Original Article **Open Access**

Surgical Intervention for Arterial Thoracic Outlet Syndrome: A Retrospective Observational Study on Post-operative Outcomes and Quality of Life; Single Center Experience from Karachi Pakistan

Muhammad Muqeem, Waryam Panhwar, Fahad Tariq Berlas, Fahad Memon, Misbah Nizamani, Asif Ali Khuwaja

Abstract:

Objective: Thoracic outlet syndrome results from compression of the brachial plexus and/or subclavian vessels. Arterial thoracic outlet syndrome carries the most severe consequences. To assess the surgical outcomes and its impact on quality of life in patients with aTOS undergoing surgical treatment.

Study Design and Setting: A retrospective study was conducted on patients undergoing surgical decompression with/without arterial reconstruction at the Department of Vascular & Endovascular Surgery SMBBIT, Karachi from July 2019 to December 2023.

Methodology: Limb salvage, complication rates and QoL using DASH score were assessed retrospectively. P-value of less than 0.05 was considered significant

Results: A total of 22 patients underwent surgery for aTOS over the past five years. The cohort was predominantly male (59.1%) with a mean age of 32.05 ± 14.3 years. All patients presented with Acute or acute on chronic limb ischemia, the most common symptoms being pain (90.9%), numbness (45.5%) and blackish discoloration (27.3%). Imaging showed post-stenotic aneurysm as the most prevalent arterial pathology (54.5%). All patients had a cervical rib, and the supraclavicular approach was used exclusively for surgery with infraclavicular incision for axillary artery control and distal anastomosis where needed. Arterial reconstruction was performed in 90.5% of patients. Postoperative complications occurred in 27.3% of patients. No in-hospital or 30-day mortality was observed. Limb salvage was achieved in 95.5% of patients. Follow-up data showed a progressive improvement in post operative DASH scores (p= <0.001).

Conclusion: Surgical decompression of aTOS with/without arterial reconstruction is associated with high limb salvage rates and QoL improvement.

Keywords: ATOS, cervical rib, DASH score

How to cite this Article:
Muqeem M, Panhwar W, Berlas FT, Memon F, Nizamani M, Khuwaja AA. Surgical Intervention for Arterial Thoracic Outlet Syndrome: A Retrospective Observational Study on Post-operative Outcomes and Quality of Life; Single Center Experience from Karachi Pakistan. J Bahria Uni Med Dental Coll. 2026;16(1):145-151 DOI: https://doi.org/10.51985/JBUMDC2025737

Muhammad Muqeem *(Corresponding Author)*
Fellow, Department of Vascular and Endovascular Surgery, SMBBIT, Karachi
Email: jmuqeem142.mm@gmail.com

Waryam Panhwar
Consultant, Department of Vascular and Endovascular Surgery, SMBBIT, Karachi
Email: Panhwarwaryam145@gmail.com

Fahad Tariq Berlas
Head Department of Vascular and Endovascular Surgery, SMBBIT, Karachi
Email: drfahadberlas@gmail.com

Fahad Memon
Consultant, Department of Vascular and Endovascular Surgery, SMBBIT, Karachi
Email: fahadhameedmemon@gmail.com

Misbah Nizamani
Medical Officer, Department of Vascular and Endovascular Surgery,
SMBBIT, Karachi
Email: misbahnizamani1999@gmail.com

Asif Ali Khuwaja
Fellow, Department of Vascular and Endovascular Surgery, SMBBIT, Karachi
Email: asifalikhowaja09@gmail.com

Received: 27-09-2025
1st Revision: 27-10-2025
Accepted: 08-01-2026
2nd Revision: 20-11-2025

INTRODUCTION:

