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When Healing Hands Hurt: Epidemiology of Thoracic Outlet Syndrome Among Physicians

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Background: Thoracic outlet syndrome (TOS) is an infrequent condition which results in disability in use of upper extremity. While TOS is often associated with manual labor, industrial workers, and accidents, it has not been reported in a physician (MD) population. Given the investment of time and effort in training to become a MD, the impact of TOS may be devastating. Our objective is to report the presentation and outcome of TOS in MDs.

Methods: A prospectively surgical database was reviewed for MDs who sought care of disabling TOS between 1997 and 2022. Demographic, clinical, outcome and pathological data were reviewed. Outcomes were assessed based on Somatic Pain Scale (SPS), Quick Disabilities of Arm, Shoulder and Hand (DASH) scores, and Derkash scores. Results were also assessed based on return to employment.

Results: A total of 19 MDs were identified, from 1,687 TOS cases. The group included 13 (63%) men, 6 (31%) women, average age 45 years (range 27−57). Presentations included 1 (5.3%) arterial TOS (ATOS), 9 (47.4%) venous TOS (VTOS), and 9 (47.4) neurogenic TOS (NTOS). All patients were right-handed, and symptomatic side was dominant hand in 7 (37%) patients. Etiologies included repetitive motion injury, athletic injury, and congenital bony abnormalities. Repetitive motion was associated with 3/9 (33%) NTOS. Significant athletic activities were noted in 12 of 19 (63%) MDs, including 8/9 (89%) VTOS and 4/9 (44%) NTOS. Athletic activities associated with VTOS included triathletes (2), rock climbing (1), long distance swimming (2), and weightlifting (3). Of the 9 NTOS cases, 3 were associated with weightlifting and 1 with skiing. Congenital causes included 1 (5%) abnormal first rib and 1 (5%) cervical rib. Time from symptom onset to consultation varied significantly according to diagnosis: ATOS 6 days, VTOS 97 days, and NTOS 2,335 days ($P < 0.05$). All underwent first rib resection (FRR), and 4 (4) patients required contralateral FRR. Time from surgery to last follow-up averaged 1,005 days (range: 37−4,535 days). On presentation, 6 patients were work disabled and 13 patients were work restricted. Following surgery, 4 MDs remained work restricted with mild to moderate symptoms. After surgery, standardized outcomes (SPS, Quick DASH, and Derkash score) improved in all metrics. All who were initially disabled returned to work without restriction. Significant non-TOS related comorbidities were present in all who had residual restriction. Return to work was documented in all.

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Conclusions: Although it has not been reported, MDs are subject to developing TOS. Causes include repetitive motions, athletic injuries, and congenital bony abnormalities. Surgical decompression is beneficial with significant reduction in pain and disability. MDs are highly motivated and insightful; accordingly, they have a very high probability of successful work resumption, with all returning to their medical positions.

INTRODUCTION

Thoracic outlet syndrome (TOS) is the result of extrinsic compression of neurovascular structures as they cross over the first rib and enter the arm. The term, first used by Peete, describes a confluence of symptoms and exam findings which relate to 3 principal presentations: neurogenic TOS (NTOS), venous TOS (VTOS) and arterial TOS (ATOS).[1] Each of these presentations reflects the symptoms resulting from compression of the related structures: the brachial plexus, the subclavian vein, and the subclavian artery. The condition is infrequent, accounting for an incidence of approximately 1−3 per 100,000 population.[2] TOS presents with a spectrum of severity and, when more severe, may result in upper extremity disability or, in rare cases, the loss of the limb.

The most common etiologies reported for neurogenic TOS include motor vehicle accidents and repetitive motion industrial injuries.[3] VTOS is most often related to muscular hypertrophy as consequence of athletic activity,[2] and arterial TOS is frequently associated with congenital bony developments.[3]

While often associated with manual labor, industrial workers and accidents, TOS has not been reported in the physician (MD) population. MDs are not considered a group at high risk of developing TOS, however many of the activities required of practicing medicine may place them at risk. The implementation of Electronic Health Records requires increased repetitive motion activity which is a well-recognized cause of NTOS. Postural stress and repetitive motions required in the professional practice of surgical, procedural, and radiological treatment may place MDs at risk of developing TOS symptoms. Our objective is to report the presentation and outcome of TOS in MD patients who received surgical treatment for TOS at our center.

