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Review Paper

Conservative Strategies for Optimal Management of the Neurogenic Thoracic Outlet Syndrome: A Narrative Overview

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ABSTRACT

Thoracic outlet syndrome (TOS) is a well-known compressive neurovasculopathy with various anatomical etiologies. Neurogenic TOS (nTOS) is the most common type of this syndrome, accounting for over 95% of all cases. Conservative treatment plays a significant role in the management of nTOS. However, there are many controversies regarding this theme. Therefore, the optimal treatment method remains unclear. Herein, a narrative review was conducted to gather recent data on the available conservative treatment methods for the management of nTOS.

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Introduction

Thoracic outlet syndrome (TOS) is a complex anatomical condition characterized by compression or irritation of nerves or blood vessels between the clavicle and first rib [1, 2]. The incidence remains elusive owing to its often misdiagnosed nature, particularly in patients with upper extremity pain and paresthesia. TOS is predominantly observed in patients aged between 20 and 50 years and is more prevalent among women, possibly due to a higher incidence of cervical ribs. The pathogenesis of TOS usually involves a combination of developmental, anatomical anomalies, positional deformities, extraordinary and repetitive physical activities, and previous traumatic events. Neck trauma often triggers symptoms in individuals [3]. There are three principal types of TOS, classified based on the affected neurovascular structures: Neurogenic TOS (nTOS), venous TOS (vTOS), and arterial TOS (aTOS). Among these, nTOS is the most common, accounting for >95% of all cases [1, 4].

The initial assessment of a patient with TOS involves a thorough evaluation of the patient's posture, alignment, and movement patterns [5]. It is necessary to examine both upper extremities for evidence of muscle atrophy, ulcerations, discoloration, or nail bed deformities. Evaluation of blood pressure and Allen's test results were essential. Moreover, examination of the cervical spine, scapular positioning, and clavicle should be considered. Range of motion and strength testing of all joints from the wrist to the shoulder should be examined and documented. A classic finding in nTOS is the Gilliatt-Sumner hand, defined as atrophy of the hypothenar, abductor pollicis brevis, and interosseous muscles. More specific tests, such as the Adson test, supraclavicular pressure test, Wright test, and costoclavicular maneuver, could help diagnose and evaluate TOS. The focus is detecting impairments potentially exacerbating brachial plexus compression [6].

The complex nature of TOS presents a challenge for healthcare providers, particularly surgeons. Management is particularly challenging in a subgroup of nTOS patients without electrodiagnostic abnormalities or bone deformities known as disputed nTOS. One study found no significant differences in long-term functional outcomes in patients with disputed nTOS who underwent surgery compared to those who received nonoperative therapy [7]. This study assessed symptom level, disease progression, return to work, and long-term medication requirements. Before deciding on surgery, patients usually undergo conservative treatment for at least 6-months. As reported in a series, 60% of patients with neurogenic TOS were symptom-free following 6-months of physical therapy [8]. Other studies reported a success rate between 59% and 88% for conservative treatment, including the combination of physical therapy with massage, acupuncture, NSAIDs, and muscle relaxants in patients with symptomatic TOS [9]. Obesity, prior trauma, chronicity, and severity of symptoms negatively affect the outcomes of conservative treatment for TOS [10]. Concomitant psychological disorders can negatively affect the outcomes of both conservative and surgical therapies [11]. Surgical decompression is considered the last resort in cases of failure of conservative treatment or patients with disabilities [10, 12, 13].

