Prevalence of cervical ribs and elongated transverse processes in Omani population: a computed tomography-based study

Marwa Al Subhi · Eiman Al Ajmi · Abdullah Al Lawati · Husain Al Aswami · Moon Fai Chan · Srinivasa Rao Sirasanagandla

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Abstract

Introduction Cervical ribs are the supernumerary ribs that usually arise from the seventh cervical vertebra. Ethnic and geographical variations in cervical ribs and elongated transverse processes have been reported. Therefore, we aimed to study the prevalence of cervical ribs and elongated transverse processes and morphometry of cervical ribs in Omani subjects using computed tomography (CT).

Methods A total of 1165 consecutive patients’ CT scans of the cervical spine who had visited the tertiary care hospital from January 2016 to December 2020 were included in the study. The CT scans were screened for cervical ribs and elongated C7 transverse processes. Fisher’s exact test was used to determine the gender influence.

Results Cervical ribs were identified in 0.94% of patients with a male-to-female ratio of 0.37:1. Most cervical ribs were unilateral (54%). The elongated C7 transverse process was identified in 18.45% of patients, with a male-to-female ratio of 1.36:1. Female patients are more likely to have cervical ribs (effect size = 5.98, 95% CI = 1.58–22.6, \( p = 0.005 \)) than male patients. In contrast, the elongated C7 transverse process is more frequent in males (effect size = 1.82, 95% CI = 1.34–2.47, \( p < 0.001 \)). The length and width of the cervical ribs are presented.

Conclusion The prevalence of cervical ribs in Omani subjects is close to that of accepted prevalence worldwide. However, the elongated C7 transverse process prevalence is comparatively high and close to the Saudi population.

Keywords Prevalence · Cervical rib · Variation · Ethnicity · Computed tomography · Morphometry

Introduction

Cervical ribs are the supernumerary ribs that form above the first ribs and usually arise from the seventh cervical vertebra. The presence of cervical ribs was previously assumed to be asymptomatic and of minimal clinical importance [7]. However, because of their important role in the pathophysiology of numerous arterial, venous, and neurological diseases, including thoracic outlet syndrome (TOS) [7, 9, 17, 23], they are becoming more well-known in the medical world. Cervical ribs can either end freely in the neck’s soft tissues or are attached to the first rib posterior to the scalene tubercle by a joint or a fibrous band [20]. Ethnic and regional variations in cervical ribs have been reported. Among different populations, its prevalence varies between 0.58% and 6.2% [4, 6, 10, 11, 22, 25]. Cervical rib prevalence in two populations from Saudi Arabia and Turkey was 3.4% and 6.2% [4, 11]. Cervical ribs typically occur unilaterally [1, 2, 4, 14, 27]. Most studies have reported a gender influence, with female...
dominance [1, 4, 6, 14]. A fine knowledge of the occurrence and anatomical variants of cervical ribs aids in understanding the various clinical conditions associated with cervical ribs. A recent study reported a positive association between cervical ribs and miscarriages [21]. Despite the increasing clinical significance, few studies have been conducted on the Middle Eastern population. Furthermore, no study has been conducted on the Omani population. The morphometry of cervical ribs is seldom reported in the literature. Therefore, we aimed to study the prevalence of cervical ribs and elongated transverse processes and the morphometry of cervical ribs in Omani subjects using computed tomography.

**Materials and methods**

**Patient population**

The present study is a retrospective cross-sectional analysis of electronic medical records of Omani patients who visited the Department of Radiology and Molecular Imaging at Sultan Qaboos University Hospital (SQUH) from January 2016 to December 2020. The Medical Ethics Research Committee approved the present study at Sultan Qaboos University.

**Acquisition protocol**

The CT scans of the cervical spine for all patients were performed using a 64-slice multidetector CT scanner (Siemens Sensation 64) with a 120 kV peak voltage and 250 mAs. The Picture Archiving and Communication System (PACS) (Synapse PACS, FUJIFILM Worldwide, version 5.7.102) was used for reviewing the scans. A slice thickness of 0.75 mm was used to assess the images in the axial plane and coronal and sagittal reformats. Each patient’s cervical spine CT scan was accessed from the CT scan database and reviewed for the presence of cervical rib (Fig. 1) and elongated transverse process. Maximum intensity projection in the coronal plane was used in all patients to evaluate the presence of an elongated transverse process of the C7 vertebra (Fig. 2), which was defined as a transverse process that extends beyond the lateral margin of the transverse process of the first thoracic vertebra. A single observer, a senior radiology resident, performed the data collection. After screening, the data from each patient were inputted into a Microsoft Excel spreadsheet.