METHODS

A prospective surgical database was reviewed for MDs who required surgical care for disabling TOS between 1997 and 2022. Demographic, clinical, and pathological data were reviewed. The etiology of TOS was classified as repetitive motion injury, athletic injury, congenital, or unknown. Time invested in medical education and years of practice were collected. Details regarding surgical procedures, complications, and postoperative follow-up were recorded.

Diagnosis of TOS

Society for Vascular Surgery (SVS) reporting standards were used in the diagnosis of TOS.[4] NTOS diagnosis was based on symptoms of radicular pain, paresthesia, and weakness accompanied by physical exam findings consistent with the diagnosis of TOS. Diagnostic testing relied on a combination of cervical spine X-rays, cervical magnetic resonance imaging, nerve conduction testing, and anterior scalene muscle blocks. Initial treatment of NTOS was based on TOS specific physical therapy. Failing this, patients were offered treatment with Botox for chemodenervation or surgical decompression. Surgery was reserved for severe, intractable, and disabling symptoms.

VTOS cases were diagnosed based on symptom and findings of limb swelling, pain, and discoloration. The diagnosis was confirmed with ultrasonography and venography. Thrombolysis was routinely employed in the acute (within 2 weeks of symptom onset) presentation. Surgery was considered for patients with evidence of extrinsic venous compression and persistent congestive symptoms. Routine post rib resection venography was performed 2−3 weeks after surgery to assess surgical results and provide angioplasty as needed.

ATOS was diagnosed based on the history of acute onset of arterial ischemia with pain, loss of pulse, and weakness. The diagnosis was confirmed with ultrasonography and computed tomography angiography. Initial treatment was by intra-arterial thrombolysis. Post-thrombolysis imaging was used to confirm extrinsic compression of the subclavian artery. Following surgical decompression, ultrasonography was used to assess patency and presence of residual stenosis.

TOS decompression was achieved in all patients by means of transaxillary resection of first and/or cervical rib.[5−7] Postdecompression venography and ultrasonography were used to follow patients

Table I. Etiology of TOS as reported by physician patients

Etiology	Number	%
Athletic Injury		
Weight training	6	32%
Triathlete	2	11%
Swimming	2	11%
Rock climbing	1	5%
Skiing	1	5%
Repetitive Motion	3	16%
Anatomic		
Cervical rib	1	5%
Abnormal first rib	1	5%
Unknown	2	11%

Table II. Medical specialties

Specialty	*N*	%
Internal medicine	5	26.3%
Anesthesia	3	15.8%
Cardiology	1	5.3%
Dentistry	1	5.3%
Dermatology	1	5.3%
Gynecology oncology	1	5.3%
Maternal fetal medicine	1	5.3%
Otolaryngology	1	5.3%
Pediatrics	1	5.3%
Plastic surgery	1	5.3%
Psychiatry	1	5.3%
Pulmonary medicine	1	5.3%
Radiology	1	5.3%

with VTOS. ATOS patients were followed with ultrasonography. Postoperative visits were conducted at 2 weeks, 6 weeks, and then every 3 months until symptoms resolved.

Analysis of Outcomes

In keeping with SVS reporting standards, outcomes were assessed based on Somatic Pain Scale (SPS), Quick Disabilities of Arm, Shoulder and Hand (DASH) scores,[8] and Derkash scores.[9] Return to employment was recorded for all patients at all clinic visits. Approval for this work was granted by the University of California, Los Angeles (UCLA) Institutional Review Board.

Statistical Analysis

Categorical data were analyzed with chi squared test; continuous data were analyzed with Student's *t*-test. Repeated measures were analyzed using Man–Whitney test. Significance was assigned at $P < 0.05$.