Thoracic outlet syndrome (TOS) is a well-recognized clinical condition caused by compression of the brachial plexus and/or the subclavian vessels within the thoracic outlet. The syndrome is categorized into neurogenic, venous, and arterial subtypes based on the structure involved. The neurogenic form constitutes over 90% of all TOS cases, making it the most prevalent, whereas the venous subtype accounts for approximately 3–5%, and the arterial form comprises less than 1%.[1,2] Arterial thoracic outlet syndrome (aTOS) is specifically defined by a demonstrable abnormality in the subclavian artery secondary to chronic extrinsic compression, most commonly by an anomalous first rib, cervical rib, or fibrous band located at the base of the scalene triangle.[3]

Although aTOS is the rarest subtype of TOS, it carries the most severe clinical implications. Patients frequently presents with upper limb ischemia, distal thromboembolism, digital gangrene, or, in advanced cases, potential limb loss.[4] The etiologies of aTOS may be broadly classified as bony or non-bony. Bony causes include congenital anomalies such

as cervical ribs or anomalous first ribs, as well as acquired pathologies such as clavicular fractures or hypertrophic fracture callus. Non-bony causes involve hypertrophy of scalene muscles, post-surgical or post-radiation fibrosis, or intrinsic arterial lesions such as aneurysmal dilation or thrombosis.[5]

Epidemiological data indicate that aTOS is more commonly observed in younger individuals, particularly those presenting within the first two decades of life.[6] The clinical presentation varies depending on the chronicity and severity of arterial compromise. Symptoms may range from acute ischemia, pain, paresthesia, and upper limb weakness to limb discoloration or cold intolerance. In long-standing or severe cases, rest pain, ischemic ulcerations, or tissue necrosis may develop.[7]

A range of imaging modalities is available for the diagnosis and etiological assessment of aTOS. These include plain chest radiography, digital plethysmography, pulse volume recordings, segmental pressure measurements, duplex ultrasonography, computed tomography angiography (CTA), and conventional catheter-based angiography. Among these, a plain chest radiograph is typically the initial investigation of choice due to its accessibility and ability to detect bony abnormalities such as cervical ribs, anomalous first ribs, and clavicular trauma or callus formation.[8] Definitive vascular imaging with duplex ultrasonography or CTA is frequently required for operative planning and assessment of arterial damage.

The management of aTOS is not standardized and largely depends on the underlying etiology, extent of arterial pathology, and patient presentation. The principal objective of surgical intervention is to relieve extrinsic compression of the neurovascular bundle and restore distal perfusion. This is commonly achieved through resection of the first rib, excision of fibrous bands, division of the anterior and middle scalene muscles, and neurolysis of the brachial plexus. In many cases, vascular reconstruction such as arterial bypass or end-to-end anastomosis is warranted when aneurysmal degeneration or post-stenotic dilation is present. Multiple surgical approaches have been described, including transaxillary, supraclavicular, infraclavicular, posterior, combined transaxillary–supraclavicular, combined supraclavicular–infraclavicular (paraclavicular), and minimally invasive techniques such as endoscopic- or video-assisted thoracoscopic surgery, with or without robotic assistance. Each technique offers distinct advantages and limitations; however, evidence suggests that when complete decompression of the compressive lesion is achieved, outcomes are comparable across approaches.[9] Although postoperative complications such as nerve injury, pneumothorax, or vascular thrombosis have been reported, overall mortality in aTOS remains exceedingly low.[10]

The objective of this study is to evaluate surgical outcomes and their impact on quality of life in patients with arterial thoracic outlet syndrome managed operatively at the Department of Vascular and Endovascular Surgery (DVES), Shaheed Mohtarma Benazir Bhutto Institute of Trauma (SMBBIT), Karachi. Current literature from developing countries, particularly within South Asia, is limited, despite notable differences in patient demographics, disease chronicity at presentation, and healthcare delivery systems compared to high-income regions. This study aims to address this gap by contributing locally relevant data on clinical presentation, surgical management, and postoperative functional recovery in patients with aTOS.

