Some Morpho-Histological Observations on the Prenatal Developing Human Fourth Typical, First and Second Ribs (With special reference to costochondral junction CCJ)

Manal G. Abdelwahab[1]; Sohair A. Sadek[2]

[1]Prof. of Anatomy, Anatomy Department, Faculty of Medicine (Girls) Al Azhar University, Cairo, Egypt, Members of Yousef Abdul LatifJameel (YAJ) Scientific Chair of Prophetic Medicine Applications, Faculty of Medicine, King Abdulaziz University (KAU) Jeddah -Kingdom of Saudi Arabia (KSA).
[2]Prof. of Anatomy, Anatomy Department, Faculty of Medicine (Girls) Al Azhar University, Cairo, Egypt.
E-mail address: profdrmanal2018@gmail.com, walad20reen@yahoo.com

Abstract: Thirty five human fetuses aged 4, 5, 6,7 months and full term and newborn infant: (4 months (13-16wks- CRL 9-14cm)., 5months old fetuses, :(17 -20weeks) CRL 15-19cm, 6-months old fetus:(21 -24weeks) CRL 20-23cm, 7 months fetus:(25-28weeks) CRL 24-27cm old fetuses. human full-term :(33-36 weeks) CRL 31-34cm) and newborn infant (37-38 weeks) CRL 35-36cm) were used in the present study. Five adult cadavers were used for comparison. The ribs were dissected and morphological studies were done using hand lens and dissecting microscope. It was found that in the fourth typical ribs in all the ages studied the rib was formed of anterior end, shaft and posterior end. The rib had an angle which divided it into posterior 1/4 cylindrical part and an anterior 3/4 flattened part from side to side. The angle became more open with age progress. The rib had two borders; upper and lower and two surfaces; inner and outer. There was slight twist in the shaft of full term only and was not noted in previous fetal ages, whereas there was a great twist in adult rib: The costal groove was hardly detected in full term. The lower border became sharper with age progress. The posterior end was formed of head, neck and tubercle which were not developed at ages 4 and 5 months fetuses and were first noted at the age of 6-months old fetus:(21 -24weeks- 20-23cm) and became more prominent with age progress. The angle of the fourth typical rib was more open in the younger ages and tended to be more acute with age progress. There was no twist in the fourth rib. Increased size and length of the ribs with age progress was noted. The fetal first rib in all ages studied was the highest, shortest, strongest, flattest and most curved and fixed rib in comparison to the other ribs. It had a broad and thick anterior end. That broadness and thickness increased with age progress. The neck of the first rib slope obliquely. It had no true angle as its angle coincided with its tubercle. That false angle increased in depth and became more acute with age progress. The first rib was flat from above downwards, it had upper and lower surfaces and outer and inner borders. The scalene tubercle and the grooves in front and behind the tubercle were only detected at full term. All the features were prominent in adult rib. In all the ages studied the length of the developing fetal second rib was two times as long as the corresponding first rib at the same age. It had upper and lower surfaces. The most characteristic of the second rib was that it developed a broad rough tubercle at the middle of its outer surface. That was first clear at the age of 5-month-old fetus and was more prominent with age progress. The change in the angle with age progress was to accommodate for the respiratory function and the position of sleeping on the back of the developing human fetus. The changes in the rib features were necessary to bring normal thoracic cage with no defects or deformity, as idiopathic scoliosis (AIS) and kyphosis. Histological examination of part of TS&LS of the 4^{th} typical developing prenatal human rib at the age of 6-months old fetus:(21 -24weeks- 20-23cm) and full term:(33-36 weeks) CRL 31-34cm) showed that the costochondral junction (CCJ was formed of chondroblasts arranged in columns embedded in matrix, standing on bony trabeculae .Some cells showed twin appearance, Few blood vessels were seen. Chondroblasts columns were regularly arranged in simple one row in the age of 6month prenatal. Chondroblasts increased in size with age progress at full term and the Chondroblasts columns were in some sections regularly arranged, and in another sections were irregular crowding, bizzar arrangement according to the cause of fetal death. Periphysis, encircling the metaphysis and depicting the wedge-shaped groove of Ranvier and the thin layer of intramembranous bone (bone collar, bone bark or perichondrial ring of La Croix) were noted, the junctional line was curved regular between two zones of the chobdroblasts columns at full term prenatal fetus. The periosteum covered both surfaces of the rib. The bone of the rib was formed of irregular anastomosing trabeculae. The trabeculae were covered with the osteoblasts which were bone forming cells. The periosteum was fibrous sheath surrounded the outer surface of the developing prenatal human rib. It composed of two layers: an outer layer made of dense white fibrous tissue consisted of blood vessels, and an inner layer consisted of loose tissue containing osteoblasts. The inner layer was the osteogenic or osteoblastic (germinative) layer which formed new bones cells. Intercostal muscles were seen. The chobdroblasts columns were simple in one row at the age of 6month fetus and became crowded complex with enlarged size of chondroblasts in full term.

[Manal G. Abdelwahab and Sohair A. Sadek. **Some Morpho-Histological Observations on the Prenatal Developing Human Fourth Typical, First and Second Ribs (With special reference to costochondral junction**

CCJ). *J Am Sci* 2023;19(4):98-119]. ISSN 1545-1003 (print); ISSN 2375-7264 (online). http://www.jofamericanscience.org 07.doi:10.7537/marsjas190423.07.

Key words: Developing prenatal human rib- costochondra junction –Morphology-histology.

Introduction:

William et al. (1995) mentioned that ribs developed from costal processes of the primitive vertebral arches, extending between the myotonic muscle plates the development of the ribs usually limited to the thoracic vertebrae although ribs could arise occasionally from the seventh cervical vertebrae. In thoracic region, costal processes grew laterally to form a series of pre-cartilagenous ribs. The transverse process, at fist connected to the rib by mesenchyme which later became differentiated into ligaments and other tissues of the costo- transverse joints

The capitular-costo-vertebral joints were similarly formed from mesenchyme between the proximalend of the costal process and the pericordal disc., and adjacent neural arch derived parts of usually two (somite one) vertebral bodies.

Duval et al. (1998) described a new autosomal recessive syndrome of sever microcephaly and skeletal anomalies including posterior gap defects.

Kunus et al. (1999) mentioned that human first ribs demonstrated pridectable, sequential changes in shape, size, texuter with increasing age, and thus could be used as indicator of age at death. Metamorphosis of the first rib shead, tubercle and costal facet was documented in cross sectional samples of pre adult and from Hamman-Todd skeletal collection (Cleveland museum of Natural History Cleveland chio).

Kunus et al. (1999) conducted blind tests of the usefulness of the rib as an age indicator, including tabulation of intra -observer, and inter - observer in accuracies and biases by decade comparable to those generated by other aging techniques. They stated that indeed the first rib method was useful as an indicator of isolated age

When used in conjunction with other age indicator. The first rib improved the quality of summary of age assessment.

Aruga et al. (1999) described skeletal abnormalities appeared in Zicl-deficient mice. The mice showed multiple abnormalities in the axial skeleton in the dorsal parts of vertebral arches, but less that 50% in the vertebral bodies (spina befida oculta) the proximal ribs were deformed having ectopic process. They attributed the abnormalities to gene mutation

Huang et al. (2000) mentioned that the somites of vertebrate gave rise to sclerotomes and dermoyotoes. The sclerotomes formed the axial skeleton. Whereas the dermomyotomes gave rise to all trunk muscles and dermis of the back. The ribs were thought to be the ventral processes of the axial skeleton and therefore to be derived from the sclerotomes; however recently the dermomyotomal origin of the distal rib (the costal shaft) was suggested with only the proximal parts (head and neck of the rib) being of the sclerotomal origin. Huang et al. (2000) reinvestigated the development of ribs in quail chimeras and stated that the cells of the dermomyotome gave rise to epaxial and hypaxial trunk muscles, dermis of the back and endothelial cells, but not to ribs. Cells of the sclerotomes formed the axial skeleton and all parts of the ribs. Their results strongly confirmed the traditional view of the sclerotomal origin of the ribs.

