Research Paper

Rib Abnormalities Investigated by Computed Tomography: A Report on Common and Uncommon Cases

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ABSTRACT

Introduction: Rib anomalies include numerical and structural categories. This study investigates the costal abnormalities by computed tomography scan in an Iranian population

Methods: In a retrospective study, 400 Chest CT scans (225 (56.2%) male, and 175 (43.8%) female) aging from 18 to 89 were investigated for one year (2020 to 2021). Images were carefully observed and various abnormalities such as cervical ribs, elongated C7 transverse processes, bridging ribs, and bifid ribs were reported.

Results: Among 400 chest CT scans investigated for this study, 375 (93.7%) cases were normal and 25 (6.3%) cases were abnormal. Fourteen (8% of all the female patients) and eleven (4.9% of all the male patients) participants of abnormal cases were female, and male, respectively. Among abnormal cases, four cases of bilateral cervical ribs (total prevalence (TP)=1%), four cases of bilateral elongated C7 transverse process (TP=1%), four cases of bridging first and second ribs on the left side (TP=1%), twelve cases of bifid ribs on the left (TP=3%), and one uncommon male case were reported.

Conclusion: Being aware of the common abnormalities of rib cage is helpful in differentiating the diagnosis and seeking for possible other accompanied diseases such as thoracic outlet or Gorlin syndrome. In this study, twenty five cases of abnormal rib morphology were reported.

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1. Introduction

Twelve pairs of ribs as essential components of the bony thorax alongside twelve thoracic vertebrae, sternum, cartilages, and associated muscles contribute to protecting (thoracic and abdominal viscera), supporting, and breathing [1]. Functionally and anatomically, the rib cage can be divided into upper and lower regions, concerning the upper limb and pulmonic part of the respiratory system and the diaphragmatic part of the respiratory system, respectively [2].

Ribs development is under the control of Hox genes [3], and like vertebrae, they originated from the somites [4]. Ribs are considered part of the axial skeleton, and rib development in birds and mammals shows region-specific morphogenesis, limited to the thoracic region [4]. The potential of rib formation in somite cell differentiation is only evident in thoracic somites [4, 5].

Rib anomalies include numerical and structural categories [6, 7]. Additional or missing ribs are considered numerical abnormalities consisting of cervical ribs, elongated C7 transverse process, or missing 12th rib [8]. Structural abnormalities include fusion, bifid, hypoplastic, and bridging ribs [7, 9]. Costal abnormalities can be asymptomatic or associated with other structural abnormalities such as vertebral malformation [9]. It may be accompanied by genetic syndromes such as nevoid basal cell carcinoma (Gorlin syndrome) [10] or even cancer [11]. Gorlin syndrome is often accompanied by developmental and skeletal abnormalities such as rib abnormalities, vertebral anomalies, macrocephaly, etc. [12].

This study investigates the costal abnormalities by computed tomography scan in an Iranian population concerning the sex and age of the participants.

2. Materials and Methods

This cross-sectional retrospective study was conducted after institutional review board approval. In a retrospective study, 400 Chest CT scans (225 [56.2%] male and 175 [43.8%] female) aging from 18-89 were investigated for one year (2020-2021) in the Medical Imaging Center of Dr. Shariati Hospital, Mahdasht, Alborz, Iran. This study used a multidetector computed tomography scan (Hitachi–Supria 16/32 with 51 kW power, 75cm gantry bore, 180cm scan range, 5 mega hit unit (MHU) X-ray tube, and 0.675 mm minimum slice thickness) [13, 14]. Chest CT scans were obtained with 7mm thickness and 5mm interval, then reconstructed with thickness and gap of 1.25mm to develop the 3-dimensional volume images of the rib cage [15, 16]. Depending upon the size and depth of tissue being exposed, patients were exposed to the effective dose of 5-11 milli-Sieverts (mSv), measured according to the dose report of the CT-scanner [13]. Images were carefully observed and various abnormalities such as cervical ribs, elongated C7 transverse processes, bridging ribs, bifid ribs, and one uncommon case of widening ribs with fusion are reported.