METHODOLOGY:

This retrospective observational study was conducted to evaluate the clinical and functional outcomes of patients undergoing surgical management for arterial thoracic outlet syndrome (aTOS) at the Department of Vascular and Endovascular Surgery (DVES), Shaheed Mohtarma Benazir Bhutto Institute of Trauma (SMBBIT), Karachi, Pakistan. All patients of any age or gender who underwent surgical intervention for arterial TOS between July 2019 and December 2023 and met the inclusion criteria were included using a consecutive sampling technique. Patients were excluded if they had other established causes of upper limb ischemia such as athero-embolic disease, had undergone prior surgical procedures for similar symptoms in other departments, or presented with a non-salvageable limb. The primary objective of the study was to assess postoperative limb salvage, graft patency, and complications following surgical management of aTOS, while the secondary objective was to evaluate postoperative quality of life using the Disabilities of the Arm, Shoulder, and Hand (DASH) score.

Data were collected using a pre-designed pro forma. Eligible patients admitted during the study period were identified, ensuring a minimum follow-up duration of 12 months. Relevant data were extracted from admission records, radiological imaging, operative notes, and outpatient follow-up documentation. Study variables included demographic characteristics, clinical presentation, comorbidities, imaging findings, surgical details, perioperative and postoperative outcomes, and functional outcomes assessed by the DASH score at 3, 6, and 12 months postoperatively. To address missing data, patients were contacted through follow-up calls or clinic visits, and additional information was obtained after informed consent.

Statistical analysis was performed using IBM SPSS Statistics version 24. Continuous variables were expressed as means and standard deviations, while categorical variables were summarized as frequencies and percentages. Data normality was assessed using the Shapiro–Wilk test. Comparisons for normally distributed continuous variables were conducted using independent sample t-tests or ANOVA as appropriate. Categorical variables were analyzed using the Chi-square

test, with Fisher's exact test applied when Chi-square assumptions were not met. For non-parametric data, the Mann–Whitney U test was used. A p-value of less than 0.05 was considered statistically significant. Ethical approval for the study was obtained from the Institutional Ethical Review Committee (IRB-000160/SMBBIT/Approval/2025).

Operational definitions:

• Quality of Life:

Quality of Life is defined as the patient's self-reported physical, psychological, and social well-being following surgical intervention for arterial TOS as assessed by change in DASH (Disability of the Arm, Shoulder, and Hand) score after surgery.[11]

• Limb salvage:

Limb salvage in this study refers to preservation of the affected limb without requiring amputation, following surgical intervention for arterial Thoracic Outlet Syndrome.

• Scher Classification:

The Scher classification was used to categorize the severity and type of aTOS based on clinical presentation and radiologic findings. This classification helped guide the choice of surgical intervention and was used in outcome analysis.

Stage 0: Asymptomatic subclavian artery compression

Stage 1: Subclavian artery stenosis with minor post-stenotic dilation but no intimal injury

Stage 2: Subclavian artery aneurysm with mural thrombus and intimal damage

Stage 3: Arterial thrombosis or distal embolization leading to occlusion [12]

RESULTS:

A total of 22 patients underwent surgery for arterial TOS at our center over the specified period of which 59.1% (n=13) were male. The mean age was 32.05 +/- 14.3 years. Most of the patients (90.9%, n=20) had no comorbid conditions. Only one patient had hypertension, and another had both diabetes mellitus and hypertension, while two patients were smokers. (Table no.1). Among the 22 patients who underwent surgery for aTOS, the most frequently reported symptom was hand and arm pain, present in 90.9% (n=20) of cases. Numbness was the second most common symptom, occurring in 45.5% (n=10) of patients. Blackish discoloration of fingers was observed in 27.3% (n=6), followed by burning sensation in 13.6% (n=3), restricted movements in 9.1% (n=2), and claudication in 4.5% (n=1). Notably one of our patients had an episode of ipsilateral cerebral ischemic event 2 weeks before presentation. Many patients experienced more than one symptom (Figure no.1). Most patients experienced symptoms for a short period before seeking medical care. The median duration of symptoms was 3 months, with IQR of 1 to 6 months. All patients were right-hand dominant (100%, n=22). Symptoms were present on the right side in 77.3% (n=17) of patients and on the left side in 22.7% (n=5). Most patients (90.9%, n=20) had not undergone any prior interventions, while 9.1% (n=2) had underwent embolectomy for acute ischemia before thoracic outlet decompression surgery. Imaging studies were performed on all patients in the cohort. Chest X-ray (CXR) and CT scan were each conducted as per departmental policy (Table no.1).