First, the patient and therapist must identify the activities and positions that exacerbate and relieve symptoms. The initial approach for conservative management involves improving the flexibility of associated soft tissues and correcting poor posture and scapular dyskinesis [5]. In addition, prescription of muscle relaxants, nonsteroidal anti-inflammatory, and non-narcotic agents could be effective [14]. Patients are educated on the positions and postures causing pressure on the brachial plexus and distal sites at the carpal and cubital tunnels. The goal of postural correction is to decompress the thoracic outlet by restoring muscle balance, strengthening the muscles that open the thoracic outlet (such as the trapezius and sternocleidomastoid), and stretching the muscles that close the outlet (such as the scalene muscles) [14]. Aerobic exercises can help strengthen the accessory inspiratory muscles, resolve muscle imbalance, and reduce weight. Physiotherapy is a preferred initial treatment for almost all patients with nTOS [5, 15]. However, the treatment's success depends on the knowledge and experience of the physiotherapist since TOS requires a different management approach than other neck, shoulder, and upper extremity disorders. Furthermore, patient compliance with a home exercise program and behavioral modifications at home and work are critical for successful conservative management [10]. Once initial improvements are noticeable, subsequent efforts focus on increasing activity levels. Although the conservative management protocol for TOS seems straightforward, no consensus exists regarding which muscles should be strengthened or stretched. This narrative review article aims to discuss all non-invasive treatment methods. Although many treatment options are available for TOS, the optimal treatment regimen remains unclear. First-line therapy is conservative and usually consists of a combination of physiotherapy and pharmacological treatment.

Manual therapy

Manual therapy and deep massage are beneficial for improving the flexibility of involved soft tissues. It can effectively restore the appropriate length of musculoskeletal units and proper body posture [13], increase the diameter of associated spaces, and subsequently decrease the compression of the neurovascular bundles. The manual therapy protocol included mobilization of the cervical spine, first rib, acromioclavicular, sternoclavicular, and scapulothoracic joints. Furthermore, deep massage and stretching of the pectoral and scalene muscles are beneficial [16]. However, some studies have reported that manual therapies can provoke neurovascular bundles and deteriorate symptoms [17].

Physical therapy

Physical therapy for the treatment of TOS is challenging for 2 reasons. The first is the lack of sufficient experience due to the small number of diagnosed patients, especially in cases of associated pathologies. Second, the prolonged duration of rehabilitation is 4-6 months [5]. Consequently, monitoring patients, mainly when they have low compliance, is challenging. Regarding TOS rehabilitation, three essential elements improved the results. First, repeated motions that compress the costoclavicular area or overstress the brachial plexus, including shoulder abduction, while extending the elbow and wrist. Second, the scalene, sternocleidomastoid, upper and middle trapezius, and deltoid muscles, which are parts of the dorsocervical and parascapular muscles, should not be strengthened. The final step was to avoid pain triggers [5]. Ten steps constitute the standard rehabilitation approach for treating TOS [18, 19]:

1. Heat and electrotherapy (trans-epidermal nerve stimulation [TENS]) to the painful muscles of the entire dorsal cervical region and shoulder while the patient lies on the back.

2. Instruction in abdominal-diaphragmatic respiration in standing, sitting, and lying.

3. Prolonged manual massage of the shoulders and the entire dorsal cervical region.

4. Achieving appropriate amplitudes in the acromioclavicular, sterno-costo-clavicular, omo-thoracic, cervical, and dorsal joints. The initial five ribs are mobilized. If required, osteopathic joint release is performed.

5. The scalene, sternocleidomastoid, pectoral, upper and middle trapezius, shoulder stabilizers, and paravertebral muscles are stretched.

6. Passive and active neurodynamic methods are used while steering clear of amplitudes that cause discomfort. The brachial plexus is stretched in seven consecutive periods using proximal and distal neuro-slip techniques sporadically to allow for nerve traction.

7. Spinal posture correction and proprioceptive rehabilitation.

8. Instruction in good posture. Repetitive shoulder abduction and retropulsion were avoided. The elbow should be closed to the body throughout the shoulder range of motion.

9. Muscle strengthening should be avoided, except for muscles that open the costoclavicular interspace, including the paravertebral, serratus, and pectoralis minor muscles. The patient should not sense trigger pain or dysesthesia with these active exercises.

