Adolescent Thoracic Outlet Syndrome: A challenging diagnosis and management dilemma

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Disclosures

- None

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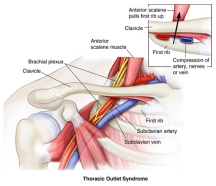
Thoracic Outlet Syndrome

- **TOS is a heterogeneous mix of compressive disorders:**
  - ATOS, VTOS, NTOS, PMS
  - Prevalence 0.3-2%
  - Women (3:1)
  - **80% between 25-40 years**
- Multifactorial pathogenesis:
  - Repetitive overhead activity
  - Hyperextension injury
  - Congenital anomalies
  - Muscle hypertrophy/fibrosis



Thoracic Outlet Syndrome

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Thoracic Outlet Syndrome- Adults

1) **Neurogenic TOS: 90-95%**
   - Incidence 3-80/1,000
   - **Work related, repetitive strain injury**
   - UE trauma
2) **Venous TOS: 4-5%**
   - Repetitive strain injury
   - SCM hypertrophy
3) **Arterial TOS: 1-3%**
   - Incidence 0.03-0.9/100,000
   - Bony anomalies are common

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Thoracic Outlet Syndrome- Adolescents

1) **Neurogenic TOS: 30-40%**
   - Female > male
   - Different pathogenesis than adults:
     - **20% congenital anomalies**
     - Development muscles and connective tissues
     - **Repetitive strain/overuse**
2) **Venous TOS: >40%**
   - Repetitive strain, SCM hypertrophy
   - Male > female
3) **Arterial TOS: 10-15%**
   - >50% bony anomalies
   - Male > female

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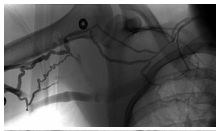
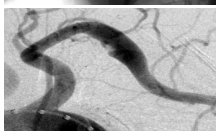
Spectrum of Thoracic Outlet Syndrome Presentation in Adolescents

Kevin Chang, BA; Emma Graf; Kylie Davis; Jasmine Demos, CRNP; Taylor Roethle; Julie Ann Freischlag, MD

- 35 adolescents (<18 years)
  - Retrospective review, single center
  - 21 females, 14 males
- **74% vascular (18 VTOS, 8 ATOS, 9 NTOS)**
- **75% ATOS cervical/rudimentary ribs**
- All underwent surgical decompression
  - NTOS- sxs began 15 months before operation (delayed referrals)

➢ **Adolescents more often present with vascular TOS than adults**



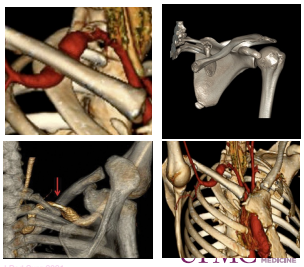


 Arch Surg 2011

Thoracic Outlet Syndrome Pathogenesis

Adults:
- 85% hyperextension injury, repetitive strain
- 15% congenital predisposition

Adolescents:
- **>50% congenital anomalies**
  - **Cervical ribs**
  - **Elongated transverse process**
  - **Fibrous bands**
  - **Scalene minimus muscle**
- 40% repetitive stress/overuse

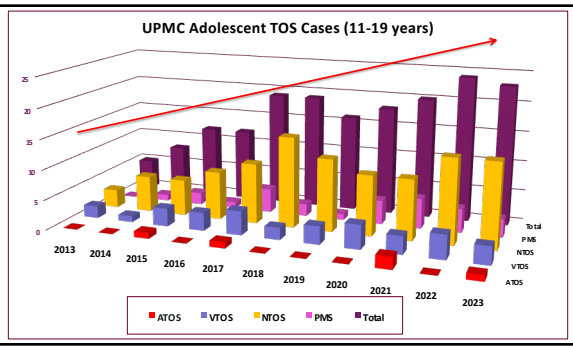


Pearl TOS Springer 2013, Chandra 2011, 2014, Peek 2016, Broglionu J Ped Surg 2021

Adolescent Thoracic Outlet Syndrome

TOS is occurring more frequently in adolescents (11-19 years):
- Combination of maturation and physical activity
  - Max velocity/weight/effort high intensity workout regimens
  - Single sport athletes
  - Repetitive stress/overuse- not just athletes
- Puberty related maturation
  - Increased muscle mass (disproportionate)
  - Rapid growth spurts
  - Joint laxity
- TO small anatomic space
  - Bony anomalies