Shi et al. (2014) in their study developed a statistical rib cage geometry model accounting for variation by age, sex. stature and body mass index (BM). Thorax CT scan were obtained from 89 subjects approximately evenly distributed among 8 age groups and both sexes, Threshold-based CT image segmentation was performed to extract the rib geometries, and a total of 464land marks on the left side of each subjects ribcage were collected to describe the size and shape of the rib cage as well as the cross section al geometry of each rib principal component analysis and multi variant regression analysis were conducted to predict rib cage geometry as a function of age, sex, stature and BMI, all of which showed strong effects on rib cage geometry .Except for BMI, all parameters showed significant effects on rib cross-sectional area using linear mixed model. That statistical rib cage geometry model could serve as a geometric basis for developing parametric human thorax finite element model for quantifying effects from different human attributes on thoracic injury risks.

Standring et al. (2016)) reported that the costal element of the seventh cervical vertebra might be a mere epiphysias on its transverse process was long enough but more often it had neck and tubercle. When a shaft was present, it was of variable length and extended anterolaterally into the posterior triangle of the neck, where it might end or join the first rib, its costal cartilage or even the sternum. Cervical rib might be partly fibrous but its effects were not related to its osseous part. If it was long enough. its relations were those of first thoracic rib: the brachial plexus and sub clavian vessels were superior and apt to suffer compression in narrow angle between the rib and scalenus anterior. Hence. Cervical ribs might first be revealed by neurovascular symptoms. Particularly those caused by pressure on the eighth and first thoracic spinal nerves. A cervical rib (pleurapophysis) might show synostosis or diarthrosis with either the anterior (parapophysial) or the posterior (diapophysial) roots of the called seventh cervical transverse process or more usually with both.

Standring et al. (2016) pointed that the ribs were of elastic arches, each consisting of highly vascular trabecular bone containing large amount of red marrow enclosed in a thin layer of compact bone, the ribs articulated posteriorly with the vertebral column and front the greater part of thoracic skeleton. Their number might be increased by cervical or lumbar ribs or reduced by the absence of the twelfth pair. The first seven (true) ribs connected to the sternum by costal cartilages; whilst the remaining lower five false ribs either join the superjacent costal cartilage (8-10) or float free at their anterior ends as relatively small and delicate structures tipped with cartilage (11-12). The tenth rib might also floated; the incidence varied from 35% to 70%depending on ancestry.

Sadler 2019 mentioned that the bony portion of each rib was derived from sletome cells that remained in the para-axial mesoderm and that grew out from the costal processes of thoracic vertebrae. Costal cartilage was formed by sclerotome cells that migrated across the lateral somatic frontier into the adjacent lateral plate mesoderm. The sternal ends were formed in the parietal (somatic)layer of lateral plate mesoderm on either sides of the midline, and those later fused to form cartilaginous model of the manubrium sternebrae and xiphoid process. They added that occasionally, extra ribs were formed usually in the lumber or cervical regions. Cervical ribs occurred in approximately 1% of the population and were usually attached to the seventh cervical vertebra. Because of its location, that type of rib might impinge on the brachial plexusus or the subclavian artery, resulting in varying degrees of anesthesia at the limb.

de Farias et al. (2020) mentioned that ribs were asymptomatic or had a nonspecific, anatomical variations, they were usually detected as incidental findings on imaging studies. Ribs might have isolated changes or could be related to anomalies or clinical syndromes. Such variations were easily seen in radiography and computed tomography if they were not actively investigated, mainly because most indications for a chest X-ray study aimed to evaluate the lung parenchyma and mediastinal structures. de Farias et al. (2020) made pictorial essay to use multislice computed tomography images to illustrate the imaging aspects of the main anatomical variations and congenital anomalies of the ribs. They reported that the cervical rib was an accessory or supernumerary rib that articulated posteriorly with the seventh cervical vertebral body (C7). Its prevalence in the general population ranges from 0.2% to 2%, and it was more common in females. However, it was a common finding in individuals with Klippel-Feil syndrome. It could be unilateral or asymmetrically bilateral and was typically asymptomatic. It could be related to brachial plexus neuropathy and vascular compressions, such as thoracic outlet syndrome and aneurysms of the ipsilateral subclavian artery. The differential diagnosis should include an elongated transverse process of C7 or a short first rib.

de Farias et al. (2020) reported that an intrathoracic rib was a very rare variation, characterized by a bony prominence of a rib into the chest cavity. It was usually a supernumerary rib, unilateral (most commonly on the right), and asymptomatic, although it might have diaphragmatic insertion with repercussions on respiratory function. They a proposed classification related to genetic changes): type Ia = supernumerary rib originating from the anterolateral portion of the vertebral body; type Ib = supernumerary rib originating from the posterior portion of another rib, adjacent to the vertebral body type II = rarer, bifid rib with the intrathoracic bony segment in the distal portion of the rib; and type III = depression of the rib into the chest cavity. The association of more than one type was also possible.

de Farias et al. (2020) demonstrated rib fusion and mentioned that it could be complete or partial, affecting the anterior portion of the rib or its posterior portion. It was believed to result from a failure of segmentation, because it could also be related to segmentation failure of vertebral bodies.

de Farias et al. (2020) pointed that short (hypoplastic) rib was one that did not extend anteriorly as far as the sternum, probably due to early fusion of the epiphyseal growth plate. That variation occurred in approximately 16% of the population, was more common on the right than on the left, and could occur bilaterally. It was usually asymptomatic, constituting an isolated finding, but might be associated with skeletal dysplasias, such as thanatophoric dysplasia, achondroplasia, Ellis-van Creveld syndrome (chondroectodermal dysplasia), Jeune syndrome (asphyxiating thoracic dystrophy), and other short-rib polydactyly syndromes. That bifid rib, also known as Luschka's forked rib, a bifid rib was the most common variation, characterized by a division in its anterior portion, in its bony and cartilaginous aspects, typically affecting the fourth rib). de Farias et al. (2020) concluded that it was also associated with Gorlin syndrome. The ribs present numerous normal radiological aspects, anatomical variations, and pathological conditions, sometimes mimicking alterations of the lung parenchyma on radiography, which were best elucidated by MSCT. Their accurate evaluation was extremely important, because various imaging findings could be useful as indicators of known or unknown bone dysplasia, heart disease, metabolic disease, trauma, and neoplasia. Radiologists should be familiar with the variations from normality, in order to avoid confusing them with pathological conditions.

Assi et al. (2021) analyzed patterns of 3D rib cage deformity in subjects with adolescent idiopathic scoliosis (AIS) and their relationship with the spinal deformity. Subjects with AIS present with rib cage deformity that could affect respiratory functions. They studied the 3D rib cage deformities in AIS and their relationship to the spinal deformity was still unelucidated: A total of 200 AIS and 71 controls underwent low-dose biplanar x-rays and had their spine and rib cage reconstructed in 3-dimensional (D). Classic spinopelvic parameters were calculated in 3D and: rib cage gibbosity, thickness, width, volume and volumetric spinal penetration index (VSPI). Subjects with AIS were classified as: group I with mild rib cage deformity (n=88), group II with severe rib cage deformity (n=112) sub grouped into IIa (high gibbosity, n=48), IIb (high VSPI, n=48), and IIc (both high gibbosity and VSPI, n=16).They found that Groups IIa and IIb had a higher Cobb angle (33 vs. 54 degrees and 46 degrees, respectively) and torsion index (11 vs. 14 degrees and 13 degrees, respectively) than group I. Group IIb showed more severe hypokyphosis (IIb=21 degrees; IIa=33 degrees; I=36 degrees; control=42 degrees) with a reduced rib cage volume (IIb=4731 cm3; IIa=4985 cm3; I=5257 cm3; control=5254 cm3) and thickness (IIb=135 mm; IIa=148 mm; I=144 mm; control=144 mm). Group IIa showed an increasingly large local gibbosity descending from proximal to distal levels and did not follow the axial rotation of the spine. Group IIc showed characteristics of both groups IIa and IIb. They Conclude that the new classification of 3D rib cage deformity in AIS showed that the management of cases with high VSPI (groups IIb and IIc) should focus on restoring as much kyphosis as possible to avoid respiratory repercussions. Treatment indications in groups I and IIa would follow the consensual basic principles reported in the literature regarding bracing and surgery.

