ELSEVIER

Relevance of Bone Anomalies in Patients with Thoracic Outlet Syndrome

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Background: Skeletal anomalies are recognized as potential causes of thoracic outlet syndrome (TOS); however, there is a paucity of information regarding the specific bone anomalies associated with TOS and their relative incidence among the different clinical types of TOS. This study describes the prevalence of bone anomalies in a population with TOS.

Methods: A retrospective chart review of the clinical records and imaging studies of all patients who were surgically treated at our institution for TOS between 1991−2011 was conducted. A descriptive analysis of the cohort of patients with associated bone anomalies was performed and compared with the cohort of patients without bone anomalies.

Results: During the study period, 400 patients underwent operative procedures for TOS. Of these, 115 (29%) harbored a bone anomaly and the remaining 285 did not. The bone anomalies included 80 (69%) cervical ribs, 25 (22%) clavicular anomalies, and 10 (9%) isolated first rib aberrations. Ninety (78%) of the bone anomalies were congenital, while 25 (22%) were posttraumatic. The bone anomaly cohort was predominantly female (76%), with an average age of 36 years. The distribution of neurogenic, arterial, and venous types of TOS in the cohort with bone anomalies was 63%, 33%, and 4%, respectively, while it was 51% neurogenic, 11% arterial, and 38% venous in the cohort without bone anomalies. These distributions were significantly different (chi-squared: 56.75; $P < 0.0001$). The likelihood of neurogenic compression was roughly equivalent between the 2 cohorts (odds ratio [OR]: 1.6; $P = 0.03$), while the likelihood of arterial compression was much higher in the presence of a bone anomaly (OR: 4.0; $P < 0.001$) and the likelihood of venous compression was much lower in the presence of bone anomaly (OR: 0.07; $P < 0.001$). Conversely, 33% of all neurogenic TOS cases, 54% of all arterial TOS cases, and 4% of all venous TOS cases were associated with a bone anomaly.

Conclusions: In our experience, the incidence of bone anomalies among patients treated for TOS was 29%, which is higher than previously reported. Cervical ribs were present in 20% of our patients with TOS, an estimated 40 times higher prevalence than that in the general population. However, acquired clavicular deformities and isolated abnormal first ribs were found in 9% of our patients, accounting for almost one-third of all bone anomalies present in this TOS population. The incidence of bone anomalies is rather different among the subtypes of TOS. The strongest association with the presence of a bone anomaly occurs in patients with arterial TOS, although 46% of all our arterial TOS cases did not have a bone anomaly. The presence of bone anomalies does not seem to influence the occurrence of neurogenic TOS, while venous TOS likely has no association with congenital bone anomalies, but occasionally mid and medial clavicular fracture calluses may cause venous TOS.

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Ann Vasc Surg 2014; 28: 924–932
http://dx.doi.org/10.1016/j.avsg.2013.08.014

Manuscript received: June 12, 2013; manuscript accepted: August 28, 2013; published online: December 9, 2013.

INTRODUCTION

Estimations of the prevalence of cervical ribs in large samples of asymptomatic general populations based on plain radiographic evaluations have ranged from 0.27−0.74%,[1−4] with an estimated prevalence of elongated transverse processes at the seventh cervical vertebra of 2.2%.[4] These radiographic studies of large populations suggest that cervical ribs are complete roughly in 50% of the cases,[1] occur bilaterally approximately 20−60% of the time, are more prevalent in women, with a 2- to 3-fold greater frequency than in men, and have no clear side dominance in individuals with unilateral cervical ribs. The prevalence of congenitally abnormal first ribs is more difficult to assess. In a study involving almost exclusively young male army recruits, anomalous first ribs were present in 0.17% of the subjects.[1] However, it is not clear how many of those first rib anomalies were not associated with the presence of a complete cervical rib. Osseous anomalies of the clavicle, in the form of hypertrophic fracture callus or bone misalignment, are largely posttraumatic in origin and of unknown prevalence in the general or in the thoracic outlet syndrome (TOS) populations.

On the other hand, the prevalence of cervical ribs in a large series of patients treated for neurogenic TOS was 4.5%,[5] while the prevalence of cervical ribs increased to 8.5% in a group of 200 patients treated for all types of TOS, including 7 arterial and 33 venous cases.[6]

The most plausible inference from the increased incidence of bone anomalies in patients with TOS is related to the anatomic conflict that these abnormal bone structures—and their muscular-tendinous attachments—produce with the brachial plexus and the subclavian artery and vein in their course through the thoracic outlet (TO).

The purpose of this study was to further elucidate the incidence of bone anomalies found in patients treated for TOS, to delineate the type of bone anomalies present in these patients, and to analyze the relationship between the bone anomalies and the different clinical presentations of TOS.

METHODS

After receiving institutional review board approval, a retrospective chart review was conducted of all patients who underwent operative procedures at our institution and who had a diagnosis of TOS between 1991−2011. All cases of TOS were divided into a bone anomaly cohort and a non−bone anomaly cohort based on imaging evidence. The osseous cohort included incomplete or complete cervical ribs (Fig. 1), congenital or acquired anomalous first ribs (Fig. 2), and congenital or traumatically altered clavicles (Fig. 3). Both the bone anomaly and non−bone anomaly cohorts were further subdivided into subtypes of TOS as follows: neurogenic (NTOS), arterial (ATOS), or venous (VTOS). Each patient was categorized by primary subtype pathology; therefore, no mixed categorization was used. A more thorough chart review was conducted of the bone anomaly cases. The thorough chart review included important historical information, such as demographic data, presentation of TOS, duration of symptoms before surgery, and presenting symptoms. The common physical examination findings were elucidated through the chart review and included tenderness to palpation overlying the scalene musculature, limb swelling or ischemia, and skin color change in the vascular cohort and positive response to testing, including the Roos' test, Wright's test, and neck tilt to the unaffected side. In addition, diagnostic testing performed, surgical procedure, complications of surgery, duration of follow-up, and activity levels at final follow-up were also reviewed.

A chi-squared analysis was conducted to compare the bone anomaly cohort with the non−bone anomaly cohort. Odds ratios (ORs) were calculated to compare the odds of each subtype of TOS occurring with or without a bone anomaly. $P < 0.05$ was considered to be statistically significant.

RESULTS

Bone Anomaly and Non−Bone Anomaly Cohort Comparison

We encountered 400 cases of TOS treated surgically at our institution between 1991−2011. Of the 400 total cases, 115 (29%) cases were associated with a bone anomaly or osseous pathology, leaving 285 (71%) cases without an appreciable associated bone anomaly or pathology. The breakdown of TOS subtype is shown in Table I, with the differences in the distribution of NTOS, ATOS, and VTOS between the 2 cohorts. The percentage of TOS cases associated with a bone anomaly varied by TOS subtype; 33% of all NTOS cases, 54% of all ATOS cases, and 4% of all VTOS cases were associated with a bone anomaly. Using chi-squared analyses and ORs, we compared the bone anomaly and pathology cohort to the nonbone anomaly and pathology cohort. The results suggest that the 2 cohorts are statistically different on the basis of the distribution of TOS subtype (chi-squared: 56.75; $P < 0.0001$). In addition, while the odds of