CASE REPORT

Case Report: Thoracic Outlet Syndrome in an Elite Archer in Full-draw Position

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Abstract

Background One possible pathomechanism of thoracic outlet syndrome (TOS) is shoulder abduction and extension inducing backward motion of the clavicle which causes compression on the brachial plexus. This position occurs during the full-draw stage of archery, by drawing and holding the bowstring.

Case Description A 28-year-old elite archer presented with a feeling of weakness and dull shoulder pain, and experienced decreased grip power and hypoesthesia in the ulnar nerve dermatome in the full-draw position. On CT angiography, the cross-sectional area of the subclavian artery in the costoclavicular space decreased to 40% compared with that of the subclavian artery in a noncompressed state. This patient had first rib resection through the supraclavicular approach with a clavicle osteotomy. At 3.5 years postoperatively, the patient maintained his job as a professional coach and did not have any specific complaints when teaching and demonstrating archery skills.

Literature Review A literature review revealed numerous causes of TOS, ranging from congenital abnormalities to repetitive postures related to sports activities. The abduction and external rotation (ABER) position (shoulder at 90° abduction and external rotation) has been suggested for detecting TOS and is a documented cause of compression of the brachial plexus and subclavian vessels. We present the case of an archer with TOS association with repeated use of the ABER position.

Purpose and Clinical Relevance TOS should be suspected when athletes repeatedly use shoulder extension and abduction for their sports if other pathologic conditions can be ruled out.

Introduction

Thoracic outlet syndrome (TOS), first described by Rogers [16] in 1949, was more precisely characterized in 1958 by Rob and Standeven [15] as “a set of symptoms that may exist due to compression on the brachial plexus and on subclavian vessels in the thoracic outlet region.” Since then, several potential sites of compression have been reported: the superior thoracic outlet [17], the scalene interval [2, 12, 19], the costoclavicular space [11], and the subcoracoid area [4]. Compression on various anatomic structures may be caused by the dynamic effects of function on these potential sites. Among these possibilities, the costoclavicular space is narrowed dynamically and affected by motion of the clavicle and first rib [7]. One possible pathomechanism of TOS related to the costoclavicular space is during downward motion of the clavicle or upward motion of the first rib, which causes excessive shoulder girdle depression or elevation in the first rib during

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Fig. 1 In the full-draw position in archery, the shoulder of the drawing side is maintained in abduction and extension. The elbow is maintained in flexion and the head is maintained in rotation to the opposite side.

hyperventilation [5, 8]. Another possible pathomechanism is the backward motion of the clavicle during arm elevation. Some biomechanical studies [9, 10] show shoulder abduction induces clavicle elevation, retraction, and posterior axial rotation. Although the effects of the combined shoulder position of abduction and external rotation (ABER) of clavicle motion have not been verified, Roos and Owens [18] suggested the ABER position (shoulder at 90° abduction and external rotation) might retract the clavicle, creating a scissorlike entrapment of the brachial plexus and subclavian vessels against the first rib. Consequently, the ABER position has been suggested for detecting TOS and is a documented cause of compression of the brachial plexus and subclavian vessels in the costoclavicular space [11, 14, 20].

It is conceivable that clavicle retraction also would be exacerbated when the shoulder is abducted and extended, a position integral to shooting in archery. An archery shot is divided into six stages: bow hold, draw, full-draw, aim, release, and follow-through. The posture that archers take in the process of drawing the bowstring and holding the full-draw position (Fig. 1) for an extended time (shoulder abduction and extension, elbow flexion and head rotation to opposite side) would place the clavicle in a backward position, which may cause compression on the brachial plexus and subclavian vessels. We present an elite archer with TOS associated with symptoms occurring in the full-draw position.

Case Report

Right upper-extremity symptoms developed in a 28-year-old right-hand-dominant elite male archer, who is an Olympic gold medalist. The symptoms began 2 years before presentation, were aggravated 1 year before presentation, and were especially evident during the full-draw position. For nearly 2 years the patient did not receive any specific evaluation or treatment. He was referred to our

institute with an impression of TOS from a tertiary hospital where he had visited first for evaluation of his symptoms.

At the time he presented to us the patient had felt weakness and dull pain in the right shoulder and experienced decreased grip power and hypoesthesia with a tingling sensation in the ulnar nerve dermatome in the full-draw position. These symptoms interrupted his ability to aim. He reported no neck pain or symptoms at rest, and the symptoms were not accompanied by substantial loss or gain of weight or muscle mass. The patient had no personal or family history of other specific disorders.