Schlager et al. (2022) studied the morphological patterns of the rib cage and lung in the healthy and adolescent idiopathic scoliosis. They ponounced that the rib cage affected both the biomechanics of the upper body's musculoskeletal structure and the respiratory mechanics. That became particularly important when evaluating skeletal deformities, as in adolescent idiopathic scoliosis (AIS). They aimed of their study to identify morphological characteristics of the rib cage in relation to the lung in patients with non-deformed and scoliotic spines. Computed tomography data of 40 patients without any visible spinal abnormalities (healthy group) and 21 patients with AIS were obtained retrospectively. All bony structures as well as the right and left lung were reconstructed using image segmentation. Morphological parameters were calculated based on the distances between characteristic morphological landmarks. Those parameters included the rib position, length, and area, the rib cage depth and width, and the rib inclination angle on either side, as well as the spinal height and length. They determined the left and right lung volumes, and the area of contact between the rib cage and lung. Differences between healthy and scoliotic spines were statistically analyzed using the t-test for unpaired data. The rib cage of the AIS group was significantly deformed in the dorso-ventral and medio-lateral directions. The anatomical proximity of the lung to the ribs was nearly symmetrical in the healthy group. By contrast, within the AIS group, the lung covered a significantly greater area on the left side of the rib cage at large thoracic deformities. Within the levels T1-T6, no significant difference in the rib length, depth to width relationship, or area was observed between the healthy and AIS groups. Inferior to the lung (T7-T12), these parameters exhibited greater variability. The ratio between the width of the rib cage at T6 and the thoracic spinal height (T1-T12) was significantly increased within the thoracic AIS group (1.1 ± 0.08) compared with the healthy group (1.0 ± 0.05). No statistical differences were found between the lung volumes among all the groups. While the rib cage was frequently strongly deformed in the AIS group, the lung and its surrounding ribs appeared to be normally developed. The observed rib hump in AIS appeared to be formed particularly by a more ventral position of the ribs on the concave side. Furthermore, the rib cage width to spinal height ratio suggested that the spinal height of the thoracic AIS-spine was reduced. Their results indicated that the spine would gain its growth-related height after correcting the spinal deformity. Those were the important aspects to consider in the etiology research and orthopaedic treatment of AIS.

Histology of the costochondral junction CCJ of the prenatal developing human rib:

Emery and Kalpaktsoglou (1967) mentioned that the rib was an ideal bone for studying linear growth, being probably the most rapidly growing bone in a linear fashion throughout the whole of intrauterine . The costochondral junction appeared as a column of cartilage cells sitting between regular strands of matrix and standing on bony trabeculae. It had a rather static architectural appearance. That gave a completely false concept. The length of a 5th or 6th rib at birth was approximately 120 mm. It had reached that length in considerably under 280 days, that was at a rate of over 0 * 43 mm. per day which implied a growth of 0 - 22 mm. (220 ,u), at each end, a day. The depth of a cartilaginous cell at the costochondral junction was approximately 14, u. If they supposed that only a half of the increased length of the rib came from the growth of the costochondral junction, that meant that a column 16 cells in depth-almost the whole of the large ballooned cartilaginous cells-were being completely replaced each day. Thus, the costochondral junction should really be considered more like a slow-firing multibarrelled rocket! Packets of cartilage cells were being pushed daily into the barrels of matrix. The cartilage cells blew up into columns and 'exploded' into the bone cavity, 'pushing' the cartilage cavity further away from the bone, and leaving a sort of slip-stream of matrix behind. Ten years ago, they established criteria for normality and abnormality of the costochondral junction for the foetus and newborn, and, after the study of about 500 costochondral junctions, their criteria were presented to the Pathological Society (Emery, 1957). Since that time, they had had the opportunity of examining over 5000 costochondral junctions from perinatal and child deaths. That had confirmed their original concepts of the normal appearances, and their conviction that the routine study of the costochondral junction was one of the most valuable examinations that could be carried out in perinatal pathology. Their paper was concerned with three objectives. (1). A description of the appearance of the normal costochondral junction at birth and during the latter third of intrauterine life. They summarized their histological study of the costochondral junction, which had been carried out on a large series of perinatal deaths, that the normal and abnormal appearances of the costochondral junction of the older foetuses were described as follows: Two types of deformity were found, interpreted as due to growth arrest and to a bizarre form of growth. The evidence suggested that, of children dying during labor or in the neonatal period, approximately 75%0 showed evidence of disordered growth in utero before labor had begun. The histological study of the costochondral junction was an extremely valuable part of the study of any perinatal death.

Gruber et al. (1990) pointed out that Knowledge of the structure of cartilage vascular canals was important for a more thorough understanding of the development of cartilage and the growth plate in the human neonate and growing child. They had studied the costochondral junction of 6 normal neonates and 12 normal children (age 4 months-16 years) and utilized quantitative histomorphometry to define the percentage tissue area occupied by canals and the number of canals/mm2. Both percentage canal area and the number of canals/mm2 were significantly greater in newborn vs. older children (percentage area: 0.42 +/- 0.15 (mean +/- S.E.M.) vs. 0.08 +/- 0.04, P = 0.003; number/mm2: 0.2 +/- 0.09 vs. 0.04 +/- 0.02, P = 0.02). Eight newborn patients with achondrogenesis II-hypochondrogenesis were also studied. Both percentage canal area and number were significantly elevated above normal (percentage area: 5.22 +/- 1.01, P less than 0.001; number/mm2: 1.45 +/- 0.26, P less than 0.001). They mentioned that their results demonstrated that: (i) quantitative differences in vascular canal area and numbers occurred during development; (ii) 10-fold increases in vascular canal area and number were present in achondrogenesis II-hypochondrogenesis. Data from normal subjects would provide normative values against which vascular abnormalities in other skeletal dysplasias could be compared.

Peltomaki and Hakkinen (1992) mentioned that the growth of the costochondral junction was important to plastic and oral surgeons and orthodontists since rib grafts were used as substitutes for ankylosed and/or underdeveloped mandibular condyles in children. The growth of a mandibular condyle reconstructed with a costochondral graft should equal that of an intact condyle in order to ensure continuous balanced facial growth. Clinical and experimental findings indicated, that the growth of rib grafts was unpredictable (Ware & Taylor, 1966; Ware & Brown, 1981; Heffez & Doku, 1984; Politis et al. 1987) and overgrowth was the most serious consequence (Peltomaki & Isotupa, 1991). The mechanisms accounting for the growth of rib grafts remained obscure, but both intrinsic (Ware & Brown, 1981; Daniels et al. 1987) and extrinsic factors (Poswillo, 1974 &1987) had been proposed. Stimulation of the longitudinal growth of ribs in situ had been seen to be due to local hypervascularisation (Agadir et al. 1989, 1990), which probably caused elevation in locally circulating humoral factors.