**Data collection and diagnostic criteria**

The study included all the consecutive Omani patients’ (aged ≥ 18 years) CT scans from January 2016 to December 2020. The study targeted the adults in our patient population. Since the cervical rib is a congenital anomaly, the age group selection will not affect the true prevalence. Given that this study aimed to determine the prevalence of cervical ribs only in Omani subjects, non-Omani patients were excluded from the study. Other exclusion criteria were inadequate coverage of the area of interest and motion artifacts, limiting the assessment of the bone details. The following diagnostic

![Fig. 1](image) Axial CT images of the cervical spine in two different patients show unilateral right-side cervical rib (a) and bilateral cervical ribs (b)
criteria for cervical ribs were used as described in previous studies [4, 19].

a. The cervical rib must form a well-defined joint with the C7 vertebra, and it must project either laterally or caudally.

b. The cervical rib may articulate with the first rib but may not do so with the manubrium sterni. This feature will help differentiate the cervical rib from the rudimentary first rib.

c. The cervical rib must be discrete from the C7 transverse process.

The data pertaining to the cervical rib side (unilateral or bilateral) and the presence of elongated transverse processes and their laterality were recorded. The patient demographics, such as age and gender, were also recorded. Additionally, the following morphometric parameters of cervical ribs were measured using tools in the PACS. The maximum width and minimal width at the anterior and posterior ends of each rib were measured. For the short rib (Fig. 3), only one measurement at the posterior end was taken. Using a polygonal measurement tool in PACS, the curved length was measured.

**Statistical analysis**

The IBM Statistical Package for the Social Sciences (SPSS) for Windows v24.0 (IBM Corp., Armonk, N.Y., USA) was used for the statistical analysis of this study. All the variables collected in the study are categorical, so descriptive statistics (e.g., frequency and percentage) were used to present the results. Fisher’s exact test was used to determine the association between gender influence on the occurrence of the cervical ribs and elongated transverse processes. In addition, the odds ratio (effect size) and 95% confidence interval were used to explore how strong these relationships were.
Results

Presence of cervical ribs

In this study, 1165 patients were included; among them, 801 (68.7%) were males, and 364 (31.24%) were females. Out of 1165 patients, cervical ribs were identified in 11 patients, with a prevalence of 0.94%. Of the 11 patients, 8 were females, and 3 were males, with a male-to-female ratio of 0.37:1. Fisher’s exact test was used to determine if there was a significant association between gender and the presence of a cervical rib. The presence of cervical ribs was statistically significant (OR = 5.98, 95% CI = 1.58–22.60, \( p = 0.005 \)). The results show that female patients are 5.98 times more likely to have cervical ribs than male patients to have cervical ribs (Table 1). The length and width of all cervical ribs are presented in Table 2. In the majority of the cases, the cervical ribs (54%) were unilateral, with 36% on the right side and 18% on the left side. Bilateral cervical ribs were observed in 45% of patients. The cervical ribs of three patients were articulating with the first rib (two on the right side). In other cases, the cervical ribs ended in the soft tissues. As shown in the Table 2, in three patients, cervical ribs were short or hypoplastic.

Presence of elongated transverse processes

Among patients with cervical ribs, six patients had elongated C7 transverse processes. An elongated transverse process was identified in 215 (18.45%) patients. The elongated transverse processes were found more in males \( (n = 124; 57.7\%) \) than females \( (n = 91; 42.3\%) \) with a male-to-female ratio of 1.36:1. Fisher’s exact test was used to determine if there was a significant association between gender and the presence of an elongated transverse process. Elongated transverse processes occurrence was significantly associated with gender (OR = 1.82, 95% CI = 1.34–2.47, \( p < 0.001 \)). The results show that male patients are 1.82 times more likely to have elongated transverse processes than female patients (Table 1). Elongated transverse processes were found to be