Hong JNS 2018, Illig 2021, Al Shakarchi 2020, Murthy 2022



Adolescent Thoracic Outlet Syndrome

- **TOS is an especially difficult diagnosis:**
  - Pediatricians lack of familiarity
  - Parents and patients minimize symptoms
  - Difficulty communicating neurogenic symptoms
  - Reluctance for invasive testing
  - NIL and college scholarships…plausible deniability
    - **Delayed/missed diagnosis**

Hong JNS 2018, Illig 2021, Al Shakarchi 2020, Murthy 2022

Diagnosing Adolescent TOS

Vascular TOS: careful history and physical exam
- Presenting features are objective
- Misperception nerve compression is causing symptoms
- Appropriate diagnosis made after vascular changes reoccur
- **Hx- repetitive strain/overuse**

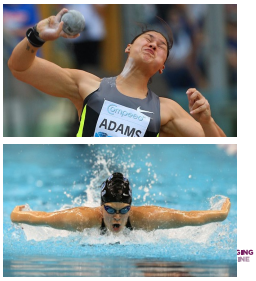
- Features of venous TOS: SCV thrombosis
  - Fatigue, fullness, cyanosis, prominent chest wall veins

- Features of arterial TOS: SCA compression
  - Pulsatile mass, bruit, digit embolization, fatigue
  - Bony anomalies

Peek 2016, Chandra 2014, Lee 2011, Talutis 2023

Diagnosing Adolescent TOS

Neurogenic TOS:
- Careful history and physical exam
  - **Wide constellation of symptoms**
  - **>40% co-existing musculoskeletal injuries**
- Nuanced symptoms, exacerbated by overhead activity
  - **Transient pain, paresthesia, weakness, fatigue, loss dexterity**
  - Diagnosis delay 11-36 months



Pearl TOS Springer 2013, Langosch 2013

Diagnosing Adolescent TOS

Neurogenic TOS: no pathognomonic finding

- P/E findings are less reliable:
  - **Subjective weakness, hand atrophy, slouching, rolled shoulders**
- Provocative maneuvers- normal 1/3rd
  - ULTT, EAST, Wright, Adson
- Tenderness to palpation scalene triangle
  - Cervical rib with referred paresthesia
- **Compensatory muscle spasm**
  - scalene, pect minor, rhomboid, trapezius

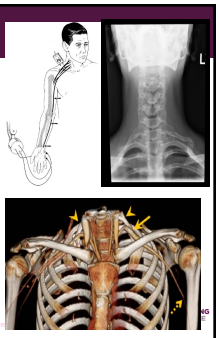
Pearl TOS Springer 2013, Langoech 2013

Diagnostic Imaging TOS

X-rays: chest and c-spine all TOS cases
- Evaluate for bony anomalies (50%)

Vascular TOS:
- **Duplex imaging:** ATOS/VTOS 90% sensitive
- **CTA/V:** bony anomalies in relation to vessels

Neurogenic TOS:
- **Duplex imaging:** NTOS 66% sensitive
- **MRI =>** negative 75% cases
  - Fibromuscular anomalies
- **Nerve conduction testing =>** unreliable
- **Muscle blocks:** ant scalene, pect minor
  - >80% sensitive
  - Determine symptoms related NTOS
  - Predict response surgical decompression



Huang 2004, Pearl TOS Springer 2013, Chandra 2014, Katiirji MN 1995, Safran AJSM 2004, Boglioni

Treatment Adolescent TOS

ATOS: **Early intervention**
- Decompress 1st rib, bony anomalies, ASM resection
- **SCA repair infrequent**

VTOS: **Treat like adults**
- Anticoagulate, lysis/thrombectomy
- Decompress 1st rib and SCM resection
- **Selective SCV repair based on symptoms**

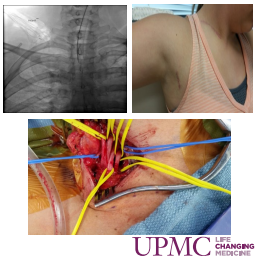
NTOS: **Conservative treatment 3-6 months**
- Avoid provocative activities
- PT- stretching, deep tissue massage, posture correction
- Anti-inflammatory meds, Botox inj. scalene triangle
  - PT- mild sxs more likely to respond
  - **PT- athletes higher failure rates**
  - **Anatomic anomalies- consider early decompression**

