The use of four-dimensional computed tomography to diagnose costoclavicular impingement causing thoracic outlet syndrome

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Abstract

Thoracic outlet syndrome is caused by compression of the neurovascular structures crossing the interscalene triangle, costoclavicular space or retropectoralis minor space. The costoclavicular space is the most frequent site of arterial compression and is mainly a result of anatomical variations and masses occupying the costoclavicular space causing a compression effect on the vascular or neural structures within it. We present a case of thoracic outlet syndrome caused by dynamic impingement of the clavicle and the second rib diagnosed by four-dimensional computed tomography scanning.

Keywords

Costoclavicular impingement, four-dimensional computed tomography, thoracic outlet syndrome

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Introduction

Thoracic outlet syndrome is caused by compression of the neurovascular structures crossing the interscalene triangle, costoclavicular space or retropectoralis minor space. The costoclavicular space is the most frequent site of arterial compression¹ and is mainly a result of anatomical variations and masses occupying the costoclavicular space causing a compression effect on the vascular or neural structures within it. We present a case of thoracic outlet syndrome caused by dynamic impingement of the clavicle and the second rib diagnosed by four-dimensional computed tomography (4D CT) scanning.

Case report

A 27-year-old left hand dominant female presented with an 18-month history of right shoulder and arm pain and crepitus when moving her scapula. The pain was over the superior aspect of the scapula and crepitus was present in the supraclavicular region. The patient described pain radiating down her arm with occasional paraesthesia and

numbness when sitting. The hand also felt cold intermittently.

Examination revealed voluntary crepitus and clunking of the shoulder. It was initially considered that this was a result of snapping scapula syndrome, although the crepitus was not located at the superomedial angle of the scapula, as would be expected with this diagnosis. Rather, the crepitus could be palpated more anteriorly and deep to the clavicle. There was a full range of motion of the shoulder and normal power of all muscle groups. Adson's test and the upper limb tension tests were negative. The right radial pulse was slightly diminished compared to the left. The patient's American Shoulder and Elbow Surgeons score² was 73, with a Simple Shoulder Test score³ of 83%.

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Plain radiographs of the cervical spine revealed no abnormalities; in particular, no cervical rib was seen. A magnetic resonance image (MRI) of the thoracic outlet was also normal. A 4D CT (wide field of view CT) was performed because of the intermittent nature of the patient's symptoms and dynamic crepitus demonstrated during physical examination.

The CT scanner used was a 320-slice, multi-detector, wide field of view scanner with 0.5-mm slice thickness (Aquilion One; Toshiba Medical Systems, Tochigi-ken, Japan). This CT scanner has a 16-cm X-ray beam (from superior to inferior) compared to traditional CT scanners (64-slice) with 4-cm coverage. It is therefore considered to be a wide field of view CT and has been utilized extensively in cardiac imaging because of its unique design. If there is no table motion during a scan, by applying continuous scanning, real-time motion assessment can be undertaken. Because the CT data set is acquired as a volume, movement of the tissue/bone of interest can be examined in any plane with the use of a post-processing workstation. This allows the optimal plane to be determined for the purpose of assessing the clinical problem.

The gantry (X-ray tube) rotation around the table and patient is performed in 0.35 seconds. Because only half of the gantry rotation cycle is required (180°) for imaging, temporal resolution is therefore 175 milliseconds. Repeating this process makes it possible to scan real-time motion within the 16-cm volume. The images can be manipulated using a workstation so that they can be examined either as a video of any structure in any plane (4D CT), a three-dimensional (3D) volume rendered view (viewing the surface of the sample being imaged) or as a two-dimensional cross-section in any plane. When the desired surface view is selected, it is possible to view the cross-section of this region/section, to examine changes with motion and to perform measurements.

