

## Congenital abnormalities of the ribs: evaluation with multidetector computed tomography

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### Abstract

**Objectives:** To evaluate congenital abnormalities of ribs using multidetector computed tomography.

**Methods:** The retrospective study was conducted at Mustafa Kemal University Research Hospital, Hatay, Turkey and comprised data of patients aged 1-45 years who attended the Radiology Department for computed tomography of the thorax between January 2010 and July 2013. Multiplanar reconstructions, maximum intensity projections, and 3-dimensional images were acquired to investigate numerical and structural abnormalities of the ribs of the patients who underwent multidetector computed tomography for a variety of indications.

**Results:** The study comprised 650 patients. Of them, 231(35.5%) were female and 419(64.5%) male. The overall mean age was  $20.9 \pm 5.1$  years. However, data of 90(13.8%) patients was excluded from cervical rib evaluation and of 120(18.5%) from lumbar rib evaluation as these regions were out of the section because of the positioning. Finally, 560(86.5%) patients were included in the cervical rib evaluations, and 530(81.5%) in the lumbar rib evaluations. All the 650(100%) patients were included in the thoracic rib evaluations. Numerical abnormalities were observed in cervical ribs in 19(3.6%), in thoracic ribs in 1(0.15%) and in lumbar ribs in 7(1.3%) cases. The structural abnormalities were bifid rib in 44(6.7%) and fused type in 17(2.6%) cases.

**Conclusion:** Multidetector computed tomography enabled evaluation of the thoracic cage as a whole.

**Keywords:** Rib, congenital abnormality, multidetector computed tomography. (JPMA 67: 178; 2017)

### Introduction

The ribs form the thoracic cage by articulating anteriorly with the sternum and posteriorly with the thoracic vertebrae. They comprise 12 pairs of bones and cartilage and are located on both sides of the thoracic cage. The head, neck and tubercle form the proximal part and the shaft forms the distal part of the rib. Intercostal muscles, nerves and vessels are located in the 11 pairs of intercostal spaces between the ribs. The ribs are mobile and flexible structures that allow inspiration and expiration to provide gas exchange in the lungs and they protect the heart, lungs and large vessels located in the thoracic cavity. Congenital abnormalities of the ribs can be classified as numerical or structural. Numerical abnormalities are classified as supernumerary (if one has more than 12 pairs of ribs) and deficient (if one has less than 12 pairs of ribs). Structural abnormalities include bifid, forked, fused, bridging and hypoplastic ribs.<sup>1,2</sup> Chest radiographs have been widely used to investigate suspected rib fracture as the first diagnostic modality, but have shown sensitivity as low as 15%.<sup>3,4</sup> It is shown that computed tomography (CT) detected chest injuries in 39% of patients with an initial normal chest radiograph.<sup>5</sup> Therefore, needs for

more sensitive imaging techniques have led to the usage of multidetector row computed tomography (MDCT) for thorax imaging.<sup>6</sup> The nearly isotropic matching of in-plane resolution and section thickness on MDCT means that multiplanar evaluation of transaxial imaging is feasible.<sup>7</sup>

Radiologists should be familiar with a number of normal variants of the ribs to avoid misdiagnoses. Although there have been few studies on congenital abnormalities of the ribs, we did not find any study that used MDCT in the evaluation of congenital rib abnormality. The current study, therefore, was planned to evaluate congenital abnormalities of the ribs by using MDCT.

### Patients and Methods

The retrospective study was conducted at Mustafa Kemal University Research Hospital, Hatay, Turkey and comprised data of patients aged 1-45 years who attended the Radiology Department for computed tomography of the thorax between January 2010 and July 2013. Informed consent and ethics committee approval were waived because of the retrospective study design. Patients who had specific indication for thorax CT, such as a lung infection, search for metastasis, or the evaluation of a congenital abnormality were included in the study. Patients who could not be evaluated optimally because of multiple bone fractures after trauma, history of thoracic surgery,