10. Other beneficial methods can also be used. These techniques include Mézières-type global stretching, temporomandibular rehabilitation, application of suction cups or magnets to painful muscles, manual therapies, sophrology, and yoga.

Rehabilitation sessions were started at a frequency of 2-3 per week. In the maintenance phase, the sessions are repeated every 15 days. Although rehabilitation programs usually include 30 to 40 sessions, severe cases may require more sessions [13, 20].

According to a retrospective study, an intensive, multidisciplinary, hospital-based rehabilitation program can be effective in patients with symptomatic TOS even after a failed private practice physiotherapy course [19, 21].

Home exercises

After the patients' postural alignment has been evaluated, a home exercise regimen should be implemented. Two of the most prevalent postural abnormalities in individuals of all ages are forward head posture and protracted shoulders (PSs) [22]. A PS is a forward displacement of the acromion about the seventh cervical vertebral process that can be measured using the shoulder angle [23]. It is often accompanied by an elongated, forward, and inwardly rotated shoulder blade and tension in the pectoralis minor muscle. Stretching the shortened upper trape-

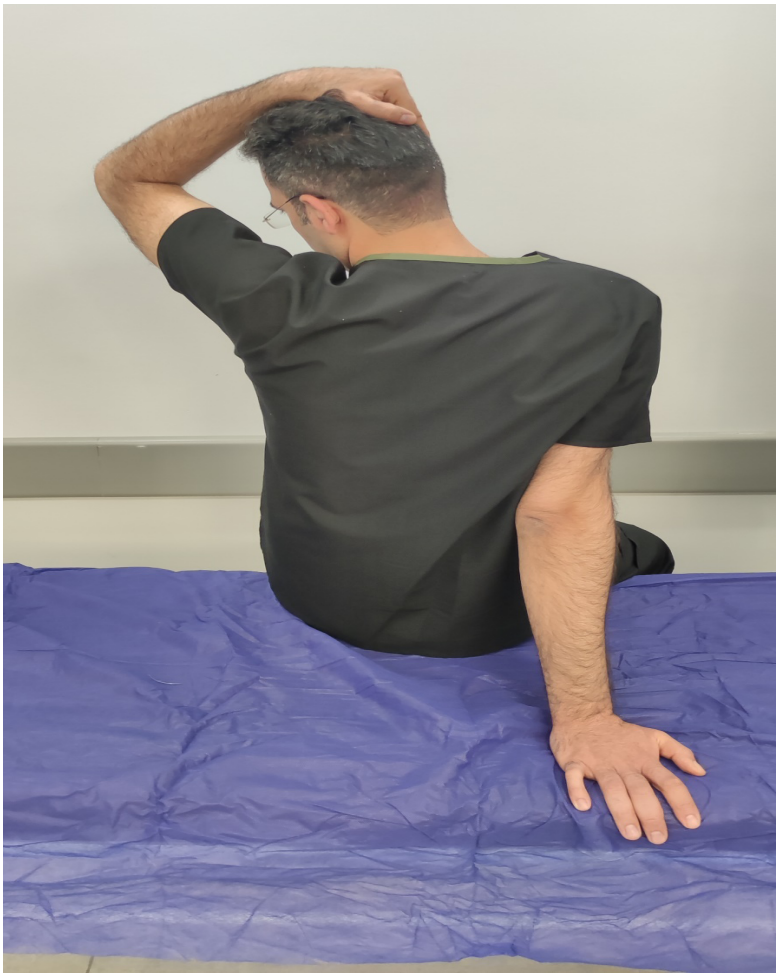

Figure 1. Stretching of pectoralis minor, levator scapula, and slightly upper trapezius

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zius, sternocleidomastoid, and levator scapulae muscles and strengthening the deep neck flexors are effective in correcting the forward posture of the head. At the same time, PS treatment is usually based on strengthening the stabilizers of the scapula and rotator cuff muscles and stretching the anterior muscles, namely the pectoralis minor (Figure 1). In a vertical sitting position, the arm on the affected side was turned outwards and abducted to 90°. This mainly stretches the pectoralis minor. Simultaneously, rotating the neck down towards the ceiling to a slight stretch, applying gentle pressure, and assisting with lateral flexion and rotation of the neck will help to stretch other muscles such as the levator scapula and upper trapezius. All exercises were performed on both sides.