The patient was positioned supine in the scanner so that their shoulder joint and scapula were within the 16-cm volume of the scan and could move freely without restrictions. During the 7-second duration of the scan, the patient rolled her shoulder through a full range of motion. This revealed that the mid-shaft of the clavicle approximated the second rib at the extreme of anteroinferior motion of the shoulder girdle (Video 1). The space between the clavicle and the second rib narrowed to 2 mm and was the cause of the patient's symptoms as a result of compression of the costoclavicular space (Fig. 1).

It is important to note that impingement of any joint may not necessarily occur at the extreme of motion. In the event of impingement occurring other than at the extremes of motion, the impingement may not necessarily be detected with routine imaging (e.g. MRI,

Figure 1. Coronal image demonstrating narrowing of costoclavicular space to 2.0 mm.

3D CT) where scans may be obtained at the beginning, mid-section and end of the motion. The ability to observe the entire motion allows the possible variations of the impingement to be fully examined.

A conservative treatment plan of physiotherapy to improve posture and a strengthening regimen for the scapula stabilizers was started. After 4 months, the patient's symptoms were improved. She experienced less pain and it was more manageable. However, there was still intermittent clunking of the shoulder. At 3-year review, the patient had minimal symptoms of clunking and no symptoms of thoracic outlet syndrome.

Discussion

The thoracic outlet includes three compartments (the interscalene triangle, costoclavicular space and retropectoralis minor space), which extend from the cervical spine and mediastinum to the lower border of the pectoralis minor muscle. Dynamic compression of the neural, arterial or venous structures crossing these compartments leads to thoracic outlet syndrome. Patients can experience symptoms of vascular compromise to the arm, paraesthesia and numbness. The diagnosis is based on the results of clinical evaluation, particularly if symptoms can be reproduced when various dynamic manoeuvres, including elevation of the arm, are undertaken. However when clinical diagnosis is difficult, the use of imaging is required to determine the nature and location of the structure undergoing compression and the structure producing the compression. Plain radiographs of the cervical spine should be performed first to identify any bone abnormalities. CT angiography or

MRI performed during postural manoeuvres are helpful in analyzing dynamically-induced compression. B-mode and colour duplex ultrasonography are supplementary imaging techniques for the assessment of dynamic vessel compression during postural manoeuvres, especially in cases with positive clinical features of thoracic outlet syndrome but negative imaging findings. MRI remains the method of choice for assessing neurological compression.⁴

Our patient also had symptoms of shoulder clicking and crepitus during forward elevation. Symptoms of shoulder clunking, clicking and popping have been attributed to many different pathologies within the shoulder joint. The aetiology is often difficult to diagnose. Painful clicking is often caused by labral pathology in younger patients⁵ and by many different causes in older patients; for example, glenohumeral or acromioclavicular joint arthritis, loose bodies, coracoid impingement⁶ and thickened bursa in the sub-acromial space.⁷ These conditions are normally identified with static imaging, such as plain radiographs, CT or MRI.

4DCT has recently been shown to be of use in describing normal joint motion. Alta et al.⁸ visualized normal motion of the acromioclavicular joint using 4DCT imaging. They were able to demonstrate that, in adduction plus resisted elevation of the arm, the main movement of the acromioclavicular joint is posterior and superior translation of the clavicle. Our patient had symptoms consistent with thoracic outlet syndrome, with minor features of vascular and neural compromise, at the same time as also demonstrating palpable crepitus during shoulder movements. The use of 4DCT was instrumental in demonstrating dynamic impingement of the mid-shaft of the clavicle with the second rib after more traditional imaging techniques failed to provide a diagnosis.

In conclusion, after no diagnosis was determined using conventional imaging, the use of dynamic imaging of the shoulder helped to identify the aetiology of painful shoulder clunking in our patient. We suggest that, with the increasing availability of 4DCT, this imaging modality may be of use in helping diagnose unusual causes of shoulder pain in patients who have otherwise normal imaging.

Declaration of conflicting interests

The authors, their immediate family and any research foundation with which they are affiliated have not received any

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Note

Ethical board review statement: no ethics approval was required.

Supplemental material

The online video is available at <http://sel.sagepub.com/supplemental>.

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