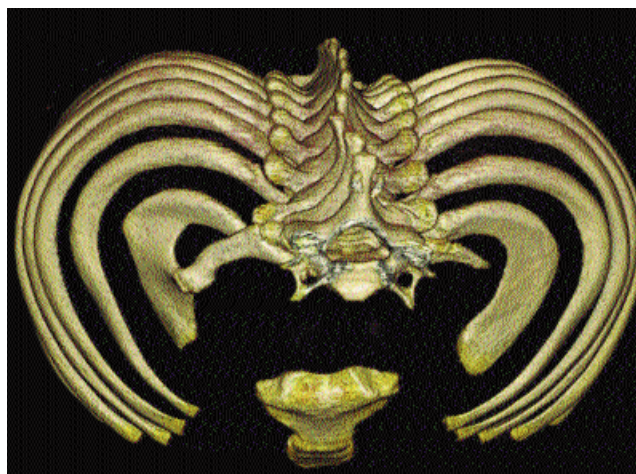
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primary or metastatic tumour, or a movement artifact were excluded from the study. The age range was limited to 1-45 years so that we did not encounter any problems with evaluation because of calcification in the costal cartilage. A 64-row MDCT scanner (Toshiba Aquilon, Toshiba Medical Systems, Otawara, Japan) was used for all the thoracic CT procedures following standard thorax protocol. At the workstation (Basic Vitrea®2, version 4.0), maximum intensity projection (MIP), multiplanar reformatting (MPR) of the sagittal and coronal plane images were performed, and three-dimensional images of the sternum were obtained. These were evaluated to explore the numerical and structural abnormalities of the ribs.

**Results**

The study comprised 650 patients. Of them, 231(35.5%) were female and 419(64.5%) male. The overall mean age was 20.9± 5.1 years. However, data of 90(13.8%) patients was excluded from cervical rib evaluation and of 120(18.5%) from lumbar rib evaluation as these regions were out of the section because of the positioning. Finally, 560(86.5%) patients were included in the cervical rib



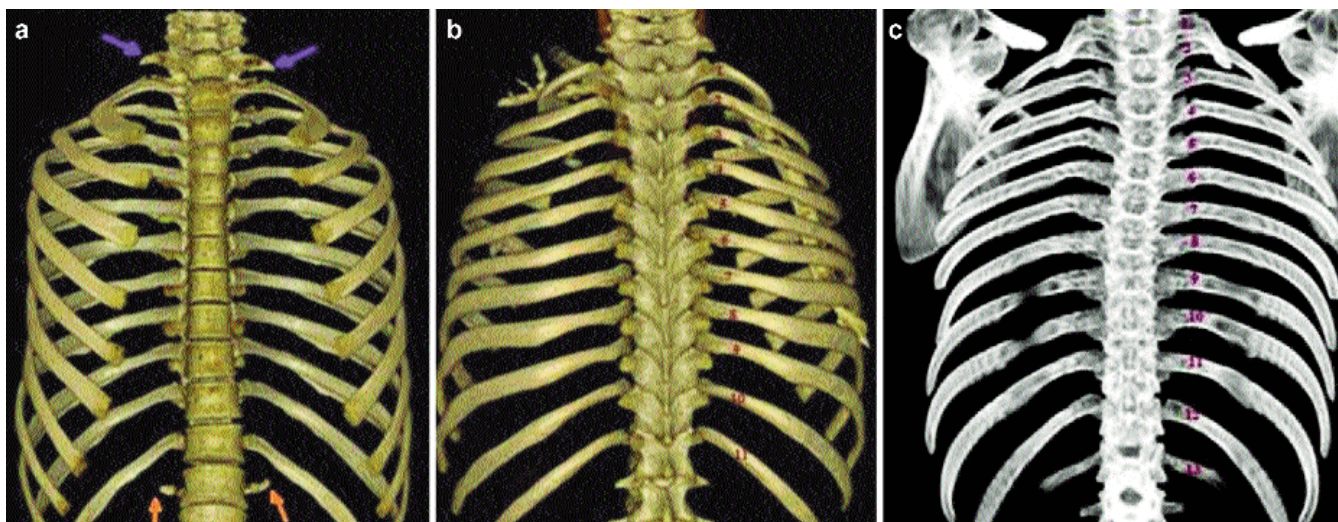
**Figure-2:** Axial 3D volume rendering multidetector computed tomography (MDCT) image shows: Bilateral supernumerary cervical ribs and fusion between the right cervical and 1st rib.

evaluations, and 530(81.5%) in the lumbar rib evaluations. All the 650(100%) patients were included in the thoracic

**Table-1:** The numbers and percentages of numerical abnormalities of ribs.

Numeric Anomaly of Ribs													
Cervical rib			Supernumerary Thoracic rib			Lumbar ribs			Pelvic rib		Deficient		
R.	L.	Bil.	R.	L.	Bil.	R.	L.	Bil.	R.	L.	Bil.	Bil.	
2	2	15	1	-	-	1	6	-	-	-	-	19	
	19 (3.39%)			1 (0.15%)		7 (1.32%)						19 (3.58%)	

R: Right; L: Left; Bil: Bilateral.



**Figure-1 A-C:** Coronal (a) 3D volume rendering multidetector computed tomography (MDCT) image shows: Bilateral rudimentary cervical ribs (blue arrows) and rudimentary 12th ribs (orange arrow), Coronal (b) 3D volume rendering MDCT image shows: Deficient type congenital abnormality (11 pairs of ribs), Coronal (c) maximum intensity projection (MIP) MDCT image shows: Supernumerary 13th ribs (lumbar ribs).

