Digital ischaemia of the upper limbs in middle age: consider arterial thoracic outlet syndrome until proven otherwise!

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Abstract

Objectives: Patients presenting with digital upper limb ischaemia are occasionally referred to rheumatology services to rule out vasculitis. We present two cases of delayed diagnosis of arterial thoracic outlet syndrome (TOS) in middle aged patients presenting with digital ischaemia in order to raise awareness of this important pathology that requires timely surgical intervention.
Methods: Two cases of progressive ischemia of the right upper extremity caused by primarily undiagnosed compression of the subclavian artery (SCA) by an accessory cervical rib are presented. Both patients case notes, radiological images, intra-operative and postoperative findings were reviewed. Patients were followed up after at least 6 months to assess prognosis.

Results: Both patients had working diagnosis of Buerger’s disease and treated with prostaglandin infusions prior to establishment of the diagnosis of arterial thoracic outlet syndrome. Both patients were heavy smokers and one patient had bilateral symptoms and history of axial spondyloarthritis and positive HLA-B27. Surgical thrombectomy of the upper limb arteries along with resection of a cervical rib and repair of the SCA with interposition graft were necessitated to successfully heal digital ulcers in one patient. However, late presentation in the second patient led to the loss of three fingers and the need of plastic reconstructive surgery following cervical rib resection and revascularisation.

Conclusion: High index of suspicion of arterial TOS should be maintained in middle aged patients presenting with digital or upper limb ischaemia even in presence bilateral symptoms or relevant risk factors of other diagnoses such as smoking or positive rheumatological history.

Keywords: digital ischaemia; arterial thoracic outlet syndrome; cervical rib
**Introduction**

Digital ischaemia of the upper limbs remains a challenging presentation for clinicians due to the long list of differential diagnoses that are covered in practice by different specialties. Thoracic outlet syndrome occurs due to compression of the brachial plexus (nTOS), the subclavian vein (vTOS) or the subclavian artery (aTOS). Due to its rarity, aTOS is occasionally undiagnosed. Symptomatic compression of the subclavian artery (SCA) represents only 1% of TOS variations and is almost always caused by bony abnormality, such as an anomalous first rib or a cervical rib\(^1\). The latter has an incidence of 0.74% in the general population\(^2\) and can compress the SCA between the first rib and the anterior scalene muscle resulting in stenosis and intimal injury with post stenotic dilatation, thrombosis, and distal embolisation. Indeed, digital ischaemia due to microembolisation is the most common presentation of aTOS. However, such presentation is also common with other causes of digital ischaemia such as proximal sources of embolisation, vasculitis, thromboangitis obliterans, connective tissue disorders (CTD) and atherosclerotic disease of the upper limbs.

The aim of this paper is to present two cases of delayed diagnosis of aTOS. Exclusion of this pathology is paramount as timely surgical intervention can significantly reduce morbidity.

**Case 1**

A 43-year old right-hand dominant male patient with background history of axial spondyloarthropathy, bilateral sacroiliitis with positive HLA-B27 and possible history of uveitis was referred in January 2020 with bilateral digital ischaemia, worse on the right side. Six weeks prior to that he presented under the rheumatology services with milder degree of skin changes affecting his fingers in the form of blisters. His working diagnosis was Beurer’s disease in the context of history of heavy smoking. He was advised to stop smoking and received a prescription for GTN patches and calcium channel blocker tablets
along with arrangements of outpatient prostaglandin infusion sessions. At that time, the patient was seen in OPD department and declined to wait for vascular assessment and subsequently did not attend MR angiogram appointment. He reported gradual progression of ischaemia over the course of 6 weeks despite vasodilator infusions and medical treatment and was referred to the oncall vascular team. He reported no previous history of arm claudication, cardiovascular disease, or exposure to vibration tools. He was unemployed and used to be a van driver.

