Imaging Assessment of Vascular Thoracic Outlet Syndrome
BALAJI A AYYAMPERUMAL
Department of Radio Diagnosis, MADRAS MEDICAL COLLEGE AND GOVERNMENT GENERAL HOSPITAL

Abstract: Thoracic outlet syndrome (TOS) is a complex symptom consisting of neural, arterial, and venous disorders of the upper extremity. These are caused by compression of the neurovascular structures between the clavicle and first rib in the thoracic outlet (TO). Diagnosis of TOS is difficult. Bony abnormalities are present in approximately 30% of patients with TOS, either as a cervical rib, a bifid first rib, fusion of the first rib and second ribs, clavicular deformities or previous thoracoplasty. These bone abnormalities can be better evaluated with a 3D-CT scan than direct cervical radiograms. In addition, the cervical ribs, their length, and their attachment zone in the first ribs are easily analyzed with 3D-CT.

Keyword: Thoracic outlet, costoclavicular interval, provocative maneuvers, cervical rib, upper limb ischemia

CASE REPORT:
52 Year old female presented with complaints of claudication pain to the right upper limb. Provocative maneuver did not cause paraesthesia. ONE WEEK LATER, on hand held doppler she had reduced flow in the Right Brachial artery and was diagnosed to have an emboli. She was taken up for Embolectomy. Arm was saved. Patient was referred to RGGGH for further evaluation for the cause of the embolism.

Doppler was done with 10 MHz probe at PRF of 1250 hz, Gain, 70 db, Medium Wall filter.

Fig1 Doppler of the Right Subclavian artery (RSA)

FINDINGS:
1. Doubling of PSV in the subclavian artery on 90° abduction indicating narrowing of vessel (Fig2).
2. On further abduction there was a decrease in flow, i.e., a decrease in PSV in the vessel (Fig3)(Pre occlusive stage)

Fig2 - Abduction of 90°

Fig3 - Abduction of 120° and external rotation

Fig4a

Reduction of more than 50% in the lumen diameter of Right Subclavian artery (Fig 4b)

Fig5 - Xray CERVICAL SPINE AP VIEW (cropped image)
Xray shows cervical ribs measuring 4 cm with attachment zone in the first ribs (Fig5)
DYNAMICS OF THORacic OUTLET ON CT ANGIOGRAM:

CT ANGIOGRAM (Fig 6 to 11) was performed first with the arms alongside the body and then with the arms elevated in an attempt to reproduce the vascular compression (1) (a position intermediate between those of the Roos and Wright maneuvers). Scan was done 15–20 seconds after the start of a monophasic injection of 80 mL of iodinated contrast medium(2) at a rate of 4 mL/sec.

**Fig 6a INTERSCALENE SPACE**

**Fig 6b INTERSCALENE SPACE - ABDUCTION EXTERNAL ROTATION**

**Fig 7a - RETROPECTORAL SPACE**

**Fig 7b - RETROPECTORAL SPACE - ABDUCTION EXTERNAL ROTATION**

**Fig 8a - COSTOCLAVICULAR INTERVAL**

**Fig 8b COSTOCLAVICULAR INTERVAL - ABDUCTION EXTERNAL ROTATION**

Findings: There was reduction of Subclavian artery size as depicted below.

<table>
<thead>
<tr>
<th>Costoclavicular interval</th>
<th>83 %</th>
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<tr>
<td>Scalen triangle</td>
<td>32 %</td>
</tr>
<tr>
<td>Retropectoral space</td>
<td>2 %</td>
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</tbody>
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**Findings:** There was reduction of Subclavian artery size as depicted below.

**Fig 9a - Subclavian artery diameter on neutral position**

**Fig 9b Subclavian artery diameter - ABDUCTION EXTERNAL ROTATION.**

CLAVICLE was seen to undergo a complex three-dimensional motion with flexion/abduction at the shoulder joint. Movement was to the greatest extent in a posterior direction with a lesser extent in a superior direction and rotates along its long axis forming a "PLIER" like configuration with the cervical rib.

**Fig 10a showing the "PLIER" compressing the artery within the jaws**

**Fig 10b CORONAL REFORMATTED image-Jaws of costoclavicular "pliers" FIRST RIB is relatively static.**

Cervical rib is complete (fig 11b) with fusion point adjacent to the site of insertion of the anterior scalene muscle displacing the supraventricular course of the subclavian artery.(fig 11a)

**Fig 11a 3D VOLUME RENDERED IMAGE - "PINCHED" appearance of RT Subclavian artery**
Fig 11 b. Synostosis - RIGHT CERVICAL RIB with ELONGATED C7 TRANSVERSE PROCESS on the LEFT

DIAGNOSIS: VASCULAR Thoracic Outlet Syndrome AT COSTOCLAVICULAR SPACE DUE TO Bony STRUCTURAL MALFORMATION - COMPLETE CERVICAL RIB (RIGHT).

