

Thoracic Outlet Syndrome Revisited: Clinical Relevance of Vertebral artery Morphology

I would like to share my thoughts on the clinical morphology of the Vertebral Artery (VA) in relation to Thoracic Outlet Syndrome (TOS), with potential relevance for chiropractors.

My focus is on the clinical morphology of the human vertebral arteries (VAs). While describing the topography of the prevertebral and cervical parts of the vertebral artery, I encountered literature reporting possible extrinsic compression of the vertebral artery caused by cervical spondylotic spurs, C7–C8 transverse processes, fibrous bands, and displacement of the vertebral artery by tumors of the C7–C8 nerve roots.^{1–5} This compression may lead not only to symptoms of vertebrobasilar insufficiency but also to disruption of blood circulation within the sheaths of the brachial plexus nerves, resulting in a set of symptoms similar to those seen in thoracic outlet syndrome.

My questions are as follows:

1. What is “classical” thoracic outlet syndrome (TOS)?
2. How is TOS interpreted and classified?
3. Can compression of the extracranial part of the vertebral artery produce or mimic TOS?
4. How important is it for the chiropractors to recognize, understand and correctly interpret symptoms related to possible pathology of the extracranial part of the vertebral artery, and to differentiate these from “classical” or typical TOS?

To address these questions, I reviewed definitions, terminology, and classification systems related to the clinical thoracic outlet and thoracic outlet syndrome.

Terminology

The vertebral arteries (VAs) typically originate from the subclavian arteries at or just above **the superior thoracic aperture**, also referred to as **the thoracic inlet** in anatomical terminology and the **thoracic outlet** in clinical terminology.⁶

Reminder – boundaries of the superior thoracic aperture:

Posteriorly, by the body of the T1 vertebra;
Laterally, by the first pair of ribs and their costal cartilages;
Anteriorly, by the superior border of the manubrium sterni.

According to anatomists, as defined in *Terminologia Anatomica* (International Anatomical Terminology), the superior thoracic aperture is termed the **thoracic inlet**, as air and food may enter the thorax only through this opening.⁷

In contrast, clinicians refer to the superior thoracic aperture as the **thoracic outlet**, emphasizing the passage of the subclavian vessels and the C8 - T1 spinal nerves as they emerge from the thorax to enter the neck.

Thus the **thoracic outlet space** (clinical term) corresponds anatomically to the **superior thoracic aperture or thoracic inlet**. These clinical versus anatomical terminological differences, although referring to the same anatomical structure, should be emphasized from the first year of anatomy education to facilitate proper understanding of the term **thoracic outlet syndrome**.

Sites of Compression:

There is considerable confusion in the literature regarding the terminology of specific anatomical regions associated with pathological compression of neural and vascular structures, as not all of these regions are directly related to the clinical thoracic outlet.⁸

Notably, the **upper part of the scalene triangle** is sometimes referred as the **cervical outlet**, where the C5-C7 roots of the brachial plexus may be affected. In contrast, the **lower part of the scalene triangle** is referred as the **thoracic outlet**, where the C8-T1 roots of the brachial plexus and the subclavian artery may be involved.

Scalene triangle:

A triangular space formed between the anterior and middle scalene muscles, with its inferior boundary formed by the superior surface of the first rib. The roots and the trunks of the brachial plexus, as well as the third part of the subclavian artery, pass through this triangle.

Costoclavicular space:

Bounded superiorly by the clavicle; inferiorly by the first rib and its costal cartilage; and anteriorly and medially by the subclavius muscle and the costoclavicular ligament. Structures that may be compressed in this space include the subclavian vein, subclavian artery, and divisions of the brachial plexus.

Pectoralis minor space:

Bounded superiorly by the pectoralis minor muscle and the coracoid process, and inferiorly by the thoracic cage. The axillary artery and the cords of the brachial plexus traverse this space and may be subject to compression.

What is Thoracic Outlet Syndrome?