On physical examination, with the arm in the neutral position, the radial artery pulse of the affected side was present and strong by palpation compared with that of the contralateral side. However, when provocation tests were applied to the affected side, the radial artery pulse became weak. This change was prominent with the Wright test [21] and Roos test [17] as compared with the Adson test [1]. When the patient assumed the full-draw position of archery, a decrease of the radial pulse also occurred, but the associated symptoms, such as a feeling of shoulder weakness or a tingling sensation in the hand, were more severe and occurred faster than in other provocation tests. Plain radiographs of the chest, cervical spine, and right shoulder did not reveal signs of a Pancoast tumor, cervical rib, degenerative spinal disease, shoulder subluxation, humeral head hypertrophy, or any other anomaly.

Based on reproducible vascular symptoms, an arteriogram was obtained to determine whether a vascular lesion was present. Three-dimensional CT angiography was performed with the patient in the supine position, his head and neck turned to the left, right shoulder abducted and extended, and the elbow flexed, similar to a full-draw position in archery (Fig. 2). During the imaging, subjective symptoms were reproduced. On axial CT scans, the lower portion of the anterior scalene muscle was compressed by the retracted clavicle, inducing secondary compression of the subclavian artery in the interscalene space (Fig. 3). The coronal reformatted images obtained in the full-draw position showed marked narrowing of the costoclavicular space compared with that of the opposite side in the neutral position (Fig. 4), and sagittal reformatted CT images obtained inside the costoclavicular space and after the exit to the costoclavicular space in the full-draw position revealed an approximately 60% reduction in the cross-sectional area of the subclavian artery (Fig. 5). An oblique long-axis reformatted CT image showed an arch-shaped distortion of the subclavian artery over the first rib (Fig. 6). MRI of the cervical spine revealed no obvious cervical disc disease, abnormal muscle (eg, scalenus minimus), fibrous bands, or anterior scalene muscle hypertrophy. A sensory nerve conduction study showed the amplitude of the medial antebrachial cutaneous nerve was markedly decreased compared with the opposite side and the

Fig. 2 A three-dimensional reformatted view of a CT angiogram shows the shoulder in the full-draw position of archery.

Fig. 3 In an axial CT scan, the lower portion of the anterior scalene muscle (black arrow) was compressed by the retracted clavicle and the anterior scalene muscle induced secondary compression of the subclavian artery (arrowhead = before compression; white arrow = after compression) in the interscalene space.

motor nerve conduction study revealed that compound muscle action potential amplitude decreased by 30% as compared with the opposite side. We therefore diagnosed a right brachial plexopathy in the lower trunk level with minimal axonotmesis.

Surgery was performed by orthopaedic and thoracic cardiovascular surgeons. Through a supraclavicular approach with a clavicle osteotomy, the brachial plexus was exposed and the posterior and anterior borders were sequentially defined. The subclavian artery was identified and cleaned superficially for exposure and the interval between the anterior scalene muscle and the subclavian artery was identified. With the arm in a full-draw position, the subclavian artery and lower trunk of the brachial plexus were compressed together by the lower anterior scalene muscle in an interscalene triangle and the first rib in the costoclavicular space. The anterior scalene muscle was divided from the first rib and the subclavius muscle off the clavicle. Then, the middle scalene was incised from the first rib, and the first rib

was cleaned of ligamentous structures and pleura. Using a microsaw, the first rib was excised anterior to the artery and posterior to the brachial plexus. All compressive elements were removed and the pulse was evaluated again in the full-draw position to confirm the decrease in vascular flow was resolved. After anatomic reduction of the clavicle, internal fixation was performed using a plate and screws.

A shoulder abduction brace was applied for 6 weeks postoperatively. After that period, physical therapist-assisted passive shoulder ROM was started. Muscle strengthening exercises began 10 weeks postoperatively. Unrestricted activity including archery exercise was allowed at 4 months postoperatively after confirmation of the union of solid bone in the clavicle. The patient returned to the preoperative level of sport activities and competitive archery 8 months postoperatively. Although the patient regained subjectively 90% of his previous shooting ability at 1 year postoperatively, he resigned as a national team player and was recruited as a coach for a professional team. Three and a half years postoperatively, the patient has maintained his job as a coach and has not had any specific complaints while teaching and demonstrating archery skills.