| Parameter                  | n (%) | n (%) | Effect size (95% CI) | \( p \) value\^<sup>*</sup> |
|----------------------------|-------|-------|----------------------|-----------------------------|
| Cervical rib Presence      | 8 (72.7) | 356 (30.8) | 5.98 (1.58–22.66) | 0.005                       |
| Female                     | 8 (72.7) | 356 (30.8) |                      |                             |
| Male                       | 3 (27.3) | 798 (69.2) |                      |                             |
| Total                      | 11 (100.0) | 1154 (100.0) |                   |                             |
| Elongated process Presence | 91 (42.3) | 273 (28.7) | 1.82 (1.34–2.47) | <0.001                      |
| Female                     | 91 (42.3) | 273 (28.7) |                      |                             |
| Male                       | 124 (57.7) | 677 (71.3) |                      |                             |
| Total                      | 215 (100.0) | 950 (100.0) |                   |                             |

\*Fisher’s exact test; effect size: odds ratio

| Positive cases | Cervical rib side | Curved length (mm) | Maximum width (mm) | Posterior minimum width (mm) | Anterior minimum width (mm) |
|----------------|-------------------|--------------------|--------------------|------------------------------|-----------------------------|
| 1              | RT                | 41                 | 9                  | 2                            | 2                           |
| 2              | RT                | 56                 | 9                  | 4                            | 6                           |
| 3              | RT                | 45                 | 11                 | 3                            | 3                           |
| 4              | RT                | 28                 | 8                  | 2                            | 4                           |
| 5              | LT                | 37                 | 6                  | 3                            | 4                           |
| 6              | B/L               | RT: 48; LT: 52     | RT: 9; LT: 13      | RT: 3; LT: 4                 | RT: 5; LT: 7                |
| 7              | B/L               | RT: 34; LT: 57     | RT: 10; LT: 13     | RT: 4; LT: 5                 | RT: N/A; LT: 5              |
| 8              | B/L               | RT: 23; LT: 25     | RT: 4; LT: 5       | RT: 1; LT: 2                 | N/A                         |
| 9              | LT                | 50                 | 8                  | 3                            | 3                           |
| 10             | B/L               | RT: 43; LT: 50     | RT: 9; LT: 9       | RT: 4; LT: 4                 | RT: 8; LT: 4                |
| 11             | B/L               | RT: 31; LT: 52     | RT: 8; LT: 12      | RT: 3; LT: 5                 | RT: N/A; LT: 4              |

\^RT right side, LT left side, B/L bilateral, N/A not applicable for short ribs
bilateral in 73 patients (34.0%), left-sided in 73 patients (34.0%) and right-sided in 69 patients (32%). The laterality of elongated transverse processes and cervical ribs was not associated with gender.

**Discussion**

Evidence from a recent meta-analysis indicates that ethnic and geographical factors influence the occurrence of cervical ribs [15]. In the general population, its prevalence ranges between 0.5 and 1% [12]. The reported cervical rib prevalence varies depending on the population. A low prevalence of 0.58% was reported in the Malawian population [10]. A prevalence rate of 0.74% was reported in a mixed ethnic population in London [6]. In the Nigerian population, it was observed in 0.65% of cases [2]. In Caucasian Americans, a prevalence of 1.35% was reported [25]. Two different studies from India reported a prevalence of 1.22% and 2.67%, respectively [3, 22]. A high prevalence of 3.4% and 6.2% was reported in the Saudi Arabian and Turkish populations, respectively [4, 11]. To the best of our knowledge, we report the prevalence of cervical rib anomalies in the Omani population for the first time. It is lower than that reported in two populations from Saudi Arabia and Turkey [4, 11].

In a meta-analysis by Henry et al., the subgroup data analysis of geographical regions revealed that the highest pooled prevalence estimate (PPE) of cervical ribs was in Oceania with 15.2% (95% CI 0.0–100.0) [15]. In other regions, the PPE is observed to be very low with 1.2% (95% CI 0.8–1.7) in Asia, 1.1% (95% CI 0.6–1.7) in North America, 1.1% (95% CI 0.6–1.7) in Europe (95% CI 0.4–2.0), and 0.8% in Africa (95% CI 0.4–1.2) [15]. In the present study, we observed a prevalence of 0.94% of cervical ribs, which is close to the value of PPE reported in Asia.