The most prevalent arterial injury observed was post stenotic aneurysmal dilation, occurring in 54.5% (n=12) of patients, followed by thrombosis in 27.3% (n=6). Only extrinsic compression without identifiable arterial damage was present in 18.2% of patients (n=4). According to the Scher classification, the majority of patients were classified as stage 3 (47.6%, n=10), followed by stage 2 (42.9%, n=9) and stage 1 (9.5%, n=2).

All patients had a bony abnormality in the form of a cervical rib (100%, n=22), with no other bony anomalies identified. The supraclavicular approach was utilized exclusively in all cases along with infra clavicular incision, for axillary artery control and distal anastomosis when required.

Arterial reconstruction was performed in 90.5% of patients (n=19), while 9.5% (n=2) did not require reconstruction. Among the patients who underwent reconstruction, the most common procedure was interposition graft placement, performed in 85.7% of cases (n=18). Distal bypass was done in 4.7% (n=1). Concomitant distal embolectomy was performed in 36.8% of cases. Autologous Vein Grafts were used in 70% (n=14) of cases while prothesis was used in 30% (n=6) of cases. In two patients, pleura was opened intra-operatively, which was repaired, without need for chest tube placement.

The mean length of hospital stay was 7.73 ± 4.06 day. No In-hospital or 30-day mortality was observed in all patients (Table no.2). Postoperative complications were observed in 27.3% of patients (n=6), while the remaining 68.2% (n=15) had an uncomplicated recovery. Among those who experienced complications, the most common issues included hematoma formation (n=2), surgical site infection (n=2), graft thrombosis (n=1) and lymphatic leak (n=1) (Table no.3). Out of the 22 patients included in the study, 21 (95.5%) achieved limb salvage, while 1 patient (4.5%) required a below-elbow amputation due to graft thrombosis.

Reintervention was required in 4 patients (18.2%). These included one case of drainage of collection, two cases of hematoma evacuation, and one suture ligation of lymphatic leak. Data on functional outcomes could be achieved only for 12 out of 22 patients. The mean DASH score demonstrated a consistent decline over time, indicating significant

Table 1: Demographics and Operative Details

Variable	N	%
Gender		
Male	13	59.1
Female	9	40.9
Co-morbid		
HTN	1	4.5
DM and HTN	1	4.5
None	20	90.9
Smokers	2	9.1
Laterality		
Right	17	77.3
Left	5	22.7
Dominant Hand		
Right	22	100
Left	0	0
Imaging Modality		
CXR	22	100
CT scan	22	100
Arterial Pathology on imaging		
Thrombosis	6	27.3
Aneurysm	12	54.5
Extrinsic compression only	4	18.2
Scher Classification		
Stage 0	0	
Stage 1	2	9.5
Stage 2	9	42.9
Stage 3	10	47.6
Surgical decompression	22	100
Type of Arterial reconstruction		
Interposition Graft	18	85.7
Distal Bypass	1	4.7
No reconstruction	2	9.5
Graft		
Vein	14	70
Prosthesis	6	30

Table 2: Postoperative Length of Stay and Functional Outcomes as assessed by DASH score

Length of stay (in days)	Mean (SD) 7.73 (± 4.06)	Median 6.5	IQR 4.75-11.25
DASH score			
Pre-op	64.78± 9.39	64	57-73
3-months	33.33 ± 3.60	34	30-37
6-months	32.25 ± 3.95	32	29-36
12-months	31.58 ± 4.21	37	28-36