**Table-2:** The numbers, localisation, level and the types of the bifid ribs.

Case	Y.	G.	S.	C.	R.	L.	BIFID RIB			Localized of anomaly in the rib				
							Type of Bifid Rib			Cartilage	Bone	Cartilage- bone		
							Cleavage type		Outgrowth type					
Fork type	Widened type	Hole type	Incomplet hole type											
1	24	M		+		3				+		+		
2	20	M	+		2, 5	3, 5	+	(3)	+	(2)	(5), (5),	+	(5), (5), (3)	
3	24	M	+			3			+		+			
4	13	M	+			4				+				
5	12	F	+		4		+						+	
6	14	M	+		4		+						+	
7	15	M		+		3				+			+	
8	7	M	+			5			+				+	
9	35	M	+		4				+				+	
10	11	M	+			4			+				+	
11	22	M	+			3				+			+	
12	35	M	+		6				+				+	
13	6	M	+			4			+				+	
14	15	F			4, 6				(6)	(4)	(6)		+	(4)
15	6	M	+			4			+				+	
16	12	M	+		4				+				+	
17	5	F	+			4	+						+	
18	45	F	+			3				+			+	
19	44	M	+			3			+				+	
20	40	F	+		4				+				+	
21	41	M	+		3	2			(3), (2)		+	(3)	+	(2)
22	21	M	+			4			+				+	
23	25	M	+			3				+			+	
24	22	M	+		3				+				+	
25	23	M		+	3	3			(3L)	(3R)	(3R)		+	(3L)
26	27	M	+			3			+				+	
27	20	F	+		4				+				+	
28	15	M	+		5					+			+	
29	26	F	+		5	3			(5), (3)				(5), (3)	
30	20	M	+			3			+			+		
31	27	M	+		5				+				+	
32	8	M			2		+					+		
33	5	M	+			4			+				+	
34	20	M	+		2			+					+	
35	27	M	+		1	1				1 (R), 1(L)	+, +		+	
36	3	M	+			2	+						+	
37	5	M	+		4	4	(4R)		(4L)				(4R), (4L)	
38	8	M	+		4	4	4, 4						4, 4	
39	38	F	+		5					+			+	
40	35	M	+		4		4						+	
41	22	M	+		4				+				+	
42	40	M	+		3		+						+	
43	40	M	+		5		+						+	
44	26	M	+			3			+				+	

Y: Years; G: Gender; S: Simple; C: Complex; R: Right; L: Left; M: Male; F: Female.

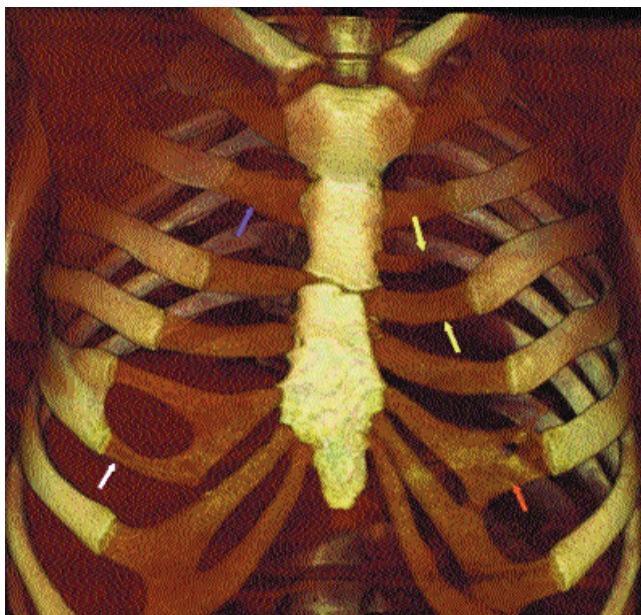
rib evaluations. In lumbar level evaluations, 7(1.32%) cases showed supernumerary lumbar ribs, 6(86%) of these were bilateral and 1(14%) was unilateral left. All were at the level of the 1st lumbar vertebra, and some

were rudimentary (Figure 1A-B). All of these patients were male. Moreover, 19(3.58%) patients had 11 pairs of ribs rather than 12 (Figure-1C), and 11(58%) of these 19 patients were male (Table-1).