On examination, he was noticed to have difficult to record BP in right arm with profoundly ischaemic hand in the form of fixed mottling of thumb, index, and middle fingers, while ulnar side was pale, insensate with reduced motor function. He was noticed to have a scar on the volar aspect of his wrist and thenar eminence from previous laceration at the age of 14 which necessitated reconstructive surgery in a different hospital. He had easily palpable subclavian pulse with suspected dilatation but no pulses below, while he reported improvement in left hand blisters which had normal full complement of pulses. All vasculitis serological markers were negative, whilst an urgent CT angiogram revealed the presence of bilateral cervical ribs, compression of the right SCA in abduction position and occluded right brachial artery due to thrombosis with normal upper limb circulation on the left side (figure1a).

Hence, he underwent an emergency right cervical rib resection and brachial thrombectomy. The latter was successful in restoring pulsatile flow to the elbow level, however, attempts for smaller vessel thrombectomy was not successful due to the presence of chronic organised thrombus. The patient had uneventful recovery with palpable brachial pulse and restoration of monophasic doppler signal in the ulnar artery at the wrist level. The irreversibly ischaemic radial side of his hand became fully demarcated dry necrosis, whilst the ulnar side was preserved (figure1b). He also underwent left cervical rib resection 6 weeks later and currently is awaiting an attempt of reconstructive surgery of his right-hand utilising a groin flap.
Case 2

A 39-year old right hand dominant male patient who is normally fit and well presented in July 2019 with right hand rest pain and digital wet necrosis of the tip of his middle finger. He presented two months prior to that with milder degree of symptoms and received a diagnosis of Buerger’s disease; based on his heavy smoking history, absent distal pulses below brachial artery and CT angiogram evidence of absent runoff in small vessels below the elbow level. He was treated with anticoagulation and prostaglandin infusion. However, as he presented with worsening symptoms 2 months later, it was noticed that he lost his subclavian and brachial pulses and a repeat CT angiogram revealed thrombosis of an aneurysmal right SCA and the presence of unilateral right cervical rib that was inadvertently unreported on his previous CT scan (figure 2a).

The patient underwent emergency right cervical rib resection and subclavian artery interposition bypass with reinforced 8 mm Dacron graft. Brachial embolectomy retrieved organised brachial thrombus but -like case 1- was unsuccessful in retrieving old clots in the small vessels of his forearm. Postoperatively, the patient had well perfused hand, palpable brachial pulse and excellent doppler signals at the digital level. He underwent debridement of his fingers after 6 weeks and follow up after 6 months showed healed fingers and patent bypass graft (figure 2b).

Discussion

TOS is defined as a constellation of clinical disorders due to compression of the brachial plexus and/or the subclavian vessels at their thoracic outlet\textsuperscript{3,4}. Two cases of delayed diagnosis of aTOS are described. Both patients presented with digital ischaemia, the commonest presentation of aTOS that tends to affect young and active adults. The mean age in most published series is 37 years, with a similar proportion of men and women reported\textsuperscript{4-7}. Bony
abnormality is usually the culprit with cervical ribs being most common. Less common causes of aTOS include anomalous first ribs, fibrocartilaginous bands associated with the anterior scalene muscle, and hypertrophic callus from healed clavicle or first rib fractures. As a result of repeated compression, SCA dilatation usually occurs and turbulent blood flow results in formation of perimural thrombi that can detach and migrate as an embolic material to the upper limb arteries. Whilst both patients presented with digital ischaemia of variable degree, the first patient’s ischaemia was compounded by history of penetrating injury to his right wrist that necessitated reconstructive surgery with reported arterial injury which meant he had compromised collateral reserve in distal forearm and palmar arch.