RESULTS

Over the study period, 1,700 TOS operations were performed. Of these, a total of 22 MDs with TOS were evaluated and 19 required surgical decompression for TOS. The surgical group included 13 (63%) men, 6 (31%) women, with an average age of 45 years (range 27–57). Patient presentations included 1 (5.3%) ATOS, 9 (47.4%) VTOS, and 9 (47.4%) NTOS. All patients were right-handed. The dominant hand was the symptomatic side in 7 (37%) patients.

Etiologies of TOS included athletic injury, repetitive motion injury, and congenital bony abnormalities. Significant athletic activities were noted in 12 of 19 (63% of all patients) patients, including 8 of 9 (89%) VTOS and 4 of 9 (44%) NTOS. Of the venous presentations, 88% were associated with high-level athletic endeavors including triathletes (2), rock climbing (1), long distance swimming (2), and weightlifting (3). In the NTOS group, athletic injuries accounted for 4 (44%) of TOS patient presentations. Of the 9 NTOS cases, 3 were associated with weightlifting, and 1 with skiing (Table I).

The second most common cause of TOS in our patients was repetitive motion activities and accounted for 33% of cases. Reported causes included use of electronic medical records, and repetitive motions related to surgical techniques. Congenital causes of TOS accounted for 9% of the patients: 1 (4.3%) abnormal first rib and 1 (4.3%) cervical rib. Significant non-TOS related comorbidities were noted in 7 of 9 (78%) of NTOS patients. Comorbidities included degenerative cervical spine disease (4), fibromyalgia (2), cubital tunnel (2), carpal tunnel (1), and labral tear (1). Two patients had prior TOS surgery.

The medical specialties represented were diverse and included a combination of procedural and non-procedural based specialties: medicine (8), anesthesia (3), surgery (3), pediatrics (2), psychiatry (1), radiology (1), and dentistry (1) (Table II). The average training period was 11.7 years with a range of 10–15; and the average time in practice was 16.4 years (range 0–29).

The average time from onset of symptoms to consultation for the entire group was 38.4 months.

Time from onset of symptoms to consultation varied significantly according to diagnosis: ATOS 0.2 months, VTOS 3.23 months, and NTOS 77.8 months ($P < 0.05$). The average time from

Table III. Time from symptom onset to consultation, to operation, and postoperative follow-up (Months)

Etiology	*N*	Onset-consultation	Onset-operation	Postoperative follow-up
ALL				
Average	19	38.4*	44.5*	33.1
Max		128.7	90.4	151.2
Min		0.1	0.4	1.2
VTOS				
Average	9	3.2*	5.2*	42.0
Max		12.6	15.0	151.2
Min		0.1	0.4	1.4
NTOS				
Average	9	77.8*	90.4*	23.1
Max		128.7	283.9	69.5
Min		5.6	6.5	1.2
ATOS				
Average	1	0.2*	2.3*	31.8*
Max		N/A	N/A	N/A
Min		N/A	N/A	N/A

Max = maximal time period in months.
Min = minimal time period in months.
*Significance defined as $P < 0.05$.

onset of symptoms to surgical decompression was 7 months. The time from onset of symptoms to surgical decompression varied significantly between groups: ATOS 2.1 months, VTOS 2.0 months, and NTOS 12.6 months ($P < 0.05$) (Table III).

Nineteen patients with TOS underwent a total of 23 first rib resections (FRR) for TOS decompression. This included 19 index operations and 4 contralateral operations. The contralateral operations were performed for 1 patient with bilateral VTOS and 3 with bilateral NTOS. The VTOS patient who required contralateral decompression presented with acute thrombosis of the index limb and high-grade nonthrombotic venous compression on the contralateral limb. The 3 NTOS patients who required bilateral FRRs presented with bilateral symptoms. Pectoralis minor syndrome (PMS) was diagnosed in 3 patients on presentation. Two had bilateral PMS and 1 unilateral PMS. Of these, 2 patients underwent surgery for PMS: 1 concurrent with index FRR and one as a later operation.