**Table-3:** The level and numbers of the fusion abnormalities of ribs and co-existing hypoplasia and interruption.

Case	Y.	G.	Fusion anomaly of ribs	
			Right	Left
1	20	M	Fusion of cartilage part of 1st and 2nd ribs	Fusion of cartilage part of 3rd and 4th ribs
2	28	M	-	Fusion of cartilage part of 1st and 2nd ribs
3	29	M	Fusion of posterior bone part of 5th and 6th ribs	-
4	31	M	Fusion of cartilage part of 1st and 2nd ribs	-
5	20	M	-	Fusion of middle bone part of 1st and 2nd ribs
6	20	M	Fusion of cartilage part of 1st and 2nd ribs	-
7	27	F	Fusion of middle bone part of 1st and 2nd ribs	-
8	27	M	Fusion of cartilage part of 1st and 2nd ribs	Fusion of cartilage part of 1st and 2nd ribs
9	20	M	Fusion of cartilage part of 1st and 2nd ribs	Fusion of cartilage part of 1st and 2nd ribs
10	24	F	Fusion of cartilage part of 1st and 2nd ribs	Fusion of cartilage part of 4th and 5th ribs
11	22	M	Fusion of middle bone part of 1st and 2nd ribs	-
12	21	F	Fusion of the bone shaft of 5th and 6th ribs with multiple bridging.	-
13	12	M	-	-Fusion of bone shaft of 1st and 2nd and 3rd -Hypoplasia bone part of 1st rib
14	27	F	Interruption the cartilage and bone part of 1st rib	Fusion of cartilage part of 1st and 2nd ribs
15	36	M	Interruption the cartilage part of 1st rib	-Fusion of middle bone part of 1st and 2nd ribs - Interruption the cartilage and bone part of 1st rib
16	19	F	-Fusion of cartilage part of 1st and 2nd ribs - Hypoplasia the bone part and interruption the cartilage part of 4th rib	-
17	6	F	- Fusion of bone shaft of 2nd and 3rd -Hypoplasia bone part of 1st rib -Interruption the cartilage part of 2nd and 3rd ribs	- Fusion of bone shaft of 1st and 2nd, Fusion of bone shaft of 3rd and 4th and 5th -Hypoplasia bone part of 1st and 2nd and 3rd and 4th -Interruption the cartilage and bone part of 1st and 2nd

Y: Years; G: Gender; R: Right; L: Left; M: Male; F: Female.



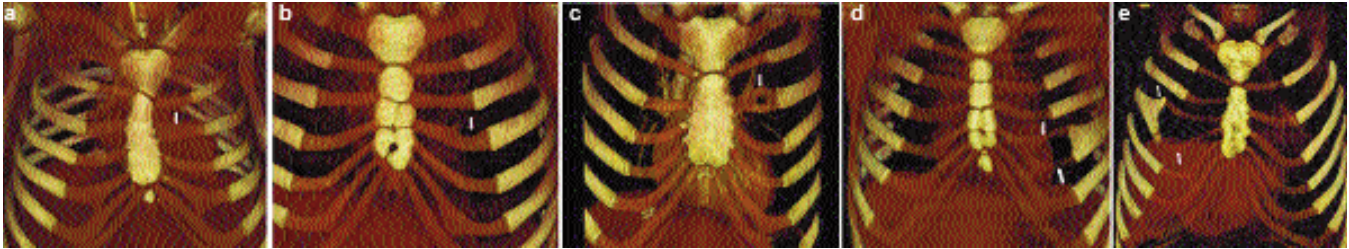
**Figure-3:** Axial 3D volume rendering multidetector computed tomography (MDCT) image shows: Having enlargement in the right 2nd rib (widened type) (blue arrow), hole type abnormality in the right 5th (white arrow) and left 5th (orange arrow) ribs and incomplete hole type in the left 3rd rib (yellow arrow), totally 4 bifid ribs (2 for each side) in a patient.

In the evaluation of the cervical region, supernumerary cervical ribs were observed in 19 (3.6%); 15(79%) of them being bilateral (Figure-2) and 14(73.6%) being male. In 2(13.3%) of the bilateral cases, the right cervical rib was prominently enlarged and had pseudoarticulation with the 1st rib.

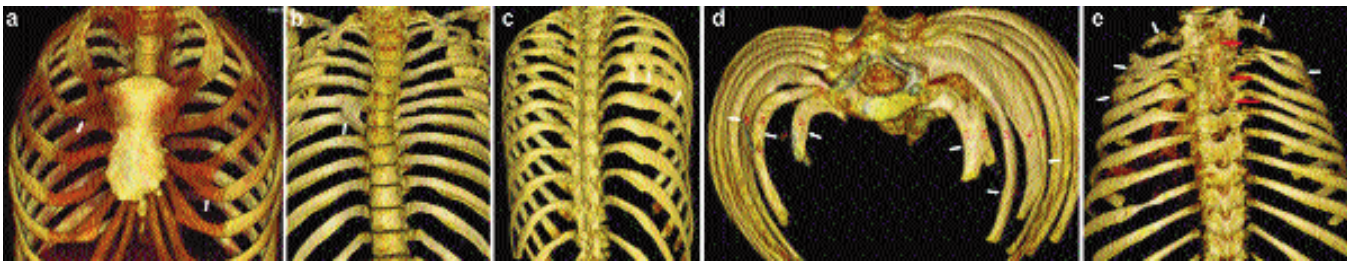
At the thoracic level, 1(0.15%) case of a 7-year-old female with a supernumerary thoracic rib started from the level of the 7th thoracic vertebra and extended parallel to the right posterior thoracic wall in a lateral and slightly anterior direction, articulating with the 7th thoracic vertebra.

