VENOUS THORACIC OUTLET SYNDROME (VTOS)

- Extrinsic compression of the subclavian vein in the Costo-Clavicular Space
- Subclavian vein thrombosis
- Symptoms of congestion, edema, pain and disability.
- Often young, athletic

Illig, JVS 2010
Venous TOS

Spectrum of Presentations:

- Acute DVT (PSS)
- Chronic post phlebitic
- Acute on Chronic
- Chronic Occlusion
- Intermittent non-thrombotic (McLeery’s Synd)
Venous TOS

Compressive Elements

- First Rib
- Clavicle
- Subclavius
- Anterior Scalene

Rationale for surgical management: deconstruct costo-clavicular space to decompress subclavian vein
Venous Channel

vTOS

nTOS
Paget Schroetter Syndrome

(most common VTOS presentation)

- Spontaneous axillo-subclavian vein thrombosis
  - Primary DVT: No CVC, no surgery, no injury.
  - ‘Effort Thrombosis’, ‘Back-pack Syndrome’

- Sir James Paget, London, 1875
- Leopold von Schroetter, Vienna, 1884
- ESR Hughes, London, 1948

- NOT synonymous for vTOS
DVT Numbers

VTOS Related DVT

- All DVT: 200,000 / yr
- UE DVT: 4-10% of all DVT
- Primary UE DVT: 30-40% of UE DVT, 2-3 per 100,000
- VTOS: 60% of Primary UE DVT
- VTOS DVT: 1-2 per 100,000 pop
- 2500 new TOS related DVT per year
- PE incidence 5-15%
- 2-300 new TOS related PE per year
- "Rarely fatal"

National Center for Health Statistics [NCHS], 2006
Flinterman. J Thrombosis and Hemostasis 2008
DVT Numbers

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Venous TOS Presentation

Venous Congestion

- Swelling
- Pain
- Heavynesss
- Cyanosis
- Venous Distension
- Colaltlementization
Diagnosis: Venous TOS

Evaluation:
- U/S
- CT Venogram
- Catheter Venogram
Diagnosis: Acute VTOS

Presumptive Diagnosis
- Based on context, hx
- Assumes compression

Confirmed Diagnosis
- Demonstrates compression at the thoracic outlet
- Thrombolysis vs Anticoag/Autolysis
Diagnosis VTOS: Thrombolysis
Acute DVT (1-14 days)

Cyanosis
Pain
Arm Edema
Distended Veins
Venogram

Lytic Therapy

Confirm Extrinsic Compression
Document Vein Patency
Assess Severity of Phlebitis
Dx VTOS: IVUS

Ulloa et. al. JVS 2020
MANAGEMENT
Paget Schroetter Syndrome

- Cyanosis
- Pain
- Arm Edema
- Distended Veins
- Venogram

Confirmed Diagnosis

Immediate FRR
Anticoagulate
Reassess
Non-Op Care
Anticoagulate
DVT Progression

**Acute DVT**
0 - 14 Days
- Soft Thrombus
- Propagation
- Embolization

**Sub-Acute DVT**
14-28 Days
- Evolving Thrombus
- Organizing

**Chronic DVT**
1-2 Month
- Organized Thrombus
- Stable Fibrosis
Management: Anticoagulation

48 pts. managed with anticoagulation  6.6 year follow-up

- Occluded Venogram: 91%
- Persistent Symptoms: 74%
- Recurrent Thrombosis: 17%

Management: Lysis

- Thrombolysis
  - Chemical
  - Pharmaco-Mechanical
  - Within 10-14 days.

“Unlike deep vein thrombosis of the lower extremity, spontaneous recanalization of axillary and subclavian veins following thrombosis is rare”.

Paget-Schroetter Syndrome
UCLA Macheleder Protocol

- Thrombolytic therapy: TPA
- Anticoagulation: 3 to 6 months

- Thoracic Outlet Decompression:
  - Persistent venous symptoms
  - High grade extrinsic venous compression
  - Recurrent thrombosis

- Post-decompression venogram / angioplasty
  - Reconstruction in selected cases

Kunkel JM, Machleder HI. Arch Surg. 1989
Clinical research study
From the Western Vascular Society

Long-term thrombotic recurrence after nonoperative management of Paget-Schroetter syndrome

Presented at the Twentieth Annual Meeting of the Western Vascular Society, Park City, Utah, Sep 24-27, 2006.