The average duration of surgery was 120 min (range 69−227 min). The average surgical blood loss was 25 cc (range 25−100 cc). The average length of stay was 1.3 days (range 1−3). No arterial or venous injuries occurred. One long thoracic nerve palsy resulted in winging of a scapula and resolved after 9 months. One symptomatic phrenic nerve injury occurred and resolved after 12 months. No brachial plexus injury occurred.

Follow-up after FRR was similar for all groups. The average time from surgery to last follow-up averaged 33.1 months (range: 1−12 years) for all. Patient follow-up did not vary significantly between different presentations: ATOS 31.8 months, VTOS 23.1 months, and NTOS 42.0 months ($P = 0.50$). No patient was lost to follow-up (Table III).

The initial somatic pain scale (SPS) for all (ATOS, VTOS, and NTOS) averaged 5.5 out of 10 (range 0−9). The average final postoperative SPS score was 1.9 (range 0−8). The initial Quick DASH score (QDS) for all averaged 42.9 (range 2.3−90.9) and improved significantly in the average postoperative QDS score of 10.8 (range 0−68). The initial mean Derkash score was 2.1 (range 1−3). And the resulting postoperative average Derkash score was 3.7 (range 3−4). Comparisons of all preoperative and postoperative scores were statistically significant ($P < 0.05$) (Fig. 1).

At the time of initial consultation, of the entire group of 19 patients, 6 were not able to work and 13 were working with symptoms and restrictions. The 6 patients who were unable to work (3 surgeons and 3 internists) were considered disabled. Postoperatively all MDs were able to return to their preoperative occupations, 3 with milder symptoms, and 3 with no restriction. Of the 13 who were restricted preoperatively, 12 were able to return to work without restrictions and 1 was improved yet still mildly symptomatic. Return to work was documented in all (Fig. 2).

One patient presented with acute limb ischemia related to ATOS. This MD was initially managed with catheter directed thrombolysis and

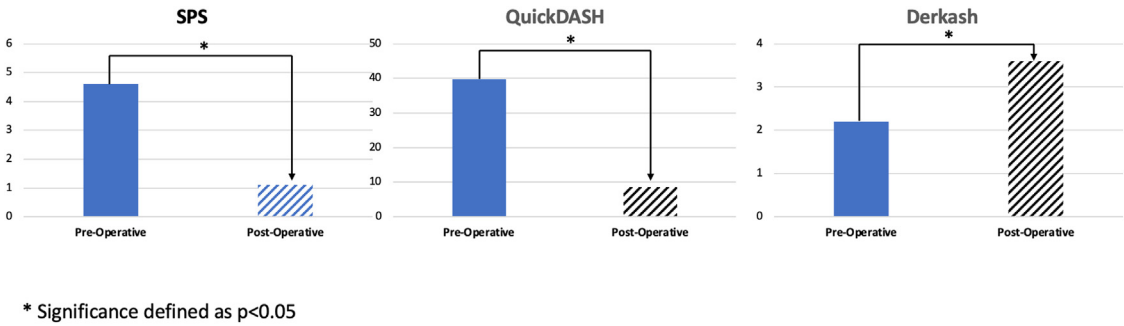

Fig. 1. Outcome metrics. Standardized outcomes (SPS, Quick DASH, and Derkash score) improved in all metrics.

anticoagulation. Subsequent evaluation identified extrinsic arterial compression at the thoracic outlet as the cause of the acute limb ischemia. The patient subsequently underwent FRR. Postoperative duplex scanning revealed no residual compression. Initial SPS, DASH, and Derkash scores were 5, 29.5, and 0. At the last follow-up these improved to 0, 0, and 4 respectively.