The exercises should start with stretching tight muscles for at least 4-6 months, followed by strengthening exercises of the inhibited muscles. The training protocol consists of at least three stretching exercises, including static stretching with a 30-second hold for two sets for 4-6 weeks (stretching exercises figures). Daily muscle stretching is the best treatment. When the pain gradually decreases and the length of the short muscles improves slightly, strengthening exercises should be started.

The deep flexor muscles of the neck, particularly the longus colli and longus capitis, should be trained for endurance. This should be a low-impact exercise in which internal positions of craniocervical flexion are performed and held, explicitly activating the deep flexors of the neck and not the superficial flexors. This exercise started in the supine position (Figure 2) and progressed to the standing position (Figure 3). Strengthening training in three sets of 10 and 12 repetitions twice a week for at least 2-3 weakened muscle groups is additionally suggested. Stretching exercises should be performed during this phase.

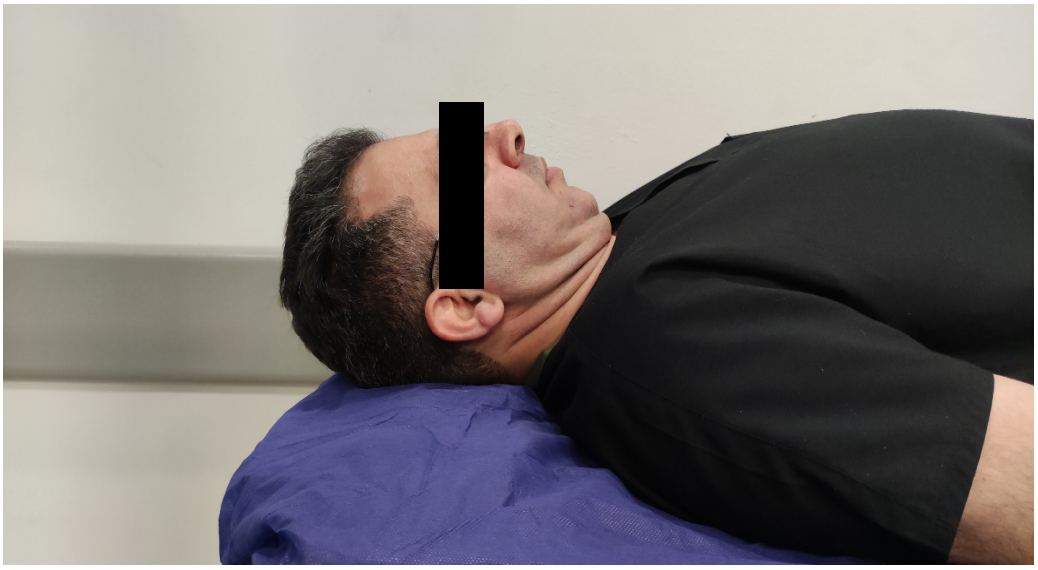

Figure 2. Chin tuck exercise, craniocervical flexion

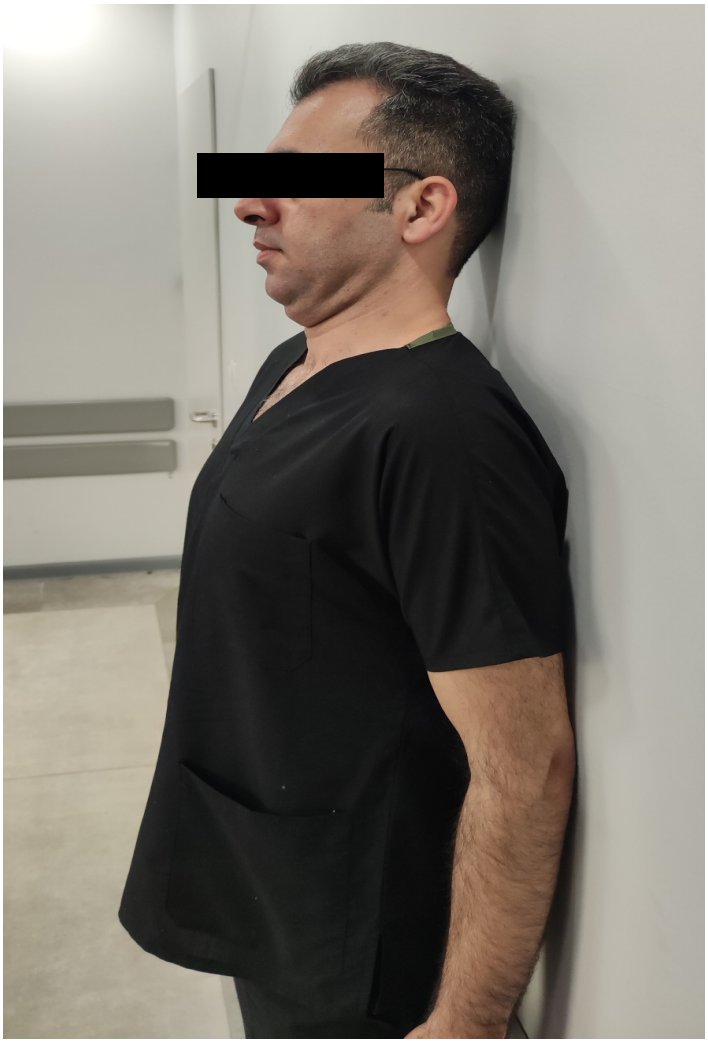

Figure 3. Standing position of chin tuck exercise

Therapeutic injection

The anterior or middle scalene muscles may compress neurovascular structures in the scalene triangle. Excessive compression of the neurovascular bundle can occur in the scalenus minimus. Anesthetic blockade of the scalene muscles produces temporary improvement in patients with TOS [24]. Steroid injections rarely result in substantial lasting relief. Botulinum toxin, which can induce muscle relaxation for up to 6 months, was previously