Peltomaki and Lari Hakkinen (1992) examined in situ the growth of the ribs at the costochondral junction by 2 methods. In the first, 3 threads were tied around the 5th, 6th or 7th ribs of 20-d-old rats. The first thread was located around the bony part of the rib close to the costochondral junction, the second around the cartilaginous part the same distance away from the junction, and the third also around the cartilaginous part but further away. They found that the distances between the threads were measured at 20 and 40 d and were found to have increased considerably. In the second part, an immunohistochemical method using bromodeoxyuridine was employed to detect proliferating cells at the costochondral junction. The most active cell proliferation was observed in the proliferative zone, but mitoses were also noticed in the germinative zone. Their results provided further evidence that the growth potential of costochondral grafts used in reconstructive surgery was related to the length of their cartilaginous portion.

Peltomäki (1994) pointed that costochondral grafts were commonly used to restore dysplastic mandibular condyles. Despite their worldwide use, the growth of the condyle-ramus unit constructed with a costochondral graft was highly unpredictable, excess growth being the most common consequential problem. In a recent series of experiments on rats, it became evident that the amount of cartilage, more precisely the amount of germinative cells, in the rib graft had a direct bearing on its growth capacity. They studied the histology of the human costochondral junction of growing individuals. It was implicit from the height of the proliferative plus hypertrophic cell zones of the junction that the grafts used clinically had always contained germinative cells, but in variable amounts. Thus, the reported growth variability of the condyle-ramus unit might be due to the amount of cartilage included in the grafts.

Yousefzadeh et al. (2008) studied gray-scale US and perfusion patterns of different cartilages in 42 normal neonates for the first time. Group A included the proximal femoral chondroepiphysis of 20 neonates as well as proximal humeral, distal femoral and proximal tibial epiphyses of 8 others. Group B included the patellar cartilage of nine neonates and group C included the rib cartilage of five neonates. They found that early ossifying cartilages all had numerous echogenic columns on US. Late ossifying patellar cartilage was amorphous and hypoechoic at birth but contained echogenic columns near the ossification age. Rib cartilage was hypoechoic and amorphous at all ages. The blood supply was detectable in all cartilages except the ribs. The rib cartilage did not have any discernable blood supply at any age. They concluded that cartilage blood flow was detectable with current technology. Cartilage blood flow correlated with the timing of its ossification. Normal cartilage blood flow might prognosticate normality of its growth and development potential.

Beresheim et al. (2020) mentioned that there was considerable variation in the gross morphology and tissue properties among the bones of human infants, children, adolescents, and adults. They studied 18 known-age individuals (n_{female}=8, n_{male}=9, $n_{unknown}$ = 1; birth to 21 years old), from a well-documented cemetery collection, Spitalfields Christ Church, London, UK, to explores growth-related changes in cortical and trabecular bone microstructure. Micro-CT scans of mid-shaft middle thoracic ribs were used for quantitative analysis. Results were then compared to previously quantify conventional histomorphometry of the same sample. Total area (Tt.Ar), cortical area (Ct.Ar), cortical thickness (Ct.Th), and the major (Maj.Dm) and minor (Min.Dm) diameters of the rib demonstrate positive correlations with age. Pore density (Po.Dn) increased, but age-related changes to cortical porosity (Ct.Po) appeared to be non-linear. Trabecular thickness (Tb.th) and trabecular separation (Tb.Sp) increased with age, whereas trabecular bone pattern factor (Tb.Pf), structural model index (SMI), and connectivity density (Conn.D) decreased with age. Sex-based differences were not identified for any of the variables included in their study. Some samples displayed clear evidence of diagenetic alteration without corresponding changes in radiopacity, which compromised the reliability of bone mineral density (BMD) data in the study of past populations. Cortical porosity data are not correlated with two-dimensional measures of osteon population density (OPD). They pointed that their results suggested that unfilled resorption spaces contributed more significantly to cortical porosity than did the Haversian canals of secondary osteons. Continued research using complementary imaging techniques and a wide array of histological variables would increase our understanding of age- and sex-specific ontogenetic patterns within and among human populations.

Elisa and Suma et al. (2021) mentioned that histological examination of the rib was of critical value in perinatal pathology and pointed to the health of the child preceding death. The rib was considered ideal because it was the most rapidly growing long bone in infants and demonstrated growth arrest at onset of the insult. They aimed to identify: 1: changes in the perichondrial ring in the rib of infants and children up to 16 months of age dying suddenly at their institution and 2: any association with presence of histological changes of vitamin D deficiency (VDD) /metabolic bone disease (MBD) in the growth plate.

They made a retrospective review of the perichondrial rib histology and comparison with the presence or absence of histological features of VDD in the growth plate of 167 cases. The cases were anonymised and divided in six age/sex categories. They found that periphyseal abnormalities were only seen in 38% of the cases; of whom 33% had established and 67% had mild changes. Only 14.5% of cases with established histological appearance of VDD at the growth plate had significant PR abnormality; of whom majority (83%) were ≤3 months of age and none ≥9 months old, reflecting a temporal relation with birth and beyond the perinatal period. They concluded that the histological changes in the perichondrial ring were significantly associated with histological changes of VDD /MBD at the rib growth plate with an Odds Ratio of 3.04.

Omar et al. (2022) pointed that the functions of the ribs were critical, as they protected the contents of the thoracic cavity and mediastinum, move superiorly, inferiorly, anteriorly and posteriorly to facilitate breathing, provided a place where some muscles originate or attach, and played a role in erythropoiesis during development.

The ribs were critical in breathing since their flexibility in their movement increased/decreased the size of the thoracic cavity; assisting the lungs in respiration. Control of these movements was via the diaphragm, external intercostals, and the intercartilaginous portion of the internal intercostals. At birth, the erythropoiesis sites changed, it receded in long bones and persisted in flat bones, like ribs. The ribs formed embryologically by the differentiation of somites. Somite formation started when the paraxial mesoderm began to spiral and form a somitomere. Subsequently, somitomeres aggregated and form somites

Omar et al. (2022) mentioned that many muscles acted on or affected the movement of the ribs. Those muscles were: Pectoralis major, Pectoralis minor, external abdominal oblique, Rectus abdominis, Subclavius, Serratus anterior, external intercostal, Internal intercostal, Innermost intercostal Diaphragm Quadratus lumborum Transversus thoracis Latissimus dorsi, Serratus posterior superior, Serratus posterior inferior.

There were variants in rib cage's volume as it was10% smaller in females than males. The cranio-caudal inclination of the ribs was greater in females. The females' ribs grew longer relative to the axial skeleton than in males. The developmental deformities and cervical/short rib that mimics true rib diseases. The ribs can be counted by palpation to determine the site of thoracentesis or a thoracostomy tube. The rib count was also done before surgery to ensure that one opened the thoracic cavity in the proper location.

Ribs fractures comprised 12% of total fractures in patients. (The risk notably increased with age). Other common abnormalities were. Rib dislocation Costochondritis, Osteoporosis Tumors

Pectus excavatum and pectus carinatum were the most common chest deformities in young patients. These lesions affected the patient psychosocially and physiologically; chiefly because the deformity was cosmetic. Besides, some of those patients might also experience difficulty with respiration. Surgical correction was done when necessary; to avoid complications affecting the heart and lungs..

The aim of the work is-1 to find out some observations on the morphology of the developing fetal fourth typical ribs, first rib and second rib. Adult corresponding ribs from new cadavers (male and female) were used in this work for comparison.2 – Some observations on the histology of the prenatal developing human 4^{th} typical rib at chostochoral junction at the ages of 6month and full term as that might indicate prenatal diseases. Knowledge of rib histology at chostochoral junction might help manage the diseases, knowledge the morphology of the prenatal developing human ribs was essential to understand the fundamental basis of the pathological lesions and chest deformeties, consequently proper diagnosis and correction of the deformaties and injured structures.