Jason T. Lee MD *, John K. Kowalski MD *, E. John Harris MD *, Jason S. Haukoos MD, MS h, t, Cornelius O'Connell IV MD *

64 PSS

Lysis, PT, Re-Eval

51 Months

37 (57%) Require FRR
Surgical Management

Costo-Clavicular Decompression: Claviculectomy

- Observation:
  - Collateral compression with abduction
  - Thrombectomy reduced long term symptoms

- Decompression improved success of thrombectomy and resolution of symptoms

Paget-Schroetter Syndrome

Adams & DeWeese 1971
Surgical Approaches for VTOS

- Transaxillary
- Paraclavicular
- Infraclavicular

Claviculecotmy
Paget Schroetter Syndrome: Post-Op Venogram

Cyanosis
Pain

Arm Edema
Distended Veins

Venogram
Lysis

Persistent Sx
High-Grade Stenosis
Rib Resection

Post-Op Venogram
100 Patients Paget Schroetter Syndrome (Acute DVT)

**LYSIS**

- N= 50
  - Pre-Op Venogram
  - Rib Resection
  - Post-Op Venogram
  - Re-Canalization PTA
  - Late Venogram
  - Final Vein Patency 94%*

**NO LYSIS**

- N=50
  - Pre-Op Venogram
  - Rib Resection
  - Post-Op Venogram
  - Re-Canalization PTA
  - Late Venogram
  - Final Vein Patency 72%*

* p<0.01

Chun et. al. 2020 Pre-Publication
100 Patients Paget Schroetter Syndrome (Acute DVT)

Quick DASH

SPS Score

Somatic Pain Scale

Chun et. al. 2020 Pre-Publication
Patients with Occluded SCV benefit from surgical decompression even if the SCV remains occluded.

Cheng et. al. 2021 Western Vascular
Venous TOS

Final Observations

- Lysis in acute thrombosis (10-14 days).
- **No Stenting** before decompression!
- Rib resection is most common operation.
- Post Op re-assessment (venogram).
- Reconstruction in selected cases.
J.R. Richard (left) and Nolan Ryan anchored the 1980 Astros

He was one of the premier pitchers in the majors, leading the National League twice in strikeouts, once in earned run average, and three times in hits allowed per nine innings, winning at least 18 games each year

Richard was felled by a stroke and Ryan was defeated in Game 5 of the NLCS by the Dodgers.
ARterial TOS (ATOS)

- **Definition**
  - Extrinsic compression and damage to subclavian artery at the Scalene Triangle
  - Arterial Occlusion, Aneurysm, Distal Embolization

- Uncommon
- Younger patients
- Sports-related injuries
- Sudden onset
- Frequently missed
ARTERIAL TOS

Definitions and diagnostic criteria. ATOS is defined as an objective abnormality of the subclavian artery caused by extrinsic compression and subsequent damage by an anomalous first rib or analogous abnormal structure (cervical rib or band) at the base of the scalene triangle. Such an abnormality can be symptomatic (ischemia or embolization) or asymptomatic (aneurysm, occlusion, or silent embolization). Loss of pulses or discoloration with provocative maneuvers in patients with NTOS does not mean that ATOS is present; documented injury to the subclavian artery or symptomatic arm ischemia with arms elevated must be present for this diagnosis to be made.
CERVICAL RIB and ATOS (33-100%)

- Compression
  - Post-Stenotic Dilatation
  - ANEURYSM

- Thrombosis
- Embolization
- Unilateral Raynauds
- Acute Limb Ischemia
- Stroke
Clinical presentation and management of arterial thoracic outlet syndrome

Chandu Vemuri, MD, Lauren N. McLaughlin, ACNP, Ahmmad A. Abuirqeba, BA, and Robert W. Thompson, MD, St. Louis, Mo