proposed as an agent that may be used to produce longer-lasting effects similar to those of steroid injections [25, 26]. A 23-gauge Teflon needle was coated and bared at the tip under fluoroscopic guidance into the anterior scalene muscle using standard electromyographic equipment, and the muscle activity is monitored simultaneously. The anterior scalene muscle should be electromyographically identified by selective activation during lateral head tilt and inspiration. Patients with refractory symptoms may benefit from botulinum toxin type A (BTX-A), steroids, or anesthetics injections. Some studies have reported that BTX-A injections significantly reduce pain and symptoms in most patients with TOS [24, 27]. However, a randomized, controlled trial study showed no statistically significant improvement in pain or symptoms after BTX-A injection in patients with TOS. The chronicity of symptoms may result in a higher risk of central sensitization and, subsequently, a lower response to BTX-A injections [28]. On the other hand, some studies have shown that BTX-A injections lead to a significant reduction in pain and symptoms for up to 3 months in 64%–69% of TOS patients [29, 30]. Adequate response to BTX-A injection is a prognostic predictor of outcomes after surgical supraclavicular decompression with a success rate of 90% [31, 32]. In addition to BTX-A injections, utilization of other agents, including steroids and local anesthetics combined with physical therapies, effectively improves symptoms and functional outcomes [1, 8, 33]. The potential for a 20% incidence of dysphagia, however mild, as observed in previous studies of botulinum injection in cervical muscles, is expected to be minimized using electrophysiological fluoroscopic guidance during injection [34].