Discussion

The effect of the postural maneuver on narrowing the costoclavicular space has been reported using CT angiography in normal or symptomatic subjects or a pressure sensor in cadavers [6, 11, 14, 20]. The clavicle above and the first rib below constitute the jaw of the costoclavicular pincers of TOS. Therefore, the distance between the clavicle and first rib and the related change of diameter of the subclavian artery have been evaluated, mainly with the shoulder in 90° abduction and external rotation, a posture that is used clinically to identify the presence of TOS. In a study of healthy subjects, Matsumura et al. [11] found the costoclavicular distance decreased nearly 50% when an arm moved from a neutral position to an ABER position; meanwhile, the subclavian artery diameter changed less than 20%. When evaluating these anatomic changes in subjects with clinical symptoms and signs of TOS, the change of costoclavicular distance was greater than 50% after a postural maneuver, and the subsequent change of the subclavian artery was recorded as a decrease in diameter from 7.5 to 5.5 mm (28%) [6]. Remy-Jardin et al. [14] noted a difference in the costosubclavian distance before and after the postural maneuver, a finding relevant to TOS owing to the discovery of the subclavian artery as being identified below the subclavius muscle in 62.5% of patients after a postural maneuver. It is reasonable that TOS could develop not only by direct bony compression but also by implication of the subclavius muscle. In our patient, TOS

Fig. 4A–B Coronal reformatted CT images obtained from both costoclavicular spaces show marked narrowing of the costoclavicular distance of (A) the affected shoulder (distance, 11.7 mm) in the full-draw position compared with (B) the opposite side in the neutral position (distance, 29.9 mm). C = clavicle; R = first rib; S = subclavian artery.

Fig. 5A–B Sagittal reformatted CT images obtained (A) inside the costoclavicular space and (B) after the exit to the costoclavicular space in the full-draw position show the cross-sectional area of the subclavian artery (7.6 mm²) decreased to 40% compared with that of the subclavian artery in the noncompressed state (19.4 mm²). C = clavicle; R = first rib; yellow arrow = subclavius muscle; white arrow = subclavian artery.

Fig. 6 An oblique long-axis reformatted CT image shows an arch-shaped distortion of the subclavian artery over the first rib. C = clavicle; R = first rib; S = subclavian artery.

was supposed to occur from compression of the clavicle and the subclavius muscle generated by retraction of the clavicle. This would yield narrowing of the costoclavicular space but not from direct contact of the clavicle or the subclavius muscle against the subclavian artery in that the

subclavian artery was encircled by surrounding soft tissue over the first rib.

Debates continue regarding the change of interscalene space after a postural maneuver [3, 11, 13, 14]. Several studies investigating healthy volunteers showed upper-limb elevation produces narrowing of the costoclavicular space and retropectoralis minor space but does not induce any obvious change in the interscalene triangle [3, 13]. However, Matsumura et al. [11] suggested there was a close relationship between the anterior scalene muscle and the clavicle with subsequent narrowing of the subclavian artery and vein after a postural maneuver in healthy volunteers. On evaluation of a patient with symptomatic TOS, Remy-Jardin et al. [14] reported a slight indentation of the anterior wall of the subclavian artery that lies behind the anterior scalene muscle was observed in 1/3 of subjects after the postural maneuver. As the clavicle passes posteriorly with abduction of the upper extremity in patients with TOS, it approaches or may ride over the anterior scalene muscle and consequently may cause arterial compression in the interscalene triangle. These events may occur more prominently with the full-draw

position in archery because this position consists of shoulder abduction and extension that induces further clavicular retraction.

Archery is described as a static activity requiring strength and endurance of the upper body, in particular, the shoulder girdle. If one remains in the draw position for an extended time, the shoulder on the drawing side is maintained in abduction and extension. Based on a biomechanical study, the general patterns of clavicle motion during arm elevation are retraction, elevation, and posterior axial rotation, which are more intense during shoulder abduction as compared with other plane elevations [10]. Therefore, shoulder abduction combined with extension would exacerbate clavicle retraction, which may be responsible for narrowing the thoracic outlet. In our patient, CT angiography showed a reduction of approximately 60% in the cross-sectional area of the subclavian artery in the costoclavicular space, which was performed in a position that mimicked the archery full-draw posture. Although the patient did not maintain the exact full-draw position owing to the restricted space of the CT tunnel, the distance between the clavicle and first rib and the cross-sectional area of the subclavian artery were substantially reduced. However, we are cautious to promote the effectiveness of the full-draw position for detection of TOS in the general population or other athletes because this case report does not provide additional information regarding changes of clavicle motion after long training in the full-draw position. TOS should be suspected when athletes have neurovascular symptoms associated with repetitive shoulder abduction and extension and other pathologic conditions can be ruled out.

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