Imaging of the patient with Thoracic Outlet Syndrome

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Please note that for this version for the syllabus, I have omitted the cases/images that will be included in the presentation.

No disclosures

Goals of this presentation

• Review the imaging modalities used in the evaluation of the patient with suspected thoracic outlet syndrome
• Present imaging findings associated with the diagnosis of thoracic outlet syndrome
• Discuss common postoperative complications of corrective surgery

What is the thoracic outlet?

• Extends from the cervical spine and mediastinum to the lower border of the pectoralis minor muscle
• 3 compartments:
  – Interscalene triangle
  – Costoclavicular space
  – Retropectoralis minor space

What is Thoracic Outlet Syndrome?

• Compression of the neurovascular structures that traverse the thoracic outlet
• More common in patients less than 40 years old
• F:M approximately 4:1
It’s really three diseases

• Neurogenic syndrome
• Arterial syndrome
• Venous syndrome
• Typically, neurogenic syndrome thought to account for over 90% of cases, but this may be an overestimate and be due to recruitment bias

Role of imaging prior to surgery

• Important to detect anatomic abnormalities
• Helpful in discriminating neurogenic from vascular thoracic outlet syndrome
  – Some centers more likely to manage neurogenic thoracic outlet syndrome conservatively
• Evaluate for other etiologies for the patient’s symptoms

Choice of modalities

• Plain radiographs
  – Excellent for initial survey of bony abnormalities
• Ultrasound
  – Can be used to look for thrombus, dilated collaterals, positional changes
• CT
  – Excellent for bony abnormalities, but has radiation concerns in typically young population
• MRI
  – Modality of choice for evaluation of vascular TOS
• Angiography
  – Choice for the acutely symptomatic patient as it provides a means of treatment

Conventional Radiographs

• Cervical rib
  – Less than 1% of the population, but seen in 5–10% of patients with TOS
  – Arises from C7
  – Can be complete or incomplete
  – Often associated with a fibrous band

Symptoms

• Neurogenic: Pain and paresthesia
  – Neck, ear, occipital region, upper back, clavicle, chest, arm -> depends on where compression is
• Arterial: Weakness, cold, pain, embolic phenomena
• Venous: Swelling and cyanosis, venous distension
• Provocative maneuvers are important in the physical exam

Conventional Radiographs

• Elongated transverse process of C7
  – Considered elongated if tip extends below transverse process of T1 below
  – Can also be associated with fibrous band
**Conventional Radiographs**
- Anomalous first rib
  - Fuses to second rib rather than sternum
- Abnormal first ribs or clavicle
  - Old fractures
  - Exostoses

**Ultrasound**
- Can assess blood flow during clinical maneuvers
- Frequently relies on indirect signs of more proximal arterial stenosis
- Difficult to image exact level of stenosis
- Can be performed with patient upright
- At our institution, ultrasound for TOS typically only done in office and as an adjunct to CT or MRI

**Angiography**
- Typically reserved for the patient presenting with acute symptoms suspicious for venous TOS
- Venogram performed with arms at varying degrees of abduction
- If thrombus is detected, a declot can be performed

**Computed Tomography**
- Technique
  - IV on asymptomatic side
  - Split bolus (5 minutes between injections)
    - 4 cc/sec injection
  - First run: Arm of interest up, head towards ipsilateral side
    - Time off aorta
    - Then venous phase at 90 seconds
  - Second run: Arm of interest down
    - Time off aorta
    - Then venous phase at 90 seconds

**Magnetic Resonance Imaging**
- Technique
  - Phased array coil
  - IV on asymptomatic side
  - Contrast agent choice
    - Intravascular agent (1 cc/sec)
      - Allows for single injection
      - Will have venous opacification on all runs after initial arterial phase
    - Extracellular agent (2 cc/sec)
      - Can get pure arterial phase with arms up and arms down
      - Requires two injections

**Magnetic Resonance Imaging**
- Protocol (for intravascular agent)
- Arms at side
  - TSE T1 Hi-res coronal
  - TSE T1 Hi-res axial
  - Test bolus timed for arch
  - 3D VIBE axial breath hold centered at arch (pre contrast)
  - 3D MRA coronal breath hold (pre contrast)
  - Give contrast
  - 3D MRA coronal breath hold (post contrast x 3)
    - Run 1 timed for aorta, Run 2 after 12 seconds, then Run 3 after 40 seconds
  - 3D VIBE axial breath hold (post contrast)
MRI Technique Continued

• Arms above head, head to symptomatic side
  – 3D MRA coronal breath hold x2
  – 3D VIBE axial breath hold
  – No need to reboatus patient when using an intravascular agent
• Post processing
  – Obtain subtractions and MIPs as needed

MRI for brachial plexus

• Not routinely performed at our institution, focus is on vascular etiologies
• Can evaluate brachial plexus by adding supplemental T1 Hi-res sagittal images with arms up and arms down

Findings on cross sectional imaging

• Arterial TOS
  – Arterial compression with arms elevated
  – Post-stenotic dilatation
  – Aneurysm or pseudoaneurysm formation
  – Collaterals
  – Fibrous bands
  – Thrombus (rare)
• Venous TOS
  – Venous compression with arms elevated
  – Significance of venous compression can be difficult to determine given predisposition of even moderate venous narrowing with positional changes in normal individuals
  – Thrombus
  – Fibrous bands
  – Enlarged collateral vessels
• Neurogenic TOS
  – Loss of fat surrounding brachial plexus with arms elevated

Imaging the post-operative patient

• Many surgical techniques available for thoracic outlet syndrome decompression
  – Different approaches
  – Most resect the entirety of the first rib and cervical ribs
  – Resection of muscles about the thoracic inlet is variable
  – Vascular reconstruction or stenting may be necessary
• Many surgeons intentionally violate the apical pleura to provide a means of decompression of postoperative fluid/hematoma into the pleural space

Imaging the post-operative patient

• Expected findings on postoperative chest radiographs
  – Small or moderate pleural fluid collections
  – Small pneumothorax
  – Extrapleural hematoma at apex

• Potential complications
  – Hemothorax
  – Chylothorax
  – Pneumothorax
  – Supraclavicular infection or hematoma
  – Pulmonary infection
  – Lung herniation
  – Nerve damage
  – Vascular injury/rethrombosis
Patients presenting with symptoms after previous decompression

- Imaging may be necessary to see exactly what procedure was performed
- Often important to assess the amount of remnant first rib
  - This is best done with CT
  - Complete resection involves resection of entire first rib posteriorly to the costovertebral junction and anteriorly to junction with sternum

Delayed presentation

- Grafts and stents prone to restenosis
  - Can evaluate with CT or MRI
  - Many of these patients go straight to angiography for attempted declot
- Imaging the contralateral side is often important as bilateral TOS is not uncommon

Conclusion

- Imaging of patients with thoracic outlet syndrome plays an important role in diagnosis and postoperative care
- CT and MRI remain the key imaging modalities for evaluating thoracic outlet syndrome patients, with CT preferred for investigating bony abnormalities and MR preferred for vascular and soft tissue abnormalities
- Knowledge of expected imaging findings in TOS patients is essential for accurate diagnosis

References/Suggested Reading