Figure 1: Presenting Symptoms

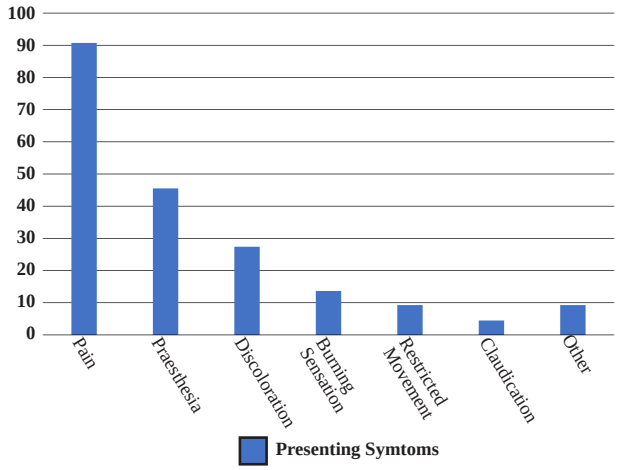
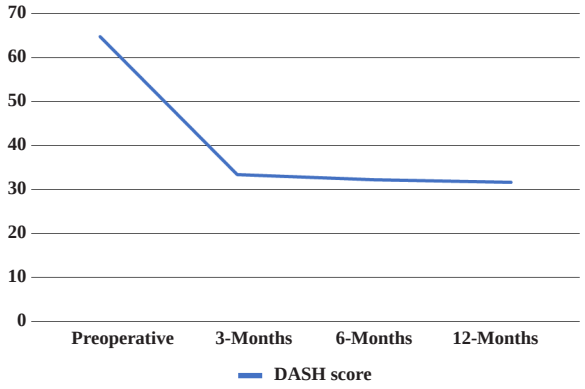


Table.3: Post-operative complications.

Post-operative Complications	**N**	**%**
Hematoma formation	2	9.1%
Infection	2	9.1%
Lymphatic leak	1	4.5%
Graft thrombosis	1	4.5%
None	16	72.7%

Figure 2: Mean DASH scores at preoperative, 3-month, 6-month, and 12-month follow-up



improvement in upper limb function following surgery. The mean preoperative DASH score was 64.78 ± 9.39, which decreased to 33.33 ± 3.60 at 3 months, 32.25 ± 3.95 in 6 months, and 31.58 ± 4.20 in 12 months. The median scores followed a similar trend, decreased steadily from 64.6 preoperatively to 30.5 in 12 months, indicating a sustained improvement in upper limb function over time. (Table no.2).

We evaluated the preoperative DASH scores and compared it with DASH scores at 3-, 6-, and 12-months follow-up using repeated measures ANOVA. The analysis revealed a statistically significant effect of time on DASH scores ($p < 0.001$) with a large effect size. The estimated marginal means showed a significant linear trend and indicated rapid early improvement in the first 3 months followed by a plateau. These findings suggest that the most functional recovery occurred within the first 3 months postoperatively, with gradual but less pronounced improvements up to 12 months (Figure no 2).

There was no notable interaction between improvement in DASH score and Scher classification (p = 0.320), indicating that the rate of improvement over time was consistent across Scher groups. No statistically significant correlation was found between operative time and the change in DASH score (p = 0.901). Additionally, there was no significant relationship between the type of arterial reconstruction and the degree of functional improvement, as assessed by the change in DASH score (p = 0.801).