In the evaluation of the structural abnormalities, all the cervical ribs were observed as rudimentary ribs except 2(0.35%) cases, both female, where the cervical ribs had pseudoarticulation with the right 1st rib. In the thoracic rib, hypoplastic changes were also observed. Apart from 2(0.37%) of the lumbar ribs, which were observed in lower thoracic region, all the others were rudimentary.

Rudimentary rib formation was noticeable in the 12th ribs in 51(9.62%) bilateral cases, 10(1.88%) unilateral left cases, and 7(1.32%) unilateral right cases. Prominent rib



**Figure-4 A-E:** Coronal (A-E) 3D volume rendering multidetector computed tomography (MDCT) images show: 8 different cases of bifid rib type congenital abnormality; (A) Enlargement in the rib (widened type), (B) Incomplete hole type, (C) Hole type, (D-E) Fork type bifid ribs (white arrows).

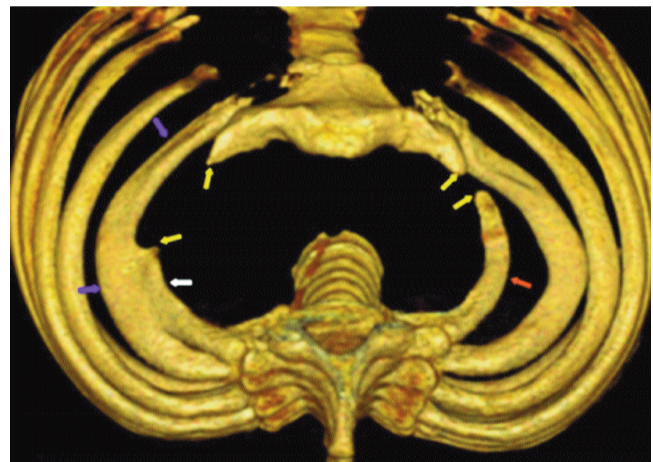


**Figure-5 A-E:** Coronal (A) 3D volume rendering multidetector computed tomography (MDCT) image shows: Fusion in the anterior cartilaginous parts of the right 1st-2nd and the left 3rd-4th ribs (white arrow), Coronal (B) 3D volume rendering MDCT image shows: Bridging type fusions (white arrows) in the posterior parts of the right 6th-7th ribs, Coronal (C) 3D volume rendering MDCT image shows: Multiple bridging type fusions between the right 5th and 6th bony ribs (white arrows), Axial (D) 3D volume rendering MDCT image shows: Fusion and hypoplastic changes between the right 2nd-3rd bony ribs and between left 2nd-3rd, 3rd-4th-5th bony ribs (white arrow), Coronal (E) 3D volume rendering MDCT image shows: Segmentation abnormality and fusion in the upper thoracic vertebrae (red arrows).

formation was not observed on the contralateral sides in 3(0.56%) of the right and 3(0.56%) of the left cases of rudimentary ribs.

