# An unusual case of Venous Thoracic Outlet Syndrome in relation to the anatomical position of the subclavian vein valves in a young athlete

Anselmo Pagani,[1] Giulia Baldazzi,[2] Roberta Ricci,[2] Maddalena Bressan,[2] Erica Menegatti[3]

[1]Department of Translational Medicine, University of Ferrara; [2]School of Vascular Surgery, University of Ferrara; [3]Department of Environmental Science and Prevention, University of Ferrara, Italy

## Abstract

Venous Thoracic Outlet Syndrome (vTOS) consists of upper extremities edema, sometimes with varicose dilation of the superficial veins of the arm, as a consequence of compression and/or thrombosis of the subclavian vein. More specific factors, such as muscle hypertrophy, have additionally been registered in athletes. The case focuses on a 20-year-old male student in medicine, with an intense training activity in bodybuilding. The subject has presented symptoms of upper limb edema. He has also reported heaviness and paresthesia in the left arm and hand. Varicose dilation of a superficial vein close to the axillary fossa was visible at naked eye. Both Doppler ultrasound evaluation and angio Computed Tomography (CT) were negative for venous thrombosis and/or complete obstruction from external compression. These reports depict an uncommon clinical scenario, which correlates an intense upper body training activity, with the presence of a second valve distally of the first valve into the subclavian vein.

Correspondence: Giulia Baldazzi, School of Vascular Surgery, University of Ferrara, via A. Moro 8, Ferrara, 44124, Italy.
Tel. +393405722686.
E-mail: giulia01.baldazzi@edu.unife.it.

Key words: Venous Thoracic Outlet Syndrome, subclavian vein, subclavian valve, ultrasound M-mode, sport medicine.

Contributions: AP, GB, contributed to the study conception; AP, RR, MB, GB, contributed to data collection; AP, GB, contributed to writing original draft; EM, GB, contributed to review and editing; EM contributed to supervision. All authors contributed to the critical review and revision. All the authors made a substantive intellectual contribution. All the authors have read and approved the final version of the manuscript and agreed to be held accountable for all aspects of the work.

Conflict of interest: the authors declare no potential conflict of interest.

Funding: none.

Availability of data and materials: all data generated or analyzed during this study are included in this published article.

Received: 24 August 2023.
Accepted: 22 September 2023.
Early view: 27 September 2023.


*Veins and Lymphatics 2023; 12:11673*
*doi:10.4081/vl.2023.11673*



## Introduction

Thoracic Outlet Syndrome (TOS) is a condition resulting from compression of the neurovascular structures traversing the thoracic outlet. The syndrome may be classified in three types, depending on the symptoms and signs of neurovascular compression: Neurogenic TOS (nTOS) results from brachial plexus compression, Venous TOS (vTOS) results from subclavian vein compression, and Arterial TOS (aTOS) results from subclavian artery compression.[1]

In some cases, patients may present with "combined TOS", the simultaneous compression of vascular and neurological structures. This may be mixture of arterial and venous or arterial/venous and neurological or all three.[2]

Venous Thoracic Outlet Syndrome (vTOS) can be defined as hemodynamically significant extrinsic compression and impingement of the subclavian vein as it passes through the thoracic outlet.[3]

This anatomical area is subdivided into three potential compression sites for the neurovascular bundle:

- The interscalene triangle
- The costo-clavicular space containing the brachial plexus and the subclavian vessels
- The sub-coracoid space containing the axillary vessels and the brachial plexus[4]

Numerous causes have been cited in the literature, ranging from congenital abnormalities to traumatic in origin.[2] Traumatic bony lesions include bone remodeling after fractures of the clavicle or first rib or posterior subluxation of the acromioclavicular joint. Soft tissue pathologies, such as anterior scalene muscle hypertrophy, muscle fiber type adaptive transformation, spasm, and excessive contraction, particularly post cervical trauma, have all been implicated in TOS.[2]