DISCUSSION:

In this retrospective cohort study, we analyzed 22 patients who underwent surgical treatment for arterial thoracic outlet syndrome (TOS) over a five-year period. This study demonstrated a slight male predominance (59.1%), which contrasts with existing literature that generally reports a higher prevalence among females.[13] The majority (77.3%) presented with symptoms on the right side. Pain was the most common presenting complaint (90.9%), followed by numbness and discoloration suggesting either acute or acute on chronic limb ischemia. One of our patients had an episode of an ipsilateral Cerebral ischemic event 2 weeks prior to presentation. Notably, posterior circulation stroke has been reported as one of the potential sequelae of arterial TOS, where retrograde embolization of clot secondary to subclavian artery injury can lead to permanent neurological deficit.[14,15]

In this study only two patients (9.1%) had undergone prior embolectomy, having presented to the emergency department with acute or subacute thromboembolic events. This approach is consistent with current practices and recommendations for the initial management of arterial TOS.[16]

The aneurysmal degeneration of the subclavian artery was the predominant vascular abnormality, followed by thrombosis. All patients had cervical ribs, and the supraclavicular (SC) approach was used exclusively in our surgical management. Although no approach has found to be superior to others as far as literature is concerned, supraclavicular approach was used for various reasons. SC exposure provides optimal vascular control and offers superior access to the anatomical structures within the scalene triangle.[17] Concomitant infraclavicular incision was used where reconstruction was required as arterial damage usually extends behind the clavicle which needs to be resected out till normal artery below the clavicle.

Arterial reconstruction was performed in most patients, with autologous vein grafts being more commonly used than prosthetic grafts. Concomitant neurolysis was performed in all the cases, due to significant overlap between arterial and neurogenic TOS in many patients.[18] Additionally, distal embolectomies were carried out during the same surgery in 36.8% of patients, reflecting the extensive nature of the disease.

Functional recovery in our cohort was evaluated using the Disabilities of the Arm, Shoulder and Hand (DASH) score. The progressive improvement in DASH scores observed in this study highlights the significant functional recovery achieved following surgical intervention. The median DASH score declined from 64.6 preoperatively to 34.0 in 3 months, with continued improvement in 6 months (31.5) and 12 months (30.5). This trend was statistically significant, as demonstrated by repeated measures ANOVA, suggesting that surgery leads to substantial and sustained improvement in upper limb function. Notably, the most marked improvement occurred within the first 3 months postoperatively, followed by a gradual plateau, a pattern that aligns with the natural course of neuromuscular recovery. These findings are consistent with prior studies that have reported early postoperative gains in function, particularly in cases involving thoracic outlet decompression or nerve release procedures. The narrowing of interquartile ranges and decreasing standard deviation over time further support the consistency of functional recovery among patients. Collectively, this reinforces the role of surgical treatment in improving quality of life and reducing disability in patients with arterial TOS.[15,19]

Kaczynski et al.[19] demonstrated that surgical intervention leads to significant improvement in functional outcomes, as reflected by the DASH score, across all subtypes of thoracic outlet syndrome. However, the improvement was most pronounced in patients with arterial TOS. Davidoviæ et al. [20] found complete resolution of symptoms in the studied patients upon follow-up, indication good functional outcome following surgical decompression in patient with TOS.

The postoperative complication rate in our cohort is within the range reported in other surgical series.[18] Graft thrombosis, hematoma formation, and wound infections were the most frequently encountered complications, reflecting the known risks associated with vascular reconstruction and decompression in this patient population. Due to the young

age of most patients, comorbidities were uncommon which otherwise could have negatively influenced the outcomes and complication. The majority of patients showed good functional recovery over time, as evidenced by declining DASH scores at 3, 6, and 12 months. The high limb salvage rate observed in our study highlights the effectiveness of timely surgical decompression and revascularization in preventing irreversible ischemic damage in patients with arterial TOS. One of our patients presented late, with a gangrenous hand at the time of admission. Although arterial reconstruction had been performed, the patient ultimately required a below-elbow amputation. This finding is consistent with the literature, which highlights that delayed presentation, particularly with gangrenous digits or extremities, often necessitates amputation despite technically successful reconstruction.[21]

This study contributes valuable regional data to the limited body of global literature on arterial thoracic outlet syndrome, addressing a significant gap in evidence from lower-middle-income healthcare settings. A distinctive strength of this research is its evaluation of postoperative functional recovery using the validated Disabilities of the Arm, Shoulder, and Hand (DASH) score, which provides an objective and internationally recognized measure of functional outcomes. Despite the inherent resource constraints of the study setting, the surgical outcomes were notably favorable, demonstrating high rates of limb salvage, a low incidence of postoperative complications, and complete absence of perioperative mortality.