Material and Methods:

35 Human (male and female) fresh fetuses aged 4, 5, 6, 7, and 9 months (full term) 4-9 months old fetuses from to4 months, (13-16wks-CRL 9-14cm). full-term :(33-36 weeks) CRL 31-34cm) new born infant) 37-38 weeks) CRL 35-36cm) were used in this investigation. The fetuses were obtained from the miscarriage and spontaneous abortion with no apparent abnormalities or macerations, obtained from Gynecology and Obstetrics Department Al -Zaharaa hospital- Faculty of medicine for girls –Al-Azhar University. Nasr City -Cairo -Egypt (according to medical ethics). They were used to study the normal morphogenesis of the developing prebatal human fetal fourth typical ribs, first rib and second rib. Adult corresponding ribs from new cadavers (male and female) were used in this work for comparison. The cadavers were obtained from the Dissection room at the – Anatomy Department - Faculty of medicine for girls -Al Azhar University, Cairo -Egypt. Dissection of the developing and adult ribs was done according to Romanes (2000). The ribs were obtained after removal of the remains of serratus anterior and pectoral muscles from upper ribs.

Morphologic examination of the ribs was done by naked eyes, magnifying lenses and dissecting microscope. To illustrate the morphology of the developing ribs, photos were photographed by Canon camera zoom.

Measurements of rib lengths were done by using the centimeter tape and measurements of the ribs angles was done by using the protractor.

The CRL of each fetus was obtained and then converted into weeks of menstrual prenatal ages according to tables of Streeter (1920), Langman (1975) and Sadler (2012) Table (A), Table(A) prenatal ages according to (Sadler2012& 2019)

Table (A): Growth in Length and Weight During the fetal Period

Proposed Age (months)	Age (wks)	Crl (cm)	Weight(g)
2-3	9-12	5-8	10-45
3-4	13-16	9-14	60-200
4-5	17-20	15-19	250-450
5-6	21-24	20-23	500-820
6-7	25-28	24-27	900-1,300
7-8	29-32	28-30	1,400-2,100
8-9	33-36	31-34	2,200-2,900
9-10	37-38	35-36	3000-3.400

Materials &Methods for Histological study

Dissection of both sides of the prenatal developing human thorax of the miscarage or spontaneous abortion obtained from al Zahraa medical hospital-Al Azhar University –Department of gynacology and obstetrics –Cairo- Egypt. Dissection was held according to Romanes (2000) to expose the ribs. For histological study, specimens from the ribs at the costochondral junctiobns, of 6 months old fetus:(21 - 24weeks) CRL 20-23cm), and full term:(33-36 weeks) CRL 31-34cm) were collected freshly and fixed in 10% formal saline solution for 10 days, then dehydrated, cleared in benzene, embedded in paraffin wax, cut serially at 7 microns thickness and stained with haematoxylin and eosin stain for detection of general histological structures, (Drury & Walington, 1980).

Results:

General Morphologic examination of thoracic cage: Figs 1-7

General morphologic examination of thoracic cage showed that the ribs were separated by the inter costal spaces, Ribs increased in length to the seventh and thereafter diminished. They decreased in breadth downwards;. The first two ribs presented special features. Whereas the remainder conformed to common plan. The angle of the fourth typical rib, rib was more open in the younger ages and tended to be more acute with age progress. Increased length of the ribs with age progress

Morphology of the developing fetal Human Fourth typical rib (Figs.1. &5a. b.c), Tables1.2&A&B

Morphological examination the of developing rib showed that fourth ribs of fetus aged 4 months (13-16wks-CRL 9-14cm) old fetuses showed that the rib had anterior which joined the costal cartilage, shaft and posterior end.

The size and length of the ribs increased with age progress (Table 1). The anterior end had shallow concave area for tis cartilage lateral end. The rib had an angle which divided it into posterior cylindrical fourth and anterior three fourth flat from side to side which formed the main part of the rib. The shaft was long and had upper rounded and lower borders, and two surfaces outer and inner. The lower border became sharper with age progress. The costal groove was not clear. The posterior end had a head, neck and tiny tubercle which was not developed at age 4 and 5 months in 5months old fetuses, :(17 -20weeks) CRL 15-19cm and was first noted at age of 6months (21 -24weeks-20-23cm) and with age progress they became more prominent., (Table 2). No twist of the fetal ribs was seen.

Morphology of Human fourth typical rib of full-term :(33-36 weeks) CRL 31-34cm) and newborn infant (37-38 weeks) CRL 35-36cm) (Figs .1 &3a. b.) &Table A&B.

Morphological examination the of full term fourth rib showed that the parts of the ribs consisted of shaft, anterior end and posterior end. The rib increased in size and length that previous age. Similar to previous age the posterior end was higher than the anterior end. The angle of the rib became more open than previous ages and the angle divided the rib into anterior cylindrical fourth and posterior three fourths. The lower border was sharper than previous ages; the rib had two surfaces with inner shallow costal groove. There were more prominentn head, neck and tubercle than the previous ages at the posterior vertebral end without clear rough areas or facet. Slight twist appeared at the full-term age.

Morphology of Human fourth typical rib of adult (Figs. &5a. b.c))

Morphological examination the of the adult rib showed that fourth

The rib had a shaft with anterior and posterior ends. The anterior end had small concave costal depression. The shaft had external convexity and was grooved internally near its lower border which was sharper in comparison with the upper border. The posterior vertebral end had a head, neck and tubercle. The head presented two facets, separated by transverse ridge. The lower and larger facet articulated with the corresponding vertebra, the ridge attached with the inter vertebral disk above. The neck was the flat part beyond the neck, anterior to the corresponding transverse process, it was oblique facing anteroposterioly. Its posterior inferior surface was rough. Its upper border was sharp and the lower border was rounded. The tubercle was prominent at the junction 1of the neck with the shaft.

Morphology of the developing fetal Human first rib (Figs.1&5a.b.c) (Tables. A & B) & (Tables.3&4)

Morphological examination the of developing first rib showed that first rib of fetuses aged 4,5.6.7 months (4 months (13-16wks-CRL 9-14cm)., In 5—months old fetuses, :(17 -20weeks) CRL 15-19cm, 6-months old fetus:(21 -24weeks) CRL 20-23cm, 7 months fetus:(25-28weeks) CRL 24-27cm old fetuses and full term showed that the first rib had two ends: anterior and posterior attached to the shaft. The anterior end joined the costal cartilage, and posterior vertebral end. The first rib was the highest, shortest, strongest, most flat, curved and most fixed in comparison to other ribs of the same age. The rib was directed downwards towards the sternum. The length and size of the rib increased with age progress (Table3)

The first rib of all ages studied; prenatal, and adult showed that it had broad and thick anterior end which joined the costal cartilage more than any other rib of the same age. The anterior end increased in broadness thickness with age progress , shaft and posterior end, of the first rib in all ages studied had external and internal borders, superior and inferior surfaces ,anterior costal end and posterior vertebral ends .The external border was convex, thick posteriorly and thin anteriorly .The anterior end of the first rib was the largest end compared with the anterior end of the other ribs, There were many features that became more prominent with age progress as scalene tubercle and shallow grooves appeared at 6-months old fetus:(21 -24weeks) CRL 20-23cm. Those features were not present on the other ribs. Those features might be the areas of muscle, tendons, pleural attachments and, vessels or nerves relation. The neck sloped obliquely. It had no true angle as the angle coincided with its tubercle. The head was small. It was smaller than the heads of typical and second ribs of the same ages., and became more prominent with age progress. The tubercle could be seen. There was slight open angle which became more deep and less open with age progress. No costal groove was seen (Table 4)

Morphology of Human first rib of full-term: (33-36 weeks) (CRL 31-34cm) and newborn infant (37-38 weeks) (CRL 35-36cm) (Figs. 1 &5, a, b, c)) & Table B.