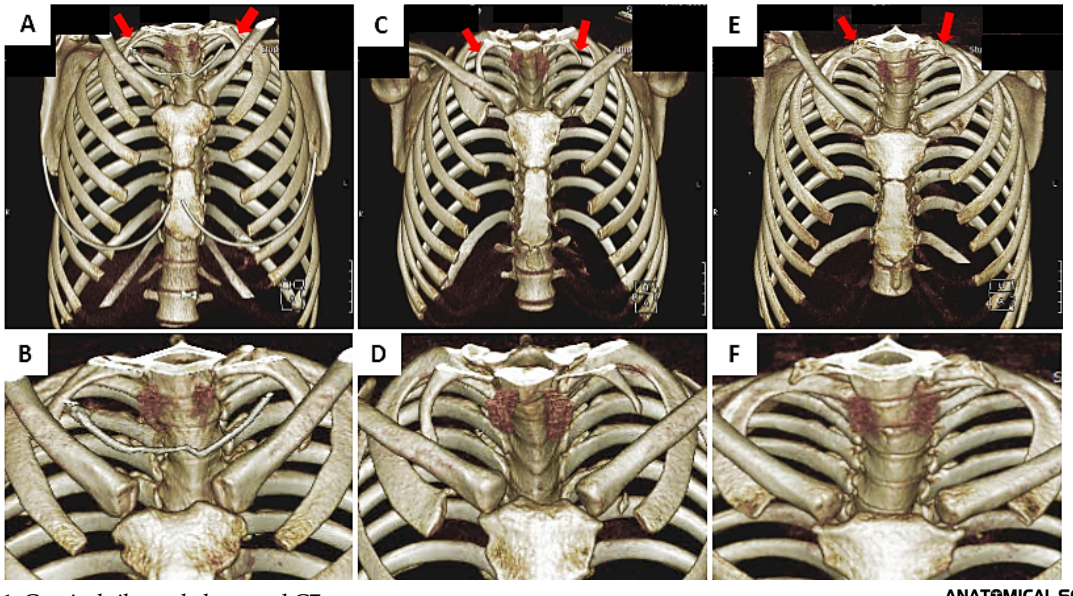

Figure 1. Cervical ribs and elongated C7 transverse process
A and C (bilateral cervical ribs), E (elongated C7 transverse process), B, D, and F are magnified images of the aforementioned images.

Table 1. Prevalence of costal abnormalities

Abnormalities												Participants					
NO. (%)																	
Total		UC*		BiR		BR		C7E		CR		Total		Abnormal		Normal	
F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
14 (56)	11 (44)	0 (0)	1 (9.1)	4 (28.6)	8 (72.7)	2 (14.3)	2 (18.2)	4 (28.6)	0 (0)	4 (28.6)	0 (0)	175 (43.8)	225 (56.2)	14 (8)	11 (4.9)	161 (92)	214 (95.1)
25		1 (4)		12 (48)		4 (16)		4 (16)		4 (16)		400		25 (6.3)		375 (93.7)	

ANATOMICAL SCIENCES

CR: cervical rib; C7E: elongated C7 transverse process; BR: bridging ribs; BiR: bifid ribs; UC*: uncommon case.

3. Results

Among 400 chest CT scans investigated for this study, 375 (93.7%) cases were normal, and 25 (6.3%) patients were abnormal. There were fourteen abnormal cases of females (8%) and eleven abnormal cases of males (4.9%). Among abnormal cases, there were four cases of bilateral cervical ribs (total prevalence (TP=1%, prevalence among abnormal cases (PAC)=16% (male=0%, female=100%)) (Table 1, Figure 1). Four cases of bilateral elongated C7 transverse process (TP=1%, PAC=16% (male=0%, female=100%)) were reported (Table 1, Figure 1). And four cases of bridging first and second ribs on the left side (TP=1%, PAC=16% (male=50%, female=50%)) were evident (Table 1, Figure 1). Twelve cases of bifid ribs on the left consisting of two bifid 3d ribs, two bifid 4th ribs, one bifid 5th rib, and one bifid 2d rib (TP=3%, PAC=48% (male=66.7%, female=33.3%)) were reported (Table 1, Figure 1). In addition, in one uncommon male case with flattened ribs, the fusion of the sternal ends of the first five ribs on the right, bridging of the first to fourth ribs on the left, and fusion of the sternal ends of the third to fifth ribs on the left was reported. This case was a 34-year-old male of 168cm height who was scanned for ruling out COVID-19. The manubrium and sternal body fusion were