This study is limited by its retrospective design, small sample size, and single-center setting, which may restrict the generalizability of the findings. Follow-up was incomplete, with DASH scores available for only 12 patients, thereby introducing the potential for selection and reporting bias. Additionally, the absence of a control group prevents direct comparison with nonoperative or alternative surgical strategies. The lack of long-term follow-up further limits the ability to assess the durability of surgical outcomes and the possibility of late complications or functional decline.

CONCLUSION:

This study offers valuable insights into the management of arterial thoracic outlet syndrome (aTOS), a rare and underreported condition, particularly from South Asia. Our findings emphasize the importance of early diagnosis and referral for surgical management in patients with arterial TOS. Given the rarity of this condition, multicenter prospective studies with larger sample sizes and standardized outcome assessments are needed to validate our results and explore long-term functional outcomes.

Conflicts of Interest: Nil

Source of Funding: Nil

Acknowledgement: Nil

Authors Contribution:
Muhammad Muqeem: Conception and data interpretation
Waryam Saleh: Conception, design, and Supervision
Fahad Tariq Berlas: Conception and Supervision
Fahad Memon: Conception, analysis and Supervision
Misbah Nizamani: Analysis and manuscript writing
Asif Ali Khuwaja: Analysis and manuscript writing

REFERENCES:

1. Kuhn JE, Lebus V GF, Bible JE. Thoracic outlet syndrome. J Am Acad Orthop Surg. 2015 Apr;23(4):222-32. doi: 10.5435/JAAOS-D-13-00215.
2. Masocatto NO, Da-Matta T, Prozzo TG, Couto WJ, Porfirio G. Thoracic outlet syndrome: a narrative review. Rev Col Bras Cir. 2019 Dec 20;46(5):e20192243. Portuguese, English. doi: 10.1590/0100-6991e-20192243.
3. Karl A. Illig, Dean Donahue, Audra Duncan, Julie Freischlag, Hugh Gelabert, Kaj Johansen, Sheldon Jordan, Richard Sanders, Robert Thompson, Reporting standards of the Society for Vascular Surgery for thoracic outlet syndrome: Executive summary, Journal of Vascular Surgery, Volume 64, Issue 3, 2016, Pages 797-802, ISSN 0741-5214.
4. Nguyen LL, Soo Hoo AJ. Evaluation and Management of Arterial Thoracic Outlet Syndrome. Thorac Surg Clin. 2021 Feb;31(1):45-54. doi: 10.1016/j.thorsurg.2020.09.006.
5. Huang J, Lauer J, Zurkiya O. Arterial thoracic outlet syndrome. Cardiovasc Diagn Ther. 2021 Oct;11(5):1118-1124. doi: 10.21037/cdt-20-149.
6. Maru S, Dosluoglu H, Dryjski M, Cherr G, Curl GR, Harris LM. Thoracic outlet syndrome in children and young adults. Eur J Vasc Endovasc Surg. 2009 Nov;38(5):560-4. doi: 10.1016/j.ejvs.2009.06.015. Epub 2009 Aug 22.
7. Enrique Criado, Ramon Berguer, Lazar Greenfield, The spectrum of arterial compression at the thoracic outlet, Journal of Vascular Surgery, Volume 52, Issue 2, 2010, Pages 406-411, ISSN 0741-5214, https://doi.org/10.1016 /j.jvs. 2010.03.009.
8. Hussain, M. A., Aljabri, B., & Al-Omran, M. (2016). Vascular Thoracic Outlet Syndrome. Seminars in Thoracic and Cardiovascular Surgery, 28(1), 151–157. doi:10. 1053/j.semtcvs .2015.10.008
9. Suzuki T, Kimura H, Matsumura N, Iwamoto T. Surgical Approaches for Thoracic Outlet Syndrome: A Review of the Literature. J Hand Surg Glob Online. 2022 May 5;5(4):577-584. doi: 10.1016/j.jhsg.2022.04.007.
10. Altoijry A, AlGhofili H, Iqbal K, Altuwaijri TA, Alsheikh S, AlHamzah M, Khoujah E, AbuAlnasr MT, Aljabri B, Al-Salman M. Vascular thoracic outlet syndrome: Registry of 30-years of patient's outcomes at King Saud University Medical City, Riyadh, Saudi Arabia. Saudi Med J. 2022 Jul;43(7):743-750. doi: 10.15537/smj.2022.43.7.20220336.
11. Gummesson C, Atroshi I, Ekdahl C. The disabilities of the arm, shoulder and hand (DASH) outcome questionnaire: longitudinal construct validity and measuring self-rated health change after surgery. BMC Musculoskelet Disord. 2003 Jun 16;4:11. doi: 10.1186/1471-2474-4-11. Epub 2003 Jun 16.
12. Scher LA, Veith FJ, Haimovici H, Samson RH, Ascer E, Gupta SK, Sprayregen S. Staging of arterial complications of cervical rib: guidelines for surgical management. Surgery. 1984 Jun;95(6):644-9.