Morphological examination the of full-term rib showed that its features were similar to previous ages. However, the anterior end of the first rib increased in broadness and thickness and the angle was less open and deeper. The head was more prominent than previous ages. Scalene tubercle and shallow grooves in front and behind the tubercle were seen. The size and length of the rib increased.

Morphology of Human first rib of adult (Figs.6 & a. b.)

Morphological examination the first rib of adult showed that the first rib was the shortest, most acutely curved, it had broad flat superior and inferior surfaces. Its borders were internal and external. It sloped obliquely down and forwards to its sternal end. The head was small, round and bearded almost circular facet, articulating with the first thoracic vertebral body. The neck was rounded and ascended poster-laterally. The tubercle, was wide, prominent and directed backward; medially an oval facet to articulate with the first thoracic transverse process. At the tubercle, the rib bent, and the head turned downward, therefore, the angle and tubercle coincided. The superior surface of the flattened shaft was crossed obliquely by two shallow grooves, separated by a slight ridge which ended at the internal border as a usually small, pointed projection, the scalene tubercle. The inferior surface was smooth and ungrooved. The external boarded was thin with scalene tubercle near the mid-point.

Morphology of the developing prenatal Human second rib (Figs. 1, 2&7a. b & Tables 5, &B)

Morphological examination the of prenatal developing second of all fetuses showed that second rib in all ages studied was twice the length of the length of the first rib of the same age, and was more oblique than the first rib. The posterior vertebral end was higher than the costal anterior end. The head was small and hardly recognized. The costal groove was developed. There was an angle dividing the shaft into anterior three fourth and posterior fourth. There was a tubercle at the middle of its outer surface that appeared first age of 5month fetus.

The surfaces were intermediate between the surfaces of the first rib which were upper and lower, and the surfaces of the typical rib which were outer and inner.

With age progress, the developing fetal second rib showed increased length and size. The angle tended to be more acute (Table5) and the tubercle was rougher and more prominent

Morphology of Human second rib of full-term: (33-36 weeks) CRL 31-34cm) and newborn infant (37-38 weeks) CRL 35-36cm) (Figs. 1, 2&7) Tables 5 &B)

Morphological examination of the second rib of full term showed that it was similar to previous ages with increase in size and length. The second rib of full term was similar in features to that of the adult rib with smaller size, but the facet was not clear.

Morphology of adult Human second rib (Fig.4):

Morphological examination of the adult second rib showed that Second rib was twice the length of the first rib and had a similar curvature. The non-particular area of its tubercle was small. The angle was slight and near the tubercle. The shaft was not twisted, but at the tubercle was convex upward as in the first rib but less. The external surface of the shaft was convex and super laterally was marked centrally by rough, muscular impression that continued posteromedially towards the tubercle as a narrow-roughened ridge. The internal surface, was smooth and concave faced inferomedially and there was a short costal groove posteriorly.

Morphogical study in the present study showed that the typical ribs in all the ages studied, the rib was formed of anterior end, shaft and posterior end. The rib had an angle which divided it into posterior 1/4 cylindrical part and an anterior 3/4 flattened part from side to side. The angle became more open with age progress. The rib had two borders; upper and lower and two surfaces; inner and outer. There was slight twist in the shaft of full term only and was not noted in previous fetal ages whereas there was a great clear twist in adult: The costal groove was hardly detected in full term. The lower border became sharper. The posterior end was formed of head, neck and tubercle which were not developed at age 4 and 5 months and were first noted at the age of 6 months and became more prominent with age progress,

Morphogical study in the present study showed that the developing fetal first rib in all ages studied was the highest, shortest, strongest, flattest and most curved and fixed rib in comparison to the other ribs. It had a broad and thick anterior end. That broadness and thickness increased with age progress. The neck of the first rib slope obliquely. It had no true angle as its angle coincided with its tubercle. That false angle increased in depth and became more acute with age progress. The first rib was flat from above downwards, it had upper and lower surfaces and outer and inner borders. The scalene tubercle and the grooves in front and behind the tubercle were only detected at full term. They were prominent in adult rib.

Morphogical study in the present study showed that in all the ages studied the developing fetal second rib was two times as long as the corresponding first rib at the same age. It had upper and lower surfaces. The most characteristic of the second rib was that it developed a broad rough tubercle at the middle of its outer surface. That was first clear at the age of 5 and was more prominent with age progress. fourth typical rib, the angle of the rib was more open in the younger ages and tended to be more acute with age progress. There was no twist in the rib.

The previous findings were in addition to increased length of the fetal ribs with age progress.

Table B: Length of a straight line extending from mid points of the anterior and posterior ends of the developing prenatal human ribs in cm. The ages were estimated according to tables of (Sadler 2012 and Sadler (2019)

Age	Length of a straight line extending from mid points of the anterior and posterior ends of the developing prenatal human ribs in cm		
RIB	Fourth Typical	First	Second
4-month fetus (13-16wks-CRL 9-14cm	7	1.5	2.5
5—months old fetuses, :(17 -20weeks) CRL 15-19cm,	7.5	2.1	3-3
6-months old fetus:(21 -24weeks) CRL 20-23cm	6.8	2. 4	3
7months fetus:(25-28weeks) CRL 24-27cm	7	2. 8	4
full-term :(33-36 weeks) CRL 31-34cm	9	3.5	5

Schematic drawing of the thoracic segment. Superior view of 6th rib pair.

Note the costal cartilage and the costochondral junction (joint) between the bony segment of the rib (from the first to the tenth) and their respective costal cartilage

Histological results

Costochondral junction at the age of 6months old fetus :(21 -24weeks) CRL 20-23cm) (Figs.I&II)

Histological examination of part of TS of part of the developing prenatal human rib at the age of months fetus 6:(21 -24weeks) CRL 20-23cm at the costochondral junction CCJ stained by H&E showed part of the trabeculea of the cancellous bone of the rib, and the cartilage cells arranged in two zones. Blood vessels were seen between cartilage cells. Figs. Ia&b showed few the presence of Chondroblasts columns, some chondroblasts had twin appearance(arrow), and massive amount of matrix . Few blood vessels were seen. (Figs. I &II) between the matrix. The chondroblasts were regularly arranged in simple columns of one cell rows (Fig. II)

Costochondral junction CCJat the age of full-term old fetus :(33-36 weeks) CRL 31-34cm) (Figs. III: -IV)

Histological examination of part of TS of part of the developing prenatal human rib at the age full term :(33-36 weeks) CRL 31-34cm) human rib at the costochondral junction showed the periphysis, encircling the metaphysis and depicting the wedge-shaped groove of Ranvier and the thin layer of intramembranous bone (bone collar, bone bark or perichondrial ring of La Croix) (Fig.III)

Peiosteum was seen. Cancellous bone of the prenatal developing rib was seen. (Fig. III)

Normal growth plate; note the orderly columns of chondrocytes, without a bulbous shape or penetrating vessels and thin perichondrial ring (Fig.IV).