Thorough clinical and radiological assessments are paramount for detecting patients with aTOS. The former includes measurement of blood pressure in both upper limbs, assessment of the upper limb pulses, palpation for cervical ribs and performing compression manoeuvres such as Adson and Roos tests. An initial radiological assessment that can be arranged by rheumatologists is a CXR including cervical spine views which often demonstrates the offending bone abnormality, while an MRI has the advantage of occasionally demonstrating fibrous bands. Vascular specialists frequently request duplex ultrasound which may demonstrate aneurysmal changes or elevated flow velocities correlating with a compressive stenosis. Imaging protocols usually involve patients’ arm positioned in abduction to demonstrate the compression. However, this should be accompanied by imaging in neutral position as abduction position can give a false impression of occluded SCA when it is simply compressed. In addition, compression of the SCA was found in 10% of healthy asymptomatic young individuals with abduction of the arm at the shoulder joint. In emergency presentations, a CT angiogram is the most readily available modality and can provide anatomical details regarding the presence of an osseous abnormality, a SCA post stenotic dilatation, the extent, and the location of thromboembolic occlusions.
Due to the common presence of a bony compression, treatment of aTOS almost always requires surgical intervention in the form of resection of the offending cervical rib. In asymptomatic patients, controversy exists over prophylactic resection of cervical ribs. However, we believe that the potential catastrophic consequences of conversion to symptomatic aTOS and the common association with nTOS justify surgical resection. For patients presenting with complications due to thrombosis or aneurysmal degeneration of the SCA, bony resection should be accompanied by surgical reconstruction of the SCA. The latter was needed in our second patient in the form of SCA interposition bypass, whilst the first patient had patent SCA with mild post stenotic dilatation. Despite persistent occlusion of the small vessels, the presence of sufficient collateralisation promoted healing of the digital ischaemia in the second patient and minimised the extent of amputation in the first patient.

The presented cases highlight several challenges in making the diagnosis of aTOS. Firstly, it remains a rare condition with several other more common pathologies that can cause hand ischaemia. Embolisation can originate from more proximal sources such as a cardioembolic origin. This tends to be more common in older patients with history of arrhythmias, hence physical examination and electrocardiogram are relevant investigations in this context. Atherosclerotic peripheral arterial disease is another differential in this age group, but this tends to have more insidious onset as patients present with arm claudication prior to progression to ulceration of their digits. In younger patients, vasculitis, CTDs, vibration syndromes and aTOS are likely causes of digital ischaemia. Our patients were heavy smokers which raised suspicion of thromboangitis obliterans (Buerger’s disease). The first patient had history of sacroiliitis, possible uveitis, raised HLA-B27 and bilateral symptoms, hence, a systemic cause was suspected initially. Low index of suspicion, relatively delayed imaging studies and underreporting of the SCA abnormality and cervical ribs contributed to the delay in diagnosing aTOS. Misdiagnosis of aTOS has been reported before, with patients labelled...
to have Buerger’s disease\textsuperscript{11-13}. We believe that the presence of smoking history can be an attributing factor for causing symptomatic presentation of aTOS due to the increased risk of thrombosis, while Buerger’s disease should be a diagnosis of exclusion. The presence of bilateral symptoms favours a systemic aetiology, however, aTOS should not be ruled out as cervical ribs tend to occur bilaterally in 50\% of cases\textsuperscript{14}. Both cases also lacked the typical angiographic appearance of corkscrew-like collateral blood vessels that characterises Buerger’s disease. Other clinical features of the latter include superficial phlebitis or Raynaud’s sign which can be present in approximately 40\% of patients\textsuperscript{15}. On the other hand, the lack of occupational exposure to vibrations in both patients rendered vibration-induced disease an unlikely explanation.

This report of delayed diagnosis of aTOS, along with similar previous reports\textsuperscript{11-13}, emphasise several key messages

- aTOS should be considered in all middle aged patients presenting with upper limb ischaemia.
- Smoking could be a risk factor that precipitates symptoms with aTOS as it aggravates thrombosis.
- aTOS can be a surgical emergency and timely referral is paramount.