13. Cralle LE, Harris LM, Lum YW, Deery SE, Humphries MD. Thoracic outlet syndrome in females: A systematic review. Semin Vasc Surg. 2023 Dec;36(4):487-491. doi: 10.1053/j.semvascsurg. 2023.09.003. Epub 2023 Sep 23.

14. Lee TS, Hines GL. Cerebral embolic stroke and arm ischemia in a teenager with arterial thoracic outlet syndrome: a case report. Vasc Endovascular Surg. 2007 Jun-Jul;41(3):254-7. doi: 10.1177/1538574407299780.

15. Palmer OP, Weaver FA. Bilateral cervical ribs causing cerebellar stroke and arterial thoracic outlet syndrome: a case report and review of the literature. Ann Vasc Surg. 2015 ;29(4):840.e1-4. doi: 10.1016/j.avsg.2014.12.008. Epub 2015 Feb 26.

16. Vemuri C, McLaughlin LN, Abuirqeba AA, Thompson RW. Clinical presentation and management of arterial thoracic outlet syndrome. J Vasc Surg. 2017;65(5):1429-1439. doi: 10.1016/j.jvs.2016.11.039. Epub 2017 Feb 8.

17. Teijink SBJ, Goeteyn J, Pesser N, van Nuenen BFL, Thompson RW, Teijink JAW. Surgical approaches for thoracic outlet decompression in the treatment of thoracic outlet syndrome. J Thorac Dis. 2023 Dec 30;15(12):7088-7099. doi: 10.21037/jtd-23-546. Epub 2023 Dec 14.

18. Likes K, Rochlin DH, Call D, Freischlag JA. Coexistence of arterial compression in patients with neurogenic thoracic outlet syndrome. JAMA Surg. 2014 Dec;149(12):1240-3. doi: 10.1001/jamasurg.2014.280.

19. KACZYNSKI, J., FLIGELSTONE, L.. Surgical and Functional Outcomes After Thoracic Outlet Syndrome Decompression via Supraclavicular Approach: A 10-Year Single Centre Experience. Journal of Current Surgery, North America, 3, jun. 2013

20. Davidoviæ LB, Koncar IB, Pejkiæ SD, Kuzmanoviæ IB. Arterial complications of thoracic outlet syndrome. Am Surg. 2009 Mar;75(3):235-9.

21. Bucek RA, Schnürer G, Ahmadi A, Maca TH, Meissl G, Minar E. A severe case of vascular thoracic outlet syndrome. Wien Klin Wochenschr. 2000 Nov 24;112(22):973-7.