The costochondral junctional line was straight. . The distinction between the first (I) and second (II) zones of the cartilage could be seen. Cancellous bone of the developing rib was formed of trabeculea and osteoblasts. (Figs. III&IV)

The periosteum covered both surfaces of the rib (Fig. V). The bone was formed of irregular anastomosing trabeculae. The trabeculae were covered with the osteoblasts which were bone forming cells, small branched cells. They formed continues layer covering the trabecular of cancellous bone. They found on the surface, meanwhile osteoclasts were between the matrix, surrounded by it. Osteoclasts could not divide. Osteoblsts were more basophilic (blue) cytoplasm due to excess RNA in the cytoplasm. The periosteum was fibrous sheath surrounded the outer surface of the prenatal developing human rib. It was composed of two layers: an outer layer made of dense white fibrous tissue consisted of blood vessels, and an inner layer consisted of loose tissue containing osteoblasts (Fig. V). The inner layer was the osteogenic or osteoblastic layer which formed new cells (germinative). The periosteuim was more adherent to under the lying bone where tendons become inserted in the bone. At these sites the coarse collagenous fibers extended from the periosteum to enter the bone and acted as nails to fix them together. Intercostal muscles were seen. Blood vessel between the trabeculea of the cancellous bone were noted. (Fig.V). The rib at the costochondral junction CCJ showed part of the costochondral columns and cartilage cells arranged in a shape like seeds in pomegrates and part of the sternum part of the intercostal muscle was seen Fig .VI -A&B:

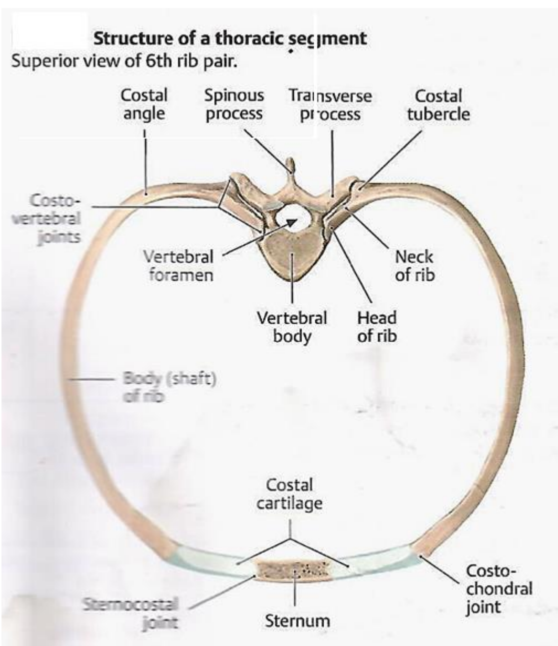


Fig. (X): Schematic drawing of the thoracic segment. Superior view of 6th rib pair.

Note the costal cartilage and the costochondral junction (joint) between the bony segment of the rib (from the first to the tenth) and their respective costal cartilage.

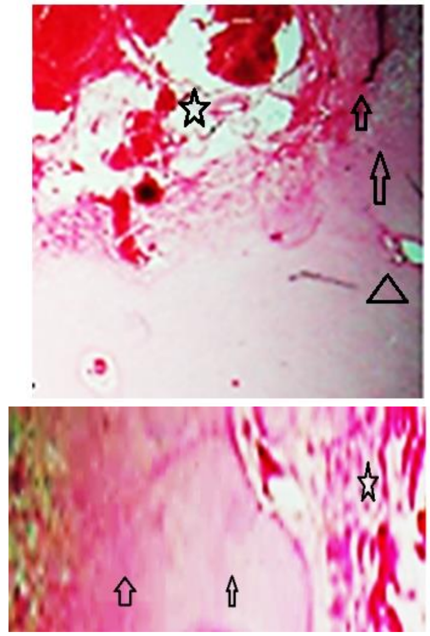


Fig. (I): photomicrograph of part of TS of part of the developing prenatal human rib at the age of 6:(21 -24weeks) CRL 20-23cm months old age fetus at the costochondral junction CCJ showing few Chondroblasts, some have twin appearance(arrow), Massive amount of matrix and small blood vessels are seen. Columns of chondroblasts are seeb at the corner of the photograph part of the cancellous bone of the rib formed of trabeculea is seen (v)H&EX1000

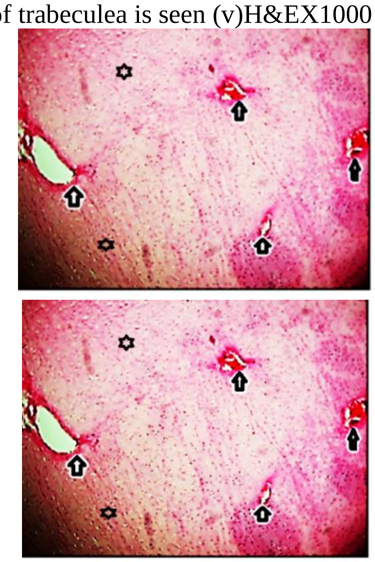


Fig.II: photomicrograph of part of TS of part of the developing prenatal human rib at the age of 6 months (21 -24weeks) CRL 20-23cm at the costochondral junction CCJ showing Chondroblasts arrange in regular simple columns present in massive amount of matrix. Blood vessels between the matrixes are seen (arrow). The chondroblass are regularly arranged in simple colums of one cell rows (star).H&EX1000

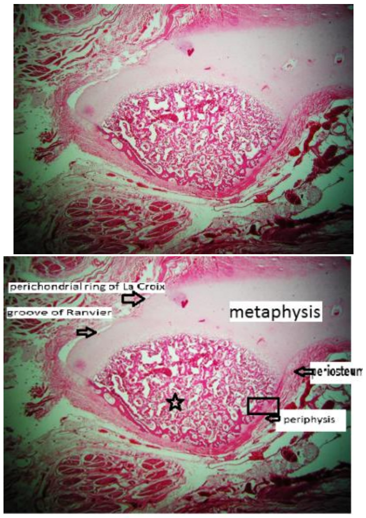


Fig. (III): photomicrograph of part of TS of part of the developing prenatal full term :(33-36 weeks) CRL 31-34cm) human rib at the costochondral junction CCJ showing. periphysis, encircling the metaphysis and depicting the wedge-shaped groove of Ranvier and the thin layer of intramembranous bone (bone collar, bone bark or perichondrial ring of La Croix). Rib growth plate GP is close to the perichondrial ring. Peiosteum is seen. cancellous bone of the prenatal developing rib is seen formed of trabeculea and osteoblasts and osteoclsts. (star) H&EX400

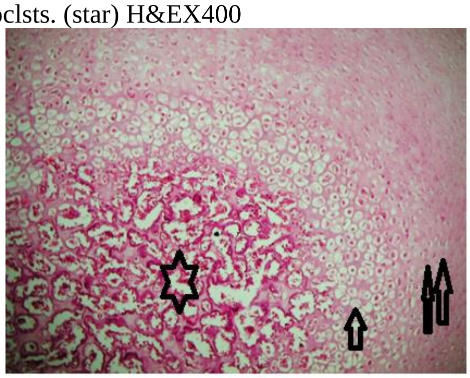


Fig. (IV): photomicrograph of part of TS of part of the developing prenatal full term :(33-36 weeks) (CRL 31-34cm) human rib at the costochondral junction CCJ showing normal growth plate; note the orderly columns of chondroblasts, without a bulbous shape or penetrating vessels and thin perichondrial ring (arrow). Note that the junctional distinction line between the first (I)(arrow) and second (II) zones (double arrow) of the cartilage columns is straight. Cancellous bone of the developing rib is formed of trabeculea and osteoblasts, osteoclasts are seen (star)H&EX1000