Of the 9 VTOS with subclavian vein thrombosis in this series, patency was restored in 8 (88%) patients; however, 1 patient developed late restenosis and declined repeat angioplasty for a final patency of 77%. One patient had been managed with stenting prior to TOS decompression at a referring institution. In this case, the stent was crushed between the clavicle and the first rib. Initial average SPS score for the VTOS patients was 0.7, and this reduced to 0 at the final evaluation. The initial DASH score was 26, and this improved to 0.125. The initial average Derkash score was 2.1 and improved to 3.9 at the final follow-up visit. Disability related to work and avocations in VTOS patients were moderate in all. At the last evaluation, all were able to return to work and athletic activities without restriction or symptoms.

The 9 patients with NTOS underwent a total of 12 FRRs. Two of these cases were reoperative where the patients had undergone prior supraclavicular resections. Initial average SPS score for the NTOS patients was 5.5 and this had reduced to 2.3 at the last evaluation. The initial DASH score was 90.5 and this improved to 23.6. The initial average Derkash score was 2.2, and this improved to 3.4 at the last evaluation. At the time of presentation 45% of NTOS patients were rated as significantly restricted or disabled, and 55% were moderately restricted in their ability to work. At final assessment, all were able to return to work, and 45% reported mild to moderate residual symptoms and 55% asymptomatic.

DISCUSSION

TOS is an infrequent condition which results in disability in use of the upper extremity. It is most often associated with manual labor, industrial work, and accidents, and has not been reported in a MD population. A recent report estimated the annual incidence of TOS operation to be between 2,000 and 3,000 per year in the United States. While still uncommon, the incidence of TOS operations has increased by 40% between 2010 and 2015.[10]

The most common TOS presentation in the general population is neurogenic, accounting for 90—95% of cases. VTOS is the second leading cause of TOS in the general population accounting for approximately 5—10% of cases. ATOS is the least common presentation of TOS in the general population, accounting for approximately 0.5—1% of reported cases. George et al. reported a survey of the National Inpatient Sample regarding TOS operations and noted the distribution of TOS surgical cases as 89.2% NTOS, 9.9% VTOS, and 0.09% ATOS.[10] In our study, we noted significant divergence in the types of TOS between our MD population and the general population. Patients with VTOS presented as frequently as those with NTOS. 52% of cases were for NTOS, while 43% were for VTOS, notably different from national trends. These differences likely reflect the mechanisms of injury noted in the MD population: far more often sports-related than repetitive strain injury or accidents.

The outcome of surgery for VTOS has been measured by re-establishment of venous patency. In an early foundational publication, Machleder reported a final venous patency of 42% among patients who underwent FRR, despite this 80% were asymptomatic.[11] More recently Chang et al. recorded a 90% restoration of patency in VTOS patients when treated with surgical decompression followed by venography and angioplasty.[12]

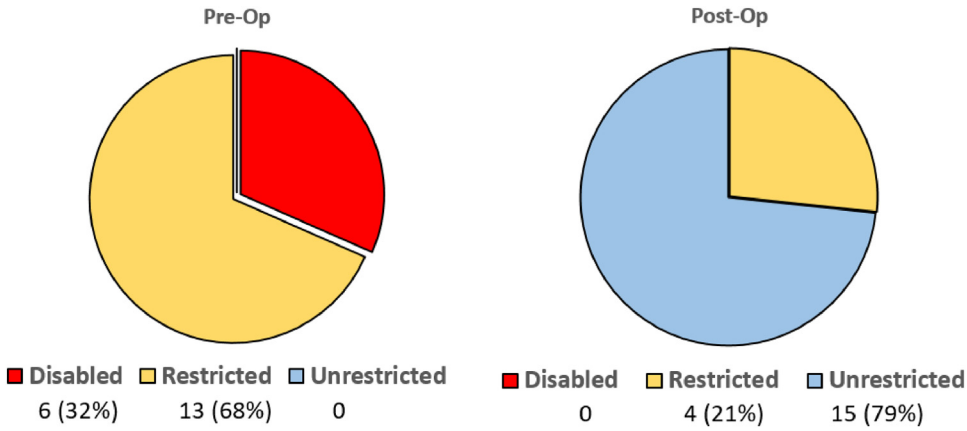

Fig. 2. Work disability and restriction.