DISCUSSION:
The term thoracic outlet syndrome was coined by Peet et al in 1956 to indicate compression of the neurovascular structures crossing the thoracic outlet. The thoracic outlet includes three confined anatomic spaces - SCALENE TRIANGLE (anterior & middle scalene muscles), COSTOCLAVICULAR INTERVAL (clavicle & first rib), RETROPECTORAL SPACE (posterior margin of pectoralis minor muscle & anterior chest wall).

Diagram showing the three compartments of the thoracic outlet and their components (modified from AJR Am J Roentgenol 2000; 174 (P)1668).

HISTORY is contributary in neurogenic TOS which helps to direct imaging. This may not be true in vascular TOS. Chest xray taken for anaesthesia fitness showed a complete cervical rib on the right. No other clavicular deformity was noted. Postural evaluation in doppler ultrasound showed a sequential narrowing of the subclavian artery determined by changes in the peak flow systolic velocity allowing more flexibility in patient positioning. On CT angiogram reduction in cross sectional area of the subclavian artery with hyperabduction was taken as a quantitative measurement of the degree of arterial compression. Our case had arterial narrowing in the Right Subclavian artery in the COSTOCLAVICULAR INTERVAL, which is formed by the clavicle and the first rib, secondary to a congenital extra rib (cervical rib) which caused arterial narrowing. The degree of compression was determined as percentage of vessel diameter reduction during the arm abduction when compared to arm at rest in concurrence with study by Masson P et al (3)

1. mild 50%
2. moderate 50 -75%
3. severe > 75%.

Our case showed 63% reduction which is a moderate reduction in lumen size. The artery remained narrowed and probably a clot formed inside the artery just beyond the narrowing due to INTIMAL STRESS causing the clot to embolise down the arm to block the circulation to hand.

Bone Abnormalities associated with TOS (4):
1. Cervical Rib
2. Elongated Transverse Process of C7
3. Abnormal First Rib or Clavicle

Soft-Tissue Abnormalities:
1. Hypertrophy of the anterior scalene muscle
2. Common belly of scalene muscle
3. Broad middle scalene muscle - inserting more anteriorly on the first rib
4. Interdigitation between the anterior and middle scalene muscles
5. Supernumerary muscles (scalenus minimus muscle)

ROLE OF MRI:
1. Demonstrate soft tissue detail including the muscles, nerves, blood vessels and fatty areas of the thoracic outlet and defines all of the vital structures of the thoracic outlet
2. Creates images in multiple planes
3. Best modality for ruling out spinal stenosis and neural foraminal stenosis.
4. Criteria for presence of neurologic compression -- Disappearance of the fat surrounding the brachial plexus and close contact with the adjacent bony structures.
5. Efficient technique to search for muscle hypertrophy (scalenus, subclavius, pectoralis minor muscles), abnormal muscles (scalenus minimus) and fibrous bands.

ROLE OF INTERVENTIONAL RADIOLOGY:
Arterial TOS: Angiography is indicated in TOS patients with suspected ischemia/embolism.

Features noted in diagnostic angiography include:
1. Stenosis and occlusion of Subclavian, Axillary, Brachial artery.
2. Extrinsic compression of vessels.
3. Increased collaterals.
4. Mural thrombosis
5. Retrograde filling of Subclavian artery from Vertebral artery.

Venous TOS: Axillo - subclavian vein obstruction at the level of first rib and clavicle noted.

Treatment of ARTERIAL TOS:
Initial Management
The initial treatment of arterial TOS is focused on revascularization in order to remedy acute ischemia if necessary. Demonstration of a fixed arterial lesion, either occlusive or aneurysmal in nature, is an indication for surgical reconstruction.

Surgical Strategies - definitive. First-rib resection via a supraclavicular approach represents the predominant treatment strategy.

Vascular Intervention:
Catheter directed thrombolysis in venous TOS during acute phase of occlusion, but the chance of restenosis is high.

Conclusions: Role of Imaging is to inform the clinician the anatomic structures undergoing dynamically induced compression, location of compression, and anatomic structures causing compression. CT with postural maneuvers is effective in demonstrating vascular compression.

Color duplex sonographic examination in association with postural maneuvers, is a valuable supplementary tool to CT and MR imaging. Arterial TOS is rare with an incidence of less than 1% and should be suspected in middle age individual with no evidence of atherosclerosis.

REFERENCE:

An Initiative of The Tamil Nadu Dr. M.G.R. Medical University
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