Huang 2004, Pearl TOS Springer 2013, Chandra 2014, Katiirji MN 1995, Safran AJSM 2004

UPMC Experience

- **176 patients** 2013-2024, mean age 16.1 years
- 72% female, **76% high school/college athletes**
  - **61% NTOS, 21% VTOS, 3% ATOS**, 15% PMS
    - 45% combined orthopedic and TOS diagnoses
    - **42% cong. anomalies**, 6% bilateral TOS
- NTOS- 100% focused PT (3 months)
  - 45% decompression with neurolysis
  - 6% recurrent NTOS symptoms at 18 months
- VTOS- 93% decompression following lysis/thrombectomy
  - 7% VTOS symptoms at 24 months
- ATOS- all decompression, 1 SCA patch and 1 bypass

  - **95% returned to academics (2 weeks)**
  - **93% returned to athletics (4.5 months)**



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Conclusion

- Adolescent TOS is a challenging diagnosis to make and has a different pathogenesis than adults
- Vascular TOS is more common in adolescents and often associated with bony anomalies
- Conservative management should be attempted for 3-6 months in most neurogenic TOS patients
- Longitudinal outcomes after decompression are very favorable
- TOS has profound effects on education and athletic endeavors, and requires early diagnosis and timely treatment

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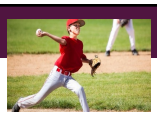
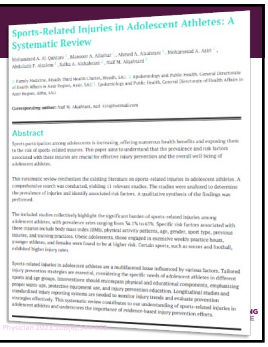


Sports related overuse injuries are increasing:

- **Sports specialization at a young age**
- Intense contact sports
- **Failure to take time off between seasons**
- **Failure to take rest days during the week**
- Inadequate warm-ups and cool-downs
- Not wearing appropriate protective gear
- Unable to be honest about injuries
- **Limited recovery time after injury**



Sports-Related Injuries in Adolescent Athletes: A Systematic Review

Abstract

19 Al-Qahtani MA, et al Cureus 15(11):e49382 DOI 10.7759/cureus.49382, Lintner LJ Am Acad Orthop Surg 2014

Presentation, management and outcome of surgically managed pediatric thoracic outlet syndrome

Nikhil K. Murthy[1,2] · Rashmi Kabre[3,4] · Kristine S. Corkum[4] · Mandana Behbahani[2] · Vineeth Thirunavu[2] · Constantine L. Karras[1,2] · Tord D. Alden[1,2]

- 44 patients single center, 15.5 years, 72% female
  - **80% NTOS, 20% Vasc TOS**
- **Symptom duration 35.2 months**
  - Numbness 72%, pain 66%, weakness 4%
  - 50% unremarkable exam
  - 59% sports activities
  - 32% underwent PT
- 50 supraclavicular operations
  - **NTOS: 90% scalenectomy, 72% FRR, 92% neurolysis**
  - Post-op PT: NTOS 21%, Vasc TOS 47%

➢ **Follow-up 11 months: 22% pain, 26% numbness, 6% weakness**

Child's Nervous System 2022

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Long-term outcomes after surgical treatment of pediatric neurogenic thoracic outlet syndrome

Jennifer Hong, MD,[1] Jared M. Pisapia, MD,[2] Zarina S. Ali, MD,[2] Austin J. Heuer,[3] Erin Alexander, BS,[3] Gregory G. Heuer, MD, PhD,[2,3] and Eric L. Zager, MD[2]

[1]Divison of Neurosurgery, Dartmouth-Hitchcock Medical Center, Lebanon, New Hampshire; [2]Department of Neurosurgery, University of Pennsylvania, Philadelphia; and [3]Division of Neurosurgery, The Children's Hospital of Philadelphia, Pennsylvania

- 12 patients 2010-2016, single center, 66% female
- Mean age 15.2 years (range 8-18)
- Duration of symptoms 15.8 months (± 6.6)
  - 75% sports related activities
  - **75% bony anomalies**
    - 33% c-ribs, 33% transverse process
- **Follow-up: 57% excellent results, 43% good results**
  - Better results- shorter duration symptoms, younger age

➢ **Pediatric NTOS often associated with bony anomalies, early decompression results in excellent symptom resolution**

J Neurosurg Ped 2018

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