It has been reported that sexual dimorphism exists in the prevalence of cervical ribs. In most studies, cervical ribs were commonly found in females [1, 4, 6, 14]. In a recent meta-analysis, the PPE of cervical ribs in females was higher than in males, although the difference was insignificant [15]. In the Saudi population, female dominance with a ratio of 2.01:1 was reported [4]. In agreement with the majority of the studies [1, 4, 6, 14], in Omani subjects the cervical rib occurrence was more frequent in females.

Cervical ribs can occur bilaterally or unilaterally. In a study by Sharma et al., on a large sample of 5000 chest radiograms, cervical ribs were more prevalent unilaterally [22]. Similarly, unilateral cervical ribs were observed more frequently in other studies [2, 4, 6, 22, 25]. In agreement with these studies [2, 4, 6, 22, 25], unilateral cervical ribs were more frequent in Omani subjects. If cervical ribs do not articulate with the transverse process, they are considered elongated transverse processes [13]. Previously, few studies have reported the occurrence of elongated transverse processes C7 (transverse apophysomegaly). In a study by Brewin et al., it was noted in 2.21% of subjects from London [6]. In a study by Bokhari et al., the elongated process was reported in 23% of Saudi subjects [4]. In Omani subjects, its prevalence is close to that of Saudi subjects. The elongated transverse process may be associated with neurological symptoms [8, 18].

The paraxial mesoderm located on either side of the neural tube forms somites. The axial skeleton is developed from the somites. The mesenchymal cells of the somites differentiate into sclerotomes and dermomyotomes [5]. The sclerotome gives rise to the whole axial skeleton. By the end of the fourth month, typical development results in 7 cervical and 12 rib bearing thoracic vertebrae formation. Hox genes direct the pattern of axial skeleton development. Any mutations in Hox genes would result in the formation of cervical ribs from the costal elements of the developing vertebral arches [6, 13].

A cervical rib may co-occur with rudimentary or absent 12th ribs or an elongated transverse process [4, 5]. In most cases, removing cervical ribs is unnecessary, as they are asymptomatic in 90% of patients. Factors such as having large breasts, poor posture, overusing the ribs, and trauma predispose to symptoms [24]. For the remaining 10% of patients with symptoms, there are numerous implications divided into neurological and vascular implications. According to a study conducted by Kataria et al., most patients with cervical ribs usually suffer due to compression [17]. Another study by Dashti and Ghasemi found that neurological symptoms were more common than vascular symptoms [9]. The shape of the cervical ribs determines the type of manifestation. Incomplete ribs affect only the brachial plexus instead of complete ribs that impact the subclavian artery. A recent meta-analysis revealed cervical rib occurrence in 30% of patients with TOS [15]. Multiple treatment modalities are available for symptomatic patients. Treatments can be conservative, including targeted muscle strengthening through exercise and pharmacological treatments [16]. Treatments can also be surgical, with resection of the first rib and scalenectomy being viable options. Newly advanced therapies such as video-assisted thoracoscopic surgeries are also available. Early treatment for symptomatic patients is preferred, as prolonged symptoms may reduce the functionality and result in deterioration [26]. The morphometry of cervical ribs reported in the present study may be useful while planning surgical procedures.

The present study has the following limitation. We could not evaluate the type of connection between the cervical rib and first rib, as it was difficult to define a free-floating or fibrous band in the CT scan for a few cases. Literature emphasized the superiority of MRI in identifying the fibrous bands since it provides higher soft-tissue resolution.
Unfortunately, MRI scans were not available for the positive cases of the study.

**Conclusion**

We report for the first time the baseline data of cervical ribs and elongated transverse process frequencies and morphometry of cervical ribs in Omani subjects. The prevalence of cervical ribs in Omani subjects is lower than that reported in other Middle Eastern population from Saudi Arabia. However, the elongated C7 transverse process prevalence is comparatively high and close to the prevalence of the Saudi population. Sexual dimorphism in occurrence of cervical ribs and elongated transverse process is observed.

**Author contributions** EAA and SRS: protocol/project development, MAS and EAA: data collection, HAA: data analysis, SRS, AAL, and MFC: manuscript writing and revision, MAS, EAA, and MFC: manuscript editing. All authors have read and agreed to the published version of the manuscript.

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**Declarations**

**Competing interests** The authors declare no competing interests.

**Conflicts of interest** The authors declare that they have no conflict of interest.

**Consent for publication** The present study has received an ethical approval to conduct the study and publish the data.

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