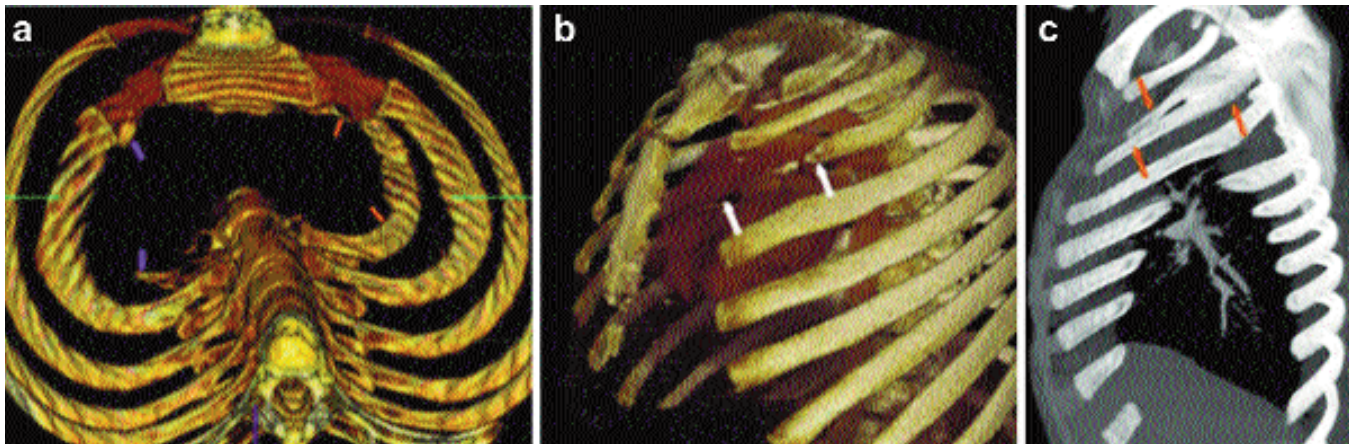
In the thoracic region, bifid rib was detected in 44(6.76%) cases that had a mean age of  $21.1 \pm 4.9$  years (range: 5-45 years). Of these, 36(82%) were male and 8(18%) were female. In these 44 cases, a total of 54 bifid ribs of various types were observed. Six (13.6%) cases had more than 1 bifid rib, with 1(16.6%) of these cases having 4 bifid ribs: 2(50%) right and 2(50%) left (Figure-3); 1(16.6%) case having 2 unilateral bifid ribs; and the other 4(66.6%) cases had 2 bifid ribs, 1(50%) on each side. In total, 27(50%) of the bifid ribs were located on the left side and 27(50%) on the right. The most common type was hole type 27(50%) cases followed by 12(22%) fork type, 10(18.5%) incomplete hole type, and 5(9.3%) widened type bifid ribs (Figure 4A-E). As no other type of rib abnormality than bifid ribs was observed in 49(7.5%) cases, these were all evaluated as a simple rib abnormality. Among them, 3(6%) cases were evaluated as complex because of the presence of another rib abnormality, 2(4%) cases showed interruption in the cartilaginous structure, and 1(2%) case showed hypoplasia (Table-2).

In total, there were 17(2.6%) case with 23 ribs having fused type congenital abnormalities. The cases had a mean age



**Figure-6:** Axial 3D volume rendering multidetector computed tomography (MDCT) image shows: Fusion between the hypoplastic left 1st rib (white arrows) and left 2nd rib (blue arrows); defect (interruption) (yellow arrows) in the right 1st rib (orange arrows) and the left 1st rib being mostly in the cartilaginous parts (yellow arrows).

of  $23.7 \pm 5.4$  years (range: 6-38) and comprised 11(65%) male and 6(35%) female. Of the 23 ribs, 12(52%) were localised on the right and 11(48%) on the left side. Having observed bilateral fusion abnormalities in 5(29.4%) cases, the most commonly observed type of abnormality was anterior fusion between the 1st and 2nd cartilaginous ribs,



**Figure-7 A-D:** Axial (A) 3D volume rendering multidetector computed tomography (MDCT) image shows: Defect (interruption) (blue arrows) in the bony and cartilaginous parts of the right 1st rib and fusion in the anterior parts of the left 1st and 2nd cartilaginous ribs (orange arrows), Sagittal (B) 3D volume rendering MDCT image shows: Hypoplasia in the bony part of the left 3rd rib and defective and bifid appearance in its cartilaginous part (white arrows), Sagittal (C) 3D volume rendering MDCT image shows: Fork type bifid appearance in the left 2nd bony rib and hypoplasia in its upper component (orange arrows), Sagittal (D) 3D volume rendering MDCT image shows: Hypoplasia in the right 4th bony and cartilaginous rib and defect (interruption) in its cartilaginous part together with the prominent enlargement in the anterior parts of the 4th-5th intercostal spaces (orange arrows).