In athletes, more specific factors, such as muscle hypertrophy, especially of the pectoralis minor, have been registered, inducing the compression of the adjacent neurovascular bundle. This hypothesis is sustained by the frequent observation of muscle hypertrophy during TOS surgical procedures.[5] Moreover, in the population considered by Farrar *et al*., about 60% to 80% of the young patients report exercise and activity involving the extremities, such as overhead throwing, swimming, wrestling, gymnastics, or other activities that may require sustained and forceful upper extremity motion. The pathogenesis of an effort

thrombosis involves a repetitive extrinsic compression of the subclavian vein that occurs with the shoulder in an abducted and externally rotated position. This repetitive motion can result in selective muscle hypertrophy. According to Garraud *et al*., a specific example is the hypertrophy of the scalene muscles, which can be seen often in weightlifters. Additionally, the clavicle and costoclavicular ligament are anatomical landmarks that, in association with the surrounding hypertrophied muscles (anterior scalene, subclavius, and pectoral muscles), can lead to a fibrous stenosis of the subclavian vein at the level of the first rib.[6]

Moreover, venous compression and flow impairment may lead to a further complicated clinical picture, namely Paget-Schroetter Syndrome (PSS), consisting of a deep vein thrombosis causing a potentially life-threating condition. The latter particularly strikes the athletes. Of the 123 cases of PSS identified by Keller *et al*., baseball and weightlifting had the highest incidence (26.8% and 19%, respectively), followed by swimming, football, and basketball.[7,8]

## Case Report

The case focuses on a 20-year-old male student in medicine, with an intense training activity in bodybuilding. He presented symptoms of upper limbs edema, and also reported heaviness and paresthesia in the left arm and hand.

Upon physical examination, the muscular hypertrophy of the upper body has been registered as evident, especially concerning pectoral muscles, deltoid muscles, trapezius muscles, scalene muscles, biceps brachii muscle, and triceps brachii muscle. Such evidence suggests that our patient's training is focused on strength and hypertrophy, therefore including a heavy weightlifting program. This methodology of training involves few repetitions at high loads, and it is known from Hackett *et al*. that a brief Valsalva Maneuver (VM) is unavoidable when lifting heavy loads (>80% of maximal voluntary contraction).[9]

A physical examination confirmed edema, with evidence of superficial vein dilation in the left arm and a visible stria rubra close to the axilla (Figure 1). The subject then underwent a color Doppler examination showing the patency of the left jugular, subclavian, axillary, and basilic encephalic veins.

During the exam, the medical staff performed a Doppler flow assessment in a resting state, and during the Adson's test, in order to evaluate absence, bi-directional or turbulent flow.

The non-detectable flow in subclavian vein during Adson's maneuver with the flow recovery, phasing with breathing, immediately after the release of the posture, suggested a functional compression from muscular hypertrophy.

In addition, the point of compression corresponds to a significant change in diameter (Figure 2) and to the B-mode and M-mode (Figure 3) detection of a bicuspid valve in the dilated segment.[10] Further investigation has been subsequently carried out by means of angio Computed Tomography (CT) scan of the vTOS. The latter confirmed a muscular compression of the subclavian vein at a distance of 30 mm from the venous angle, with a dilation corresponding to the valve detected by the means of ultrasound.

The absence of thrombosis and/or venous obstruction from external compression cannot explain the collateral varicose superficial veins, as well as post-training upper extremity edema.

## Hypothesis

In more than 97% of human beings, the subclavian vein flow is regulated by just one valve, located very close to the so-called venous angle. In the reported case, this valve was present, but the ultrasound exploration has shown the presence of a second valve, located 30 mm more distally in relation to the main valve (Figure 3).