Dry needling

Sensational back pain arising from a muscular source not directly related to nerve compression has been reported in cases reported. Myofascial pain syndrome is usually associated with myofascial trigger points which are highly localized, hyperirritable spots in a palpable, taut band of skeletal muscle fibers. Trigger points should be examined as a source of complaints in patients with TOS [35]. Assuming that the complaints are reproduced by manual compression of these trigger points, an additional treatment method of dry needling concurrent with other methods should be suggested [36]. While the patient was seated, sterile 0.25×40 mm acupuncture needles were inserted into the skin over the palpated trigger points and advanced deep into the taut ligaments. Reproduction of pain or localized twitching is considered to be an appropriate needle position. The needles were left in situ for 10 minutes, rotated clockwise after the 10th minute, and left in situ for another 10 minutes. After a total of 20 minutes, the needles were removed [37]. Relevant trigger points, common in the infraspinatus, pectoralis minor, and teres minor, should be treated using fast-in and fast-out techniques with multiple rapid needle insertions [38]. The patient is seated in this technique, and sterile 22 G needles, 32 mm long, are inserted into the taut ligaments. The trigger points were needled by moving the needle back and forth eight to ten times at the same point, turning it clockwise, and then needling the surrounding muscle tissue by changing the angle of inclination of the needle. Reproduction of pain or local twitching is considered a suitable needle position [39]. However, gentle coning until a local twitch response is achieved has been previously reported [36]. All treatment protocols were performed three weekly sessions for at least three weeks [40].

Orthoses and braces

Previous studies have shown that passive elevation and retraction of the shoulder can help reduce pain and paresthesia in patients with moderate-to-severe symptoms [41, 42]. Ortaç et al. reported the effectiveness of kinesio-taping (KT) in improving pain, paresthesia, and functional outcomes in patients with symptomatic TOS. With a mechanism similar to KT, night splints and orthoses combined with a physical therapy program can be beneficial [41].

Patient education and behavior modification

Patients must clearly understand the mechanisms and postures that lead to provocation of the symptoms [43]. Patient should also be educated in positions that relieve symptoms during acute exacerbations [43]. For example, passive shoulder elevation or resting the affected arm on the armrest of a chair or pillow for 30 minutes could relieve symptoms during acute exacerbation. Modifying sleep habits is also crucial, especially in patients with increased nocturnal paresthesia and discomfort. Changing the sleeping side of the bed can resolve this problem. The patient should maintain the affected arm in a neutral

position and not place it in a hyperabduction position using an extra pillow during sleep. Patients must avoid intensive aerobic activities. These activities lead to exertional breathing and subsequently increase activity of the scalene muscles [19].

The shoulder strap of an automobile seatbelt can lead to excessive compression of the thoracic outlet. The patient could diminish this pressure by adding padding to the strap. Female patients should wear strapless bras or apply extra padding to shoulder straps to decrease pressure. Heavy objects, especially handbags or backpacks, may increase depression of the affected shoulder and cause excessive traction on neurovascular structures. Accordingly, carrying heavy objects with an affected arm should be avoided.

Conclusion

Early detection and appropriate individualized treatment are crucial in managing patients with nTOS, although this is often difficult due to the non-specific symptoms at initial presentation. Conservative therapy remains the first-line treatment and usually consists of a combination of physiotherapy and exercise rehabilitation. Injection therapy and dry needling can also help control pain. Surgical intervention is considered only when conservative therapy fails.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

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Authors' contributions

Conceptualization and methodology: Niki Tadayon; Investigation, resources, data curation, software, validation, and formal analysis: Azadeh Hakakzadeh; Visualization, supervision, project administration, and funding acquisition: Seyed Mohammad Reza Kalantar-Motamedi; Writing the original draft: Farsad Biglari; Review and editing: Meisam Jafari Kafiabadi.

Conflict of interest

The authors declared no conflict of interest.

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