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**Conflict of interest**

the authors declare no conflicts of interest
References

1. Cronenwett JL, Johnston KW. Rutherford's Vascular Surgery E-Book. Elsevier Health Sciences; 2014 Mar 12.

2. Haven H. Neurocirculatory scalenus anticus syndrome in the presence of developmental defects of the first rib. The Yale Journal of Biology and Medicine. 1939 May;11(5):443.

3. Vaught MS, Brismée JM, Dedrick GS, Sizer PS, Sawyer SF. Association of disturbances in the thoracic outlet in subjects with carpal tunnel syndrome: a case–control study. Journal of Hand Therapy. 2011 Jan 1;24(1):44-52.

4. Colli BO, Carlotti Jr CG, Assirati Jr JA, Marques Jr W. Neurogenic thoracic outlet syndromes: a comparison of true and nonspecific syndromes after surgical treatment. Surgical neurology. 2006 Mar 1;65(3):262-71.

5. Murphy T. Brachial neuritis caused by pressure of first rib. Aust Med J. 1910;15:582-5.

6. Ochsner A, Gage M, DeBakey M. Scalenus anticus (Naffziger) syndrome. The American Journal of Surgery. 1935 Jun 1;28(3):669-95.

7. Peet RM. Thoracic outlet syndrome: evaluation of a therapeutic exercise program. InProc Mayo Clin 1956 (Vol. 31, pp. 281-287).

8. Durham JR, Yao JS, Pearce WH, Nuber GM, McCarthy III WJ. Arterial injuries in the thoracic outlet syndrome. Journal of vascular surgery. 1995 Jan 1;21(1):57-70.

9. Criado E, Berguer R, Greenfield L. The spectrum of arterial compression at the thoracic outlet. Journal of vascular surgery. 2010 Aug 1;52(2):406-11.
10. Dzieciuchowicz Ł, Włodarczyk W, Oszkinis G. Critical upper limb ischemia caused by initially undiagnosed thoracic outlet syndrome-case report. Polish Journal of Surgery. 2012 Feb 1;84(3):158-62.

11. Hugl B, Oldenburg WA, Hakaim AG, Persellin ST. Unusual etiology of upper extremity ischemia in a scleroderma patient: Thoracic outlet syndrome with arterial embolization. Journal of vascular surgery. 2007 Jun 1;45(6):1259-61.

12. Dzieciuchowicz Ł, Włodarczyk W, Oszkinis G. Critical upper limb ischemia caused by initially undiagnosed thoracic outlet syndrome-case report. Polish Journal of Surgery. 2012 Feb 1;84(3):158-62.

13. Tiengo C, Monticelli A, Bonvini S, Wassermann V, Dalla Venezia E, Bassetto F. Critical upper limb ischemia due to brachial tourniquet in misdiagnosed thoracic outlet syndrome after carpal tunnel decompression: a case report. World journal of plastic surgery. 2017 Sep;6(3):375.

14. Luoma A, Nelems B. Thoracic Outlet Syndrome Thoracic Surgery Perspective. Neurosurgery Clinics of North America. 1991 Jan 1;2(1):187-226.

15. Olin JW. Thromboangiitis obliterans (Buerger's disease). New England Journal of Medicine. 2000 Sep 21;343(12):864-9.
Figures

Figure 1: Radiological and clinical findings of case 1

*Figure 1a: CT angiogram of the right upper limb demonstrated bilateral cervical ribs (blue arrows) and compression of the right SCA in abduction position (red arrows). The right SCA was found to be patent in neutral position with mild dilatation distal to the cervical rib.*
Figure 1b: Right hand dry necrosis 6 weeks postoperatively. The old scar on the volar side of the wrist from penetrating trauma at age of 14 is demonstrated.
Figure 2: Radiological and clinical findings of case 2

Figure 2a: CT angiogram of the right upper limb demonstrated unilateral right cervical rib (blue arrow) and compression of the right SCA in abduction position (red arrows).
Figure 2b: Right hand 6 months postoperatively with healed terminalisation of the middle finger.