with 7(30.4%) ribs on the right and 4(13.3%) on the left; a total of 11(48%) (Figure-5A). In 1(5.9%) case, anterior fusion was observed between the cartilaginous ribs at the level of the 3rd and 4th ribs, and in another (5.9%) case, bridging type of fusion was observed between the bony ribs at the posterior part of the 5th and 6th ribs (Figure-5B). In 1(5.9%) case, multiple bridging-type fusions were observed between the 5th and 6th ribs (Figure-5C). In 1(5.9%) case, fusions between the left 1st, 2nd and 3rd ribs was detected, and in another (5.9%), there was fusion between the right 2nd-3rd ribs and between the left 1st-2nd and 3rd-4th-5th ribs together with a deformed appearance of the ribs. In these 2(12%) cases, hypoplasia and defects in the bony and cartilaginous ribs at different levels, together with fusion abnormalities, were noticeable; prominent segmentation and fusion abnormalities in the body and posterior elements of the thoracic vertebrae were also observed (Figure 5D-E). In 3(18%) cases, 2(12%) on the right side and 1(6%) on the left, fusion was observed at the midpoint of the shafts of the 1st and 2nd ribs (Figure-6) (Table-3). Isolated hypoplasia and interruption were detected overall in 2(0.3%) cases. One (0.15%) of these patients was a 21-year-old male with isolated defective (interruption) ribs in the cartilaginous component of the right 1st rib and left 2nd rib. The other (0.15%) was a 19-year-old female with prominent hypoplasia in her right 4th rib. More than 1 type of abnormality of the ribs (complex rib abnormality) was seen in 3(0.46%) cases of bifid rib and defective (interruption) rib, and in 4(0.6%) cases of fusion and interruption abnormalities (Figure-7A-D).

## Discussion

Various numerical and structural congenital abnormalities of the ribs are observed in humans. Previous research has indicated an incidence between 0.15% and 0.32%, and different results have been observed in different studies. In one study that included 40,000 subjects, the incidence of congenital abnormality of the ribs in the population was 1.4%.<sup>8</sup> Within this proportion, bifid type rib abnormality incidence was 0.6%, fusion type rib abnormality was 0.3%, cervical rib was 0.2%, hypoplastic and rudimentary rib was 0.2%, and pseudoarthrosis of the 1st rib was 0.1%. In another study, the incidence of having a rudimentary 12th rib was 6.6% in 881 children.<sup>9</sup>

It has also been reported that congenital abnormalities of the ribs are more common in women and on the right side.<sup>10</sup> Cervical rib, being a supernumerary and accessory rib, develops from the 7th cervical vertebra. Cervical ribs are twice as common in women as in men (68% versus 32%), are bilateral in more than 50% of cases, and are asymptomatic in 90% of cases. The 10% of patients with a supernumerary cervical rib who are symptomatic usually have neurogenic symptoms, although some have arterial symptoms.<sup>11</sup>

It may be in the form of enlargement of one of the transverse processes of the C7 vertebrae or in the form of bilateral wholly developed ribs. It may show fusion with the 1st thoracic rib and may also occur with a fibrous band between 1st rib and itself. In 10% of cases, it becomes

symptomatic by pressing on the vessel-nerve sheath that extends from the neck to the upper extremity, giving rise to neurogenic symptoms.<sup>12</sup> Although generally asymptomatic, cervical ribs have been implicated in cases of thoracic outlet syndrome (TOS) because of the pressure on the brachial plexus nerves by the rib or a fibrous band that often connects the cervical rib to the 1st rib.<sup>13</sup>

If there is any pressure on a nerve, the result is neurogenic TOS, whereas pressure on vascular structures results in vascular TOS. Neurogenic TOS occurs much more frequently than vascular TOS. Pressure may be caused either by the cervical rib itself or by a fibrous band.<sup>14,15</sup> In the present study, a supernumerary cervical rib was observed in 19 (3.39%) cases, with 70% of these being bilateral. Most of our cases had rudimentary cervical ribs and no remarkable clinical findings were observed. In 2 cases, pseudoarticulation with the 1st rib was detected.

Bifid rib is seen 0.15%-0.31% of the population, more commonly in females, and occurs more frequently on the right side than on the left.<sup>16</sup> Bifid ribs are most commonly found in the 3rd and 4th ribs and less commonly found in the 2nd, 5th and 6th ribs. They are frequently asymptomatic and are detected incidentally.<sup>17</sup> They can also be observed together with Gorlin-Goltz (basal cell nevus) syndrome, Kindler syndrome, and Job's syndrome.<sup>18-21</sup>

In our study, the incidence of bifid rib was 6.76% (44 cases), of which 27 ribs were on the right side and 27 on the left. The most common location was the 3rd and 4th ribs, which is consistent with previous studies.<sup>8,17,22</sup> Although it is very rare to observe bifid ribs in the 1st ribs, but 1 case in our study had bilateral incomplete hole type bifid ribs in the 1st ribs. Bilateral and more than 1 bifid ribs are reported very rarely, but in our study we observed 6 cases; 1 of them with 2 bilateral bifid ribs (a total of 4), and 4 of the remaining 5 cases having 1 bifid rib on each side at different levels. In all of our cases, we did not observe any remarkable clinical findings. In our study, bifid rib was more common in men and was observed evenly on both sides.