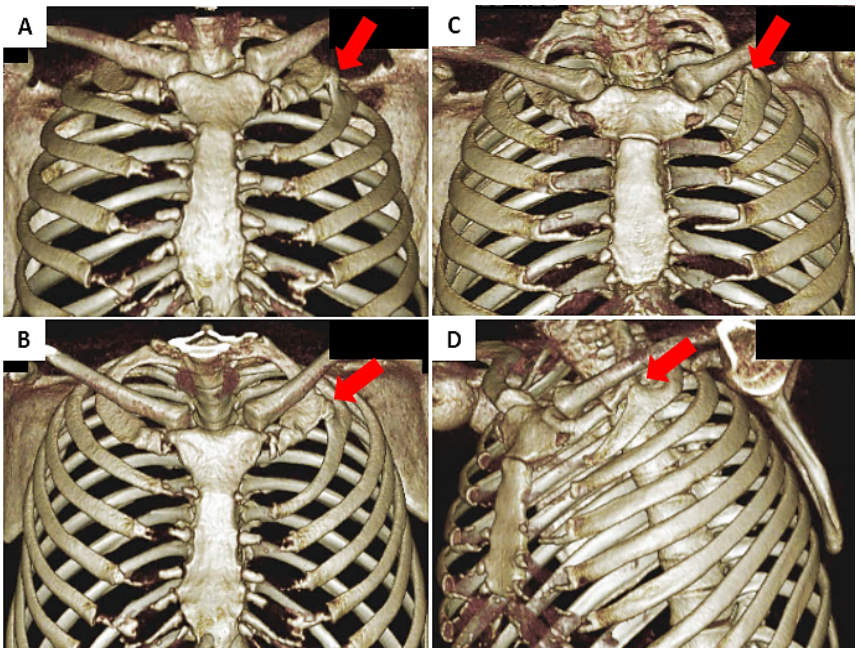

Figure 2. Rib bridging

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A and C (Rib bridging in two different cases between the first and second rib on the left); B and D (aforementioned images in different views).

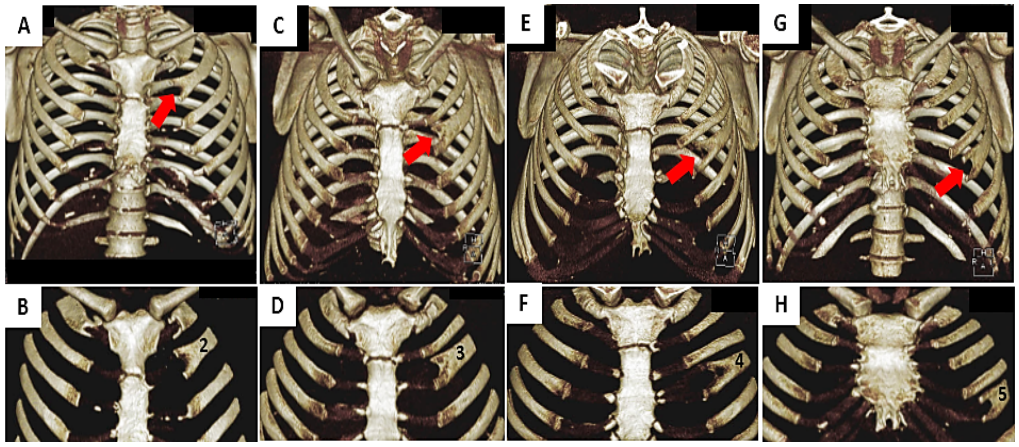

Figure 3. Bifid ribs
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A (bifid second rib), C (bifid third rib), E (bifid fourth rib), G (bifid fifth rib); B, D, F, and H (magnified aforementioned images with clear backgrounds).

observed, as well. No vertebral defect was evident (TP=0.25%, PAC=4%) (Table 1, Figures 4).

4. Discussion

Several reports of costal abnormalities exist in the literature [7, 14, 15]. In cervical ribs known to be caused by hox gene mutations [16], there is a long history of diagnosis from Galen and Vesalius to surgical excision of a symptomatic cervical rib by Cote [17]. Later cervical rib was classified into five types based on its development and attachment to the sternum [18]. The clinical significance of the cervical rib is that it may cause thoracic outlet syndromes, including vascular or neurogenic symptoms caused by compression of great vessels and brachial nerve plexus [15]. The pooled prevalence estimate of the cervical rib is 0.9%-1.4%, and it is more common in females (0.9-1.7%) than in males (0.5%-1%) [15]. As mentioned in the literature, cervical ribs are often asymptomatic and considered incidental findings in standard radiology procedures [19]. In Chang et al.'s study, 23 patients with thoracic outlet syndrome who developed subclavian artery thrombosis or aneurysm and ischemic upper extremity underwent cervical rib resections [20]. Their study also mentioned a female dominance of cervical rib presence, and cervical ribs with large size and fusion to the first rib cause significant symptoms [20]. The prevalence and female dominance of cervical ribs is reported in our study, as well.