A **syndrome** is defined as a set of **symptoms** that tend to occur together and characterize a particular medical condition. In the case of **thoracic outlet syndrome (TOS)**, it refers to a collection of symptoms-such as pain, numbness, paresthesias, weakness, and functional impairment of the upper limb resulting from compression of neurovascular structures.⁹

These symptoms arise from underlying disorders (e.g., muscle tightness, trauma) or anatomical abnormalities (e.g., cervical rib, subclavius posticus muscle) that compress elements of the brachial plexus and/or the subclavian vessels (subclavian artery, subclavian vein) within specific anatomical regions.¹⁰

The term **thoracic outlet syndrome** and its formal definition were first introduced by **Peet, Henriksen, Anderson, and Martin in 1956** to describe compression of the neurovascular structures (brachial plexus, subclavian artery, or subclavian vein) as they

pas through the clinical thoracic outlet. This work established the modern conceptual foundation of TOS.¹¹

Between the **1960s and 1980s**, the concept of TOS expanded to include multiple potential sites of compression namely:

1. The **scalene triangle (interscalene space)**
2. The **Costoclavicular space**
3. The **Pectoralis minor (subcoracoid) space**

Modern Classification (1990 - Present)

The modern and widely accepted classification of thoracic outlet syndrome was formally standardized by the **Society for Vascular Surgery (SVS) in 2016**.¹²

This classification system provides reporting standards for the diagnosis and management of TOS and remains the current framework:

Classification of Thoracic Outlet Syndrome

The thoracic outlet syndrome is classified into three main types:

1. **Neurogenic TOS (nTOS)**
Accounts for approximately 90-95% of cases and results from compression of the **brachial plexus**.
2. **Venous TOS (vTOS)**
Results from compression of the **subclavian vein** and includes **Paget-Schrotter syndrome**, a form of upper-extremity deep vein thrombosis (DVT), also referred to as *effort thrombosis*. This condition typically affects young, physically active individuals and is associated with repetitive or strenuous arm movements that compress the vein between the clavicle and the first rib. Clinical features include upper limb pain, swelling, and venous distension. Prompt diagnosis is essential, as management commonly involves anticoagulation and, in selected cases, surgical decompression to relieve the underlying compression.
3. **Arterial TOS (aTOS)**
Caused by compression of the **subclavian artery**, often associated with structural abnormalities such as cervical ribs or anomalous fibrous bands.

Multifactorial Etiology of TOS

Thoracic Outlet Syndrome (TOS) has a **multifactorial etiology**, including congenital anatomical anomalies, postural and functional factors, trauma, repetitive occupational activities, and rarely, space-occupying lesions.¹²

1. Congenital (Anatomical) Factors

Present at birth and predispose to compression:

- Cervical rib
- Elongated C7 transverse process
- Fibrous bands
- Congenital muscle anomalies (e.g., scalene muscle hypertrophy or abnormal insertion)

- Narrow thoracic outlet
- Anomalous first rib or clavicle

2. Acquired (Postural & Functional) Factors

Develop over time and increase susceptibility to compression:

- **Poor posture**
 - Forward head posture
 - Rounded shoulders
- Drooping shoulders
- **Muscle imbalance**
 - Tight scalene, pectoralis minor
 - Weak deep neck flexors, scapular stabilizers
- **Repetitive overhead activity**
 - Common in athletes and manual workers

3. Traumatic Factors

Lead to structural and soft-tissue changes and may cause compression

- Whiplash injury
- Clavicle or first rib fractures
- Shoulder girdle trauma
- Post-surgical scarring

4. Occupational & Activity-Related Factors

Increase functional narrowing of the thoracic outlet:

- Repetitive arm elevation
- Heavy lifting
- Prolonged static postures (e.g., computer work)
- Exposure to vibration

5. Space-Occupying Lesions (Rare)

Direct compression of neurovascular structures may result from:

- Tumors
- Callus formation after fracture
- Enlarged lymph nodes

6. Physiological & Demographic Factors

Contribute to susceptibility and symptoms manifestation:

- Female sex (more common)
- Rapid weight loss (loss of shoulder support)
- Large breasts (added load on the shoulder girdle)
- Pregnancy (postural and ligamentous changes)

Conclusion

I initiated this topic to highlight the clinical relevance of thoracic outlet syndrome in relation to vertebral artery morphology, an area that may be underrecognized in chiropractic practice.

The Vertebral Arteries are the principal segmental arteries supplying the cervical spinal cord and the cervical spinal nerves, including the roots of the brachial plexus. Consequently, pathology affecting the vertebral arteries may result in insufficient blood supply to the sheath of the brachial plexus nerves. Such vascular compromise may produce symptoms resembling neurogenic thoracic outlet syndrome, most commonly presenting with pain, numbness, tingling, weakness, and vasomotor changes in the upper extremity.

Recognizing the potential contribution of extracranial part of the vertebral artery pathology to TOS-like presentations is therefore important for accurate clinical assessment, differential diagnosis, and safe patient management.

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