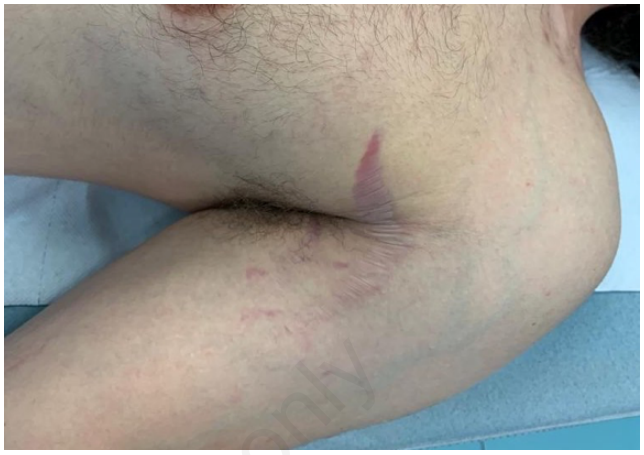

**Figure 1.** Left axilla *Stria rubra.*

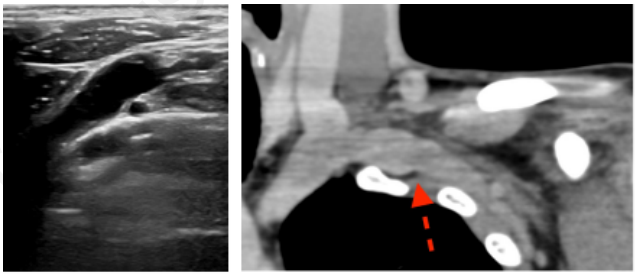

**Figure 2.** Left: high-resolution ultrasound image of the change in diameter of the right subclavian vein. Right: corresponding Magnetic Resonance (MR) image (red arrow).

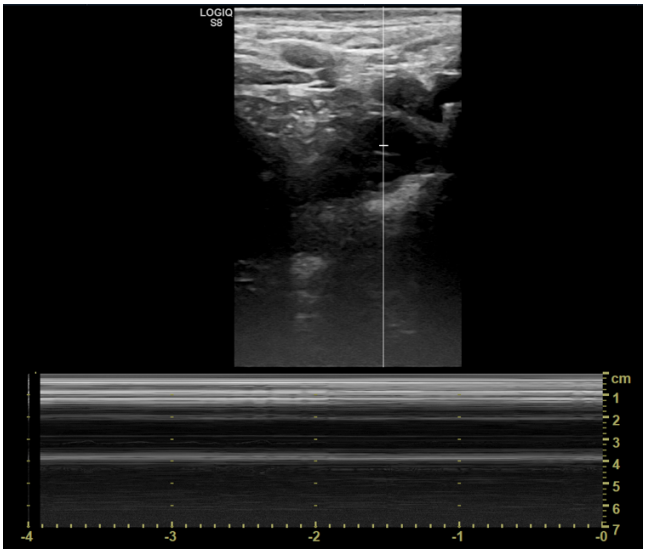


**Figure 3.** M-mode intra-luminal trace of the right distal subclavian valve (S2).

Taking into consideration the repeated Valsalva maneuver during the training, the transmission of a wave of hyper-pressure along the subclavian axillary segments seems plausible,[11] with a hyper-pressure chamber between the two valves.

Contralaterally, just one valve in the same subclavian vein has been found out. Despite the same training condition and muscular hypertrophy, neither edema nor superficial vein dilation were present, corroborating our pathophysiologic hypothesis.

In their explorative morphologic study, Celepci *et al.* determined the frequency and position of the valves in the axillary and subclavian vein. The "first" valve was present in all 30 left subclavian veins observed within 2.5 to 27.5 mm distally of the venous angle. Only in one of these veins (3.3%) a "second" valve could be identified, at a distance of 30.5 mm to the venous angle.[12]

The presence of both valves[13] (referring to the Celepci *et al*. Study sections called S1 and S2) in the patient, as well as the repeated Valsalva maneuver during his training, led us to advance the following hypothesis. The increased pressure between the two valves in consequence of Valsalva could cause a hyper-pressure chamber during exercise. Along time this mechanism of stop flow and increased lateral pressure might favorite the development of a collateral circle readily visible as superficial varicosities (Figure 1).