Bifid ribs usually occur at the end of sternal ends and are reported to be asymptomatic and found incidentally [21]. The general Prevalence of bifid rib is 1.7 to 6.75% [8, 21]. In most cases, there are unilateral bifid ribs on the left [7] or right [21] with male dominance [7]. However, bilateral or multiple bifid ribs on the same side have also been reported, which may be associated with Gorlin syndrome [10, 22]. Although rib abnormality is considered a minor criterion for diagnosis of Gorlin syndrome, it has to be considered for possible co-occurrence of the disease [12]. This syndrome is caused by activation of the hedgehog signaling pathway due to loss of function mutations in the patched (PTCH1) receptor [23]. This leads to smoothened

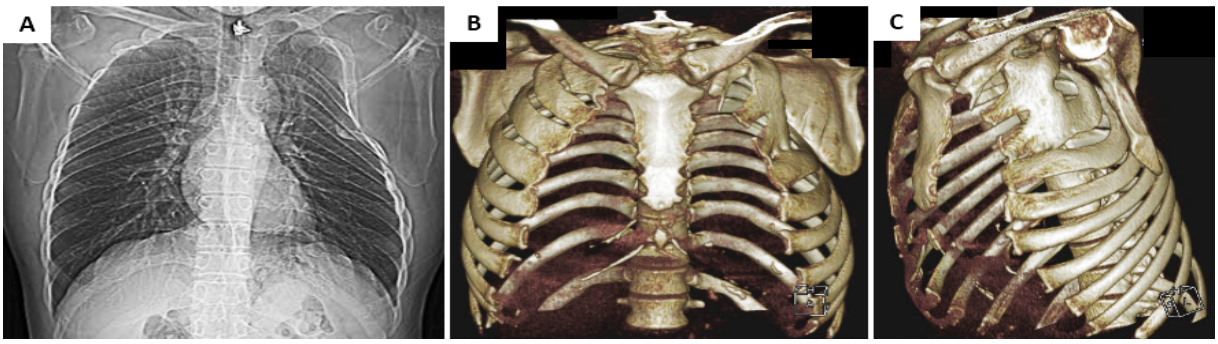

Figure 4. An uncommon case of the rib cage in a male
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A participant with flattened ribs, the fusion of the sternal ends of the first five ribs on the right, bridging of the first to fourth ribs on the left, and fusion of the sternal ends of the third to fifth ribs on the left.

(SMO) co-receptor activation, which causes activation of downstream transcription factors and target genes [24]. Activating this signaling pathway leads to cell proliferation, migration, and differentiation, resulting in several conditions, including basal cell carcinoma, medulloblastoma, and skeletal malformations [12].

In this study, the Prevalence of bifid ribs was 3%, with male dominance (66.7%) and left side occurrence of 100% (all the cases were on the left side) involving second to fifth ribs. One hundred percent (12 cases) of left side occurrence of bifid ribs in this study is a rare report because the literature implies that this anomaly is usually located on the right side [21]. No specific explanation was stated in the literature on the cause of the side-specific occurrence of bifid ribs.

5. Conclusion

This study evaluated common costal abnormalities by computed tomography in an Iranian population. Awareness of the common abnormalities of the rib cage helps differentiate the diagnosis and seek for possible other accompanying diseases such as Gorlin syndrome. Genetic testing for common genes related to Gorlin syndrome should be considered in patients with noticeable rib cage abnormalities.

Ethical Considerations

Compliance with ethical guidelines

All ethical principles are considered in this article. The participants were informed of the purpose of the research and its implementation stages. They were assured about the confidentiality of their information and were free to leave the study whenever they wished, and if desired, the research results would be available to them. A written consent has been obtained from the subjects.

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Authors' contributions

Both authors equally contributed to preparing this article.

Conflict of interest

The authors declared no conflict of interest.

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