Additionally, these investigators reported 77% of VTOS patients were able to return to premorbid daily work and activities Postoperative reduction of VTOS symptoms in patients with patent subclavian veins has also been measured using standardized instruments. Lee noted DASH scores reduced from 36 to 4.9 and 91% return to baseline activity.[13] We identified initial patency of 88% and late patency of 77% this was accompanied by a 35-point reduction in DASH scores. All our patients resumed their normal daily work and activities following FRR. Machleder noted that patency alone does not dictate resolution of symptoms and restoration of function.[11] This was again noted in this series where all patients experienced improvement despite a lack of final venous patency.

The outcomes of surgery for NTOS in the general population have varied considerably. Altobelli et al. noted a 64% success rate over a 5-year follow-up period.[14] Using life-table analysis methods, Sanders and Pearce reported that success rate after surgery was between 70% and 73% at 5 years.[15] Freischlag observed improvement of NTOS Quick DASH scores from 50 to approximately 30 over a 2-year period. Additionally, 50% of NTOS were able to return to full-time work.[16] More recently, Balderman et al. reported an average reduction of 29% of Quick DASH scores, and patient reported outcomes of good to excellent in 63%, and substantial improvement in 90%.[17] The outcome of NTOS surgery in our patients was remarkably good with an average decrease in SPS of 65% and a reduction of Quick DASH score of 74%.

While MDs may seem like an unusual population for developing TOS, TOS has been noted in several unique populations with characteristics common to our subjects. Some of the MDs patients suffered injuries likely related to their work activities. Patients injured on the job represent a well-described subset of NTOS. Work-related injury has been identified as an adverse prognosticator for the recovery of function and return to employment following TOS surgery. These injuries are often covered by worker's compensation insurance. The outcomes of TOS surgery in worker's compensation cases have been reported to be poor. In his 2,000 publication, Franklin reports that following TOS surgery, 72.5% of injured workers reported persistent significant disability.[18] Sanders and Hammond reported that only 60% of injured workers were able to return to work.[19] All of our NTOS patients were able to return to work, although 45% of them had residual symptoms. The unique insight and motivation of our patients may have accounted for their ability to return to work.

Athletes are another unique population of TOS patients who share common traits with our MD patients. In a group of 41 competitive athletes treated at Stanford, Lee observed that 85% were able to return to competition, including 93% VTOS and 81% NTOS.[20] In a later publication from Dallas, Pearl et al. reported about 232 athletes with NTOS.[21] They noted 82% resolution of symptoms, 96% improved pain, and 70% who returned to athletic competition. In a 2017 report of professional baseball pitchers, Thompson et al. (2017) found 10 of 13 (77%) Major League Baseball (MLB) pitchers achieved sustained return to MLB pitching.[22] While differing in many ways from MDs, athletes are highly motivated and driven to excellence. The investment of time for training are comparable to the investments in time made by MDs. It is notable

that our MDs have improved ability to return to work when compared to competitive athletes. We would attribute this to the arduous physical demands of high-level athletic competition which is not equivalent in the MD population.

Study Limitations

Our report is limited by its retrospective nature and small cohort size. The small sample size limits our ability to analyze and compare the data to other studies. The unique nature of the subjects limits the comparison to TOS in the general population. The MDs who were affected had invested long periods of time in training and developing their practices. The potential loss of employment as a MD was a likely significant factor in motivating return to work.

CONCLUSION

Although rare, MDs are subject to developing TOS. Causes include repetitive motion, athletic injuries, and congenital bony abnormalities. Athletic injuries accounted for 63% of cases and repetitive motion was an element in 16% of TOS patients. Surgical decompression is beneficial with reduction in pain and disability, and restoration of work ability. MDs are highly motivated; accordingly, they have a high probability of successful resumption of work and athletics. This high degree of motivation may contribute to the good outcomes in this group of patients.

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