The lower frequency of vTOS versus nTOS has evidently emerged in studying the epidemiology of the TOS. According to Davidovic *et al*. (2003), 98% of all patients with TOS fall into the nTOS category, and only 2% have vTOS.[14] Vascular TOS is known to be usually caused by a structural lesion, either a cervical rib or another bony anomaly (Rayan, 1998), but no one has investigated the correlation between vein morphology and the development of venous symptoms.[15] The low frequency of venous symptoms could be correlated with the presence in the 3.3% of the population of a secondary valve that could modify, if exposed to high pressure, and constrained by other anatomical structures, the correct blood flow. Additionally, the hypothesis of repeated Valsalva maneuver suggested that the vessel is subject to internal high-pressure stress and constrained by the hypertrophic muscles. However, the lack of studies on the morphology of this vessel shall limit the hypothesis at this stage, as further research would be needed in order to investigate the pathophysiology of this event.

## Conclusions

Our hypothesis has led to explaining cases of edema in athletes with a functional mechanism, such edema not being linked to venous thrombosis or obstruction alone but, sometimes, to an anatomical variation of the position of the valves in the subclavian vein. In the light of results, further investigation on the presence of a second valve in these cases by the means of ultrasound is highly encouraged.

## References

1. Sidawy AN, Perler BA. Rutherford's Vascular Surgery and Endovascular Therapy. Elsevier, Amsterdam, The Netherlands. 2018. 2832 pp.
2. Watson LA, Pizzari T, Balster S. Thoracic outlet syndrome part 1: clinical manifestations, differentiation and treatment pathways. Man Ther. 2009;14:586-95.
3. Modi BP, Chewning R, Kumar R. Venous thoracic outlet syndrome and Paget-Schroetter Syndrome. Semin Pediatr Surg. 2021;30:151125.
4. Li N, Dierks G, Vervaeke HE, et al. Thoracic Outlet Syndrome: a Narrative Review. J Clin Med. 2021;10:962.
5. Garraud T, Pomares G, Daley P, et al. Thoracic Outlet Syndrome in Sport: a Systematic Review. Front Physiol. 2022;13:838014
6. Farrar TA, Rankin G, Chatfield M. Venous thoracic outlet syndrome: approach to diagnosis and treatment with focus on affected athletes. Curr Sports Med Rep. 2014;13:81-5.
7. Zell L, Kindermann W, Marschall F, et al. Paget-Schroetter Syndrome in sports ac-tivities - case study and literature review. Angiology. 2001;52:337-42.
8. Keller RE, Croswell DP, Medina GIS, et al. Paget-Schroetter Syndrome in athletes: a comprehensive and systematic review. J Shoulder Elbow Surg. 2020;29:2417-25.
9. Hackett DA, Chow CM. The Valsalva maneuver: its effect on intra-abdominal pressure and safety issues during resistance exercise. J Strength Cond Res. 2013;27:2338-45.
10. Mohammed NY, Di Domenico G, Sisini F, et al. Mechanical function of internal jugular vein valve: post analysis of M-mode imaging under cardiac monitoring. Veins and Lymphatics. 2019;8:8379.
11. Zamboni P, Tavoni V, Sisini F, et al. Venous compliance and clinical implications. Veins and Lymphatics. 2018;7:7367.
12. Mohammed NY, Di Domenico G, Sisini F, et al. Mechanical function of internal jugular vein valve: post analysis of M-mode imaging under cardiac monitoring. Veins and Lymphatics. 2019;8:8432.
13. Celepci H, Brenner E. Position of valves within the subclavian and axillary veins. J Vasc Surg. 2011;54:70S-6S.
14. Davidovic LB, Kostic DM, Jakovljevic NS, et al. Vascular thoracic outlet syndrome. World J Surg. 2003;27:545-50.
15. Rayan GM. Thoracic outlet syndrome. J Shoulder Elbow Surg. 1998;7:440-51.