In the present study, we observed 17 cases with 22 fusion type congenital abnormalities and 4 of these cases had additional abnormalities such as hypoplasia and interruption. Twelve of the abnormalities were on the right and 11 were on the left. The most common form was fusion between the 1st and 2nd ribs, which was present in 11 cases. These findings were consistent with the literature<sup>1,8</sup> In 2 cases, we detected more than 2 ribs having fusion together with noticeable congenital

abnormalities in the upper thoracic vertebrae.

Hypoplastic (short) and defective (interruption) ribs are one of the least common structural congenital abnormalities of the ribs. Short rib is diagnosed if the lateral margin of the affected rib is more than 4-mm medial to a tangent drawn between the lateral margins of adjacent ribs. This variant has been reported in only the 6th, 7th and 8th ribs.<sup>19</sup> It is slightly more common in women and on the right side. Usually asymptomatic, it is detected incidentally. It may sometimes be associated with a decrease in thoracic capacity and limitation in respiratory movement and may result in respiratory problems. It is frequently confused with rib fracture, or infectious, inflammatory or tumoral lesions of the rib.<sup>23</sup>

In 9 of our cases, hypoplasia and interruption were observed. Two of them were isolated, 3 were observed together with bifid rib, and the remaining 4 were accompanied by fusion type abnormality of the rib.

Hypoplasia and aplasia of the rib (11 pairs of ribs) can be observed together with Down Syndrome and Poland Syndrome.<sup>24,25</sup> In the lower thoracic region, a rudimentary 12th rib and asymmetry in its size are frequently encountered, but this does not show any significant clinical importance. A rudimentary 12th rib was also observed in 51 (9.62%) cases in our study, and 11 pairs of thoracic rib were observed in 19 of our cases. No remarkable clinical findings were found in our cases. The most common abnormalities reported in the literature with the highest prevalence in society are also abnormalities of the 12th rib.<sup>18</sup>

The prevalence of abnormalities was found to be higher than in other studies.<sup>1,8</sup> The reasons underlying this difference may originate from selecting the cases from people who presented at our hospital and from the high diagnostic value of MDCT.

MDCT is being used increasingly frequently in radiology. For instance, in their study as conventional radiography was found insufficient for accurate scaphoid fracture detection, Behzadi et al. offered MDCT as a first-line diagnostic tool for the detection of scaphoid fractures.<sup>26</sup> In another study which evaluated fractures of the thoracic spine in patients with minor trauma it was found that MDCT was more effective than biplane radiography in terms of diagnostic accuracy.<sup>27</sup> Yelkeler et al. evaluated effectiveness of MDCT to detect sternal variations and anomalies. They concluded that MDCT was useful to show sternal variations and anomalies and provided a better differential diagnosis with pathologic

conditions.<sup>28</sup>

In recent years, over utilisation of CT has become a critical issue with the administration of unnecessary radiation to the patients.<sup>29</sup> In a study which compared the impaired energy and effective dose values of radiography and MDCT in the diagnostic workup of the wrist, the effective dose of MDCT was calculated to be approximately 0.1 mSv.<sup>26</sup> The impaired energy of MDCT exceeded conventional radiography by far. Nonetheless, compared to the yearly natural background radiation of approximately 2 mSv in Germany, the radiation dose of an MDCT could be considered negligible.<sup>30</sup>

Our study has some limitations. First, the sample size is relatively small. Secondly, with data being retrieved from only one hospital, the results may not be generalised. Thirdly, as our study was retrospective in nature, clinical findings and congenital abnormalities observed together with the congenital rib abnormalities could not be mentioned sufficiently. Multi-centre, prospective studies with larger sample sizes are needed to generalise the results.

Despite these limitations, however, we tried to determine the efficiency and advantages of MDCT and the prevalence of congenital abnormalities of the ribs among the patients who attended our hospital. The ribs demonstrate a wide range of radiographic appearances and should be kept in mind and given attention in radiographic findings. Several such findings may be useful in identifying and diagnosing rib diseases and systemic diseases affecting the ribs. Most congenital abnormalities of the ribs are asymptomatic. However, they can sometimes be confused with traumatic, inflammatory, or tumoural pathologies. Radiologists and clinicians should, therefore, take care in the correct interpretation of these cases.

## Conclusion

MDCT has been a major technique for non-invasive evaluation of the thorax, as it provides isotropic imaging, thereby increasing the quality of all types of 3D visualisation. MDCT enabled evaluation of the thoracic cage as a whole instead of axial slices of conventional CT. While use of MDCT does increase visualisation of rib abnormalities, as clinical relevance of detection of such abnormalities is limited and to avoid unnecessary radiation burden, it will be more appropriate not to use MDCT for screening. More accurate results can be achieved if the number of cases is increased.

**Acknowledgement:** None.

**Disclaimer:** None.

**Conflict of Interest:** None.

**Funding Source:** None.

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