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Vascular (n = 23)</th>
<th>Nonvascular (n = 17)</th>
<th>Total (N = 40)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, years</td>
<td>40.3 ± 2.4</td>
<td>40.2 ± 4.0</td>
<td>40.3 ± 2.2</td>
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<tr>
<td>Female gender, %</td>
<td>15 (65)</td>
<td>14 (82)</td>
<td>29 (72)</td>
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<tr>
<td>Right side affected, %</td>
<td>10 (44)</td>
<td>12 (71)</td>
<td>22 (55)</td>
</tr>
<tr>
<td>Dominant side affected</td>
<td>12 (52)</td>
<td>10 (59)</td>
<td>22 (55)</td>
</tr>
<tr>
<td>Ischemia/emboli</td>
<td>21 (91)</td>
<td>0 (0)</td>
<td>21 (52)</td>
</tr>
<tr>
<td>Posterior stroke</td>
<td>2 (9)</td>
<td>0 (0)</td>
<td>2 (5)</td>
</tr>
<tr>
<td>Neurogenic TOS</td>
<td>0 (0)</td>
<td>11 (65)</td>
<td>11 (28)</td>
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<tr>
<td>Asymptomatic neck mass</td>
<td>0 (0)</td>
<td>6 (35)</td>
<td>6 (15)</td>
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<tr>
<td>Recurrent arterial TOS</td>
<td>1 (4)</td>
<td>2 (12)</td>
<td>3 (7)</td>
</tr>
<tr>
<td>Recent thrombectomy</td>
<td>8 (35)</td>
<td>0 (0)</td>
<td>8 (20)</td>
</tr>
<tr>
<td>Cervical rib</td>
<td>17 (74)</td>
<td>13 (76)</td>
<td>30 (75)</td>
</tr>
</tbody>
</table>

*Continuous data are shown as the mean ± standard error of the mean and categoric data as number (%) or as indicated.
Arterial TOS

Presentations:

- Acute Limb Threatening Ischemia (ALTI)
- Chronic Embolization: Unilateral Raynauds Loss of vasculature
- Asymptomatic: Aneurysm Fixed Stenosis

Neurogenic symptoms may accompany
Symptoms in 55 cases

- Limb threat: 14 (25%)
- Asx aneurysm: 14 (25%)
- Digital gangrene: 9 (16%)
- Claudication: 10 (18%)
- Vasomotor: 8 (15%)
- Additional Neurological sx: 30%

Cromier JVS 1989
**Arterial TOS**

**Additional Neurogenic Findings**

- SEP testing: 11 (47%)
- Positive SEP: 9 (39%)
- Muscles Wasting: 3 (13%)

Arterial TOS
Acute Ischemia - Initial Management

Ischemia, Thrombosis, Emboli

Pulse Deficit

Imaging U/S, CT, MR

Revascularize

Resolve Acute Ischemia

Lysis Thrombectomy Anticoagulation

Evaluate
Demonstrate arterial injury associated with compression at the thoracic outlet

- **U/S**: subclavian aneurysm, clot
- **CXR**: cervical rib, enlarged C 7 transverse process, clavicular fracture, abnormal first rib
- **Angio**: aneurysm, compression, ulceration, distal arterial occlusion
- **CT scan**: bony anomalies, arterial compression, aneurysm formation
Diagnosis

Arterial TOS

Evaluate

- Extrinsic Compression
- Fixed High-Grade Stenosis
- Post-Stenotic Dilatation / Aneurysm
- Thrombus in Aneurysm or Arterial Tree

Angiogram, CTA, MRA

Vemuri, JVS 2017
Aneurysms may be underestimated on angiograms.
Diagnosis

Arteriography

Arterial Occlusion

Intraluminal Defects
Management

Arterial TOS

Evaluate

- Angiogram
- CTA
- MRA

Dx Established:

- Extraneous Compression
- High Grade Stenosis
- Aneurysm
- Thrombus

Decompress

Reconstruct
Arterial TOS

Management

Decompress

First Rib Resection  20-95%
Cervical Rib Resection  33-100%
Soft Tissues / Fibrous Bands  5-40%
Arterial TOS

