJ. A video-assisted thoracoscopic approach to transaxillary first rib resection. *Innovations (Phila)* 2015; 10: 21e6.
 17. Hwang J, Min BJ, Jo WM, Shin JS. Video-assisted thoracoscopic surgery for intrathoracic first rib resection in thoracic outlet syndrome. *J Thorac Dis* 2017; 9: 2022e8.
 18. Nuutinen H, Riekkinen T, Aittola V, Mäkinen K, Kärkkäinen JM. Thoracoscopic versus transaxillary approach to first rib resection in thoracic outlet syndrome. *Ann Thorac Surg* 2018; 105: 937e42.
 19. Buero A, Chimondeguy DJ, Auvieux R, et al. Resección de la primera costilla por videotoracoscopía en el síndrome de Paget-Schroetter. *Medicina (B Aires)* 2021; 81: 31e6.
 20. George RS, Milton R, Chaudhuri N, Kefaloyannis E, Papagiannopoulos K. Totally endoscopic (VATS) first rib resection for thoracic outlet Syndrome. *Ann Thorac Surg* 2017; 103: 241e5.