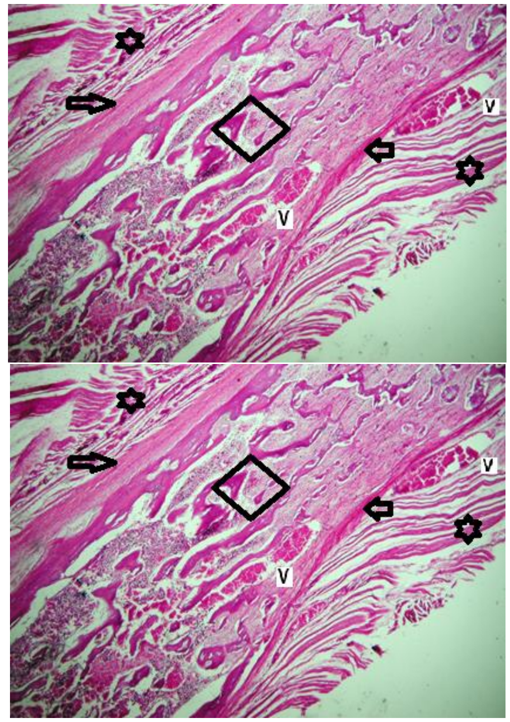
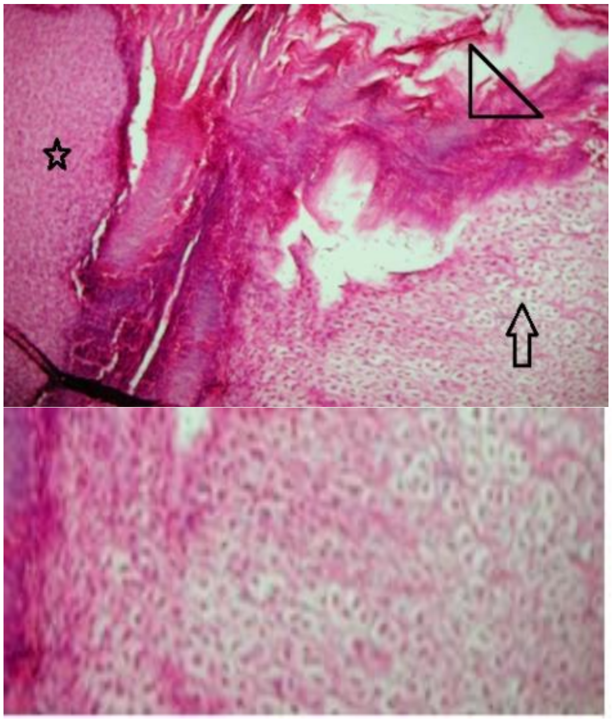


Fig. (V): photomicrograph of part of LS of part of the developing prenatal human rib of full term :(33-36 weeks) CRL 31-34cm) at the costochondral junction CCJ showing the periosteum(arrow) cover both surfaces of the rib. The cancellous bone of the rib is formed of irregular trabeculae and appeared as anastomosing with each other(sqaure). The trabeculea are covered with the osteoblasts which are bone forming cells, small branched cells. They formed continues layer covering the trabecular of cancellous bone. they found on the surface, meanwhile osteoclasts are between the matrix. Osteoclasts cannot divide. Osteoblasts are more basophilic(blue)cytoplasm due to exess RNA in the cytoplasm. The periosteum is fibrous sheath surrounded the outer surface of the developing human rib. It composed of two layers: an outer layer made of dense white fibrous tissue consisted of blood vessels., and an inner layer consisted of loose tissue containing osteoblasts. The inner layer was the osteogenic or osteoblastic layer which formed new bones cells (germinative). The periosteuim is more adherent to under lying bone where tendons become inserted in the bone. At these sites the coarse collagenous fibers extended from the periosteum to enter the bone and acted as nails to fix them together.

Note the Intercostal muscles are seen (star)

Note the blood vessel (V) between the trabeculea of the) cancellous bone and under the periosteum are seen. H&EX1000



• **Fig. (VI -A&B):** photomicrograph of part of TS of part of the developing prenatal developing full term :(33-36 weeks) CRL 31-34cm) rib at the costochondral junction CCJ showing. A-Part of the costochondral cartilage(C) and part of the sternum(S), PART of the intercostal muscle is seen(M)

• B-Higher magnification of part of the previous photomicrograph showing the regular dividing columns of chondroblasts, arranged in a shape like seeds in pomegrates.H&EX1000

•

Discussion

A: Morphology of the developing prenatal ribs:

In the present study, the ribs were separated by inter costal spaces. The ribs increased in length from the first rib till the seventh rib, and thereafter diminished in length. The surface rib breadth decreased from the first till downwards. The first two ribs presented special features. Whereas the remainder conformed to common plan. That agreed with Quran, surety al wakea 37 the meaning of the word (atraba) was explained by Asfahani in the meaning of the words of Quraan as the females in Janna looked similar to each other similar to the repeated typical ribs.

In the present study the fourth typical ribs in all the ages studied, the rib was formed of anterior end, shaft and posterior end. The rib had an angle which divided it into posterior cylindrical 1/4 and an anterior 3/4 flattened part from side to side. The angle became more open with age progress. The rib had two borders; upper and lower and two surfaces; inner and outer. There was slight twist in the shaft of full term only and was not noted in previous fetal ages whereas there was a great clear twist in adult: The costal groove was hardly detected in full term. The lower border became sharper with age progress. The posterior end was formed of head, neck and tubercle which were not developed at age 4- and 5-months fetus, and were first noted at the age of 6-months old fetus:(21 -24weeks) CRL 20-23cm, and became more prominent with age progress.

In the present study, the developing prenatal fetal first rib in all ages studied, the rib was the highest, shortest, strongest, flattest and most curved and fixed rib in comparison to the other ribs. It had a broad and thick anterior end. That broadness and thickness increased with age progress. The neck of the first rib sloped obliquely. It had no true angle as its angle coincided with its tubercle. That false angle increased in depth and became more acute with age progress. The first rib was flat from above downwards, it had upper and lower surfaces and outer and inner borders. The scalene tubercle and the grooves in front and behind the scalene tubercle were only detected at full term, and were prominent in adult rib.

In the present study in all the ages studied the developing fetal second rib was two times as long as the corresponding first rib at the same age. It had upper and lower surfaces. The most characteristic of the second rib was that it developed a broad rough tubercle at the middle of its outer surface. That was first clear at the age of 5 months prenatal fetus and increased in prominence with age progress.

The angle of the fourth typical rib was more open in the younger ages and tended to be more acute with age progress. There was no twist in the rib.

The previous findings were in addition to increased length of the ribs with age progress.

The change in the angle with age progress was essential for the respiratory function of the developing human fetus. The changes in the rib features were necessary to bring up normal thoracic cage with no defects or deformity

In the present work, the development of the angle was essential to give the thoracic cavity its kidney shape in transverse section which was different from quadruped. That was because the ribs in human were carried backwards beyond the level of the bodies of the thoracic vertebrae almost at the level of the spinous processes of the tips where they bend to form the angles of the ribs. That allowed the human to lie on his back. The ribs of quadruped had no angles (El Rakawy 2000) to allow the quadruped to lay on his back. The quadruped could not lie on his back. The median sagittal section plane which passed through the angles of the ribs was the greatest.

That also coincided with Quraan Suret EL teen4 (Figs): the creation of human by Allah was in the BEST form and shape (Ahsan taqweem). (Erect posture without kephosis)

In the present work, the changes in the rib features with age progress were necessary to bring up normal thoracic cage with no defects or deformity, to fulfill the respiratory functions and the normal position of the nediastnal organs and heart.

The results of the present study agreed with (Garcia et al., 1998, Duval et al. 1998, Aruga et al., 1999and Huang et al., 2000).

Garcia et al., 1998 mentioned that rib growth cartilage morphology showed structural anomaly in Down's syndrome fetuses 17-22 weeks old, might represent early manifestation of an abnormal growth of cartilage maturation pattern, which manifested post natal in long bones, leading to diminished growth rates.

Aruga et al. (1999) reported rib deformity and abnormality with different syndromes. They attributed these abnormalities and deformities to genetic mutations.

Huang et al. 2000 mentioned that ablation of the malformation of the ribs, was probably due to disturbed inter- actions between dermomyotome and sclerotomes. The change of rib features was necessary to normal development of ribs otherwise there would be defects and deformities in the form of thoracic scoliosis, ectopic process, gap