Management

Reconstruct

Arterial Graft
SVG
Homograft
Prosthetic
Stent Graft

Adjunct

Sympathectomy
Management

Arterial TOS

- Interventions (23 pts):
  - First Rib Resection 22 (96%)
  - Cervical Rib Resection 8 (36%)
  - Arterial Reconstruction 8 (36%)
  - Sympathectomy 7 (32%)

### SURGICAL INTERVENTIONS

<table>
<thead>
<tr>
<th>Procedure</th>
<th>No</th>
<th>% of Pts</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cervical Rib</td>
<td>22</td>
<td>44</td>
</tr>
<tr>
<td>First Rib</td>
<td>48</td>
<td>96</td>
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<tr>
<td>Sympathectomy</td>
<td>9</td>
<td>18</td>
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<tr>
<td>Bypass</td>
<td>11</td>
<td>22</td>
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<tr>
<td>Primary Repair</td>
<td>2</td>
<td>4</td>
</tr>
<tr>
<td>Stent Graft</td>
<td>7</td>
<td>14</td>
</tr>
</tbody>
</table>
Endovascular Management

All TOS
N=2200 (100%)

Arterial TOS patients
N=47 (2%)

Endovascular Procedures
N=55

Angiograms
N=33

Thrombolysis
N=14

Stent Graft
N=8

Pantoja et. al. 2021 Pre-Publication
26 yo right handed woman presents with abrupt onset of left hand and arm pain.

Remote history (4 yrs) of trauma, clavicular fracture.

Exam: Hand cold, pale, numb, weak.
Arterial TOS case
Arterial TOS case
Arterial TOS case
Thrombolysis: After 48 hrs
Arterial TOS case

Thrombolysis: After 48 hrs
Thrombolysis: After 48 hrs
Surgical Thrombectomy → Anticoagulation
Return to OR for Definitive Repair: Decompression
Return to OR for Definitive Repair: Reconstruction
One year post-op follow up Duplex scan.
## Arterial TOS

<table>
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<th></th>
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<tbody>
<tr>
<td># Patients</td>
<td>30</td>
<td>41</td>
<td>55</td>
<td>40</td>
<td>47</td>
</tr>
<tr>
<td>Improved</td>
<td>56%</td>
<td>71%</td>
<td>91%</td>
<td>ns</td>
<td>98%</td>
</tr>
<tr>
<td>Same</td>
<td>30</td>
<td>25</td>
<td>8</td>
<td>ns</td>
<td>2</td>
</tr>
<tr>
<td>Amputation</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Stroke</td>
<td>7</td>
<td>0</td>
<td>0</td>
<td>5</td>
<td>0</td>
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<td>Death</td>
<td>3</td>
<td>0</td>
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* Aggregated cases
## Arterial TOS Results

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</tr>
<tr>
<td>Death</td>
<td>3</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

* Aggregated cases
Long-term Patency of Arterial Reconstruction

Fig. 1. Primary (□) and secondary (●) patency of arterial reconstructions.
Final Observations:

- Often confused with collagen vascular disease, or Raynaud’s disease.
- Common error: failure to appreciate thoracic outlet compression / cervical rib.
- **Unilateral hand symptoms** should generate suspicion.
Neurogenic TOS

Symptoms + Phys Exam + Testing

Confirmed Diagnosis

Conserv Rx

Limb Rest
Physical Tx
Medication

Follow
Improved
Sx Persist
Surgery

Improved
Sx Persist
Surgery
Paget Schroetter Syndrome: vTOS

Cyanosis
Pain

Arm Edema
Distended Veins

Venogram
Lysis

Persistant Sx
High-Grade Stenosis

Rib Resection

Post-Op Venogram
Arterial TOS

Ischemia, Emboli

Pulse Deficit

Declot & Angiogram

Dx ATOS:

Extrinsic Compression

High Grade Stenosis

Aneurysm

Thrombus

Decompress

Reconstruct
Thank You
There was no haemorrhage, but the operation was naturally an anxious one, as any deviation to the right or the left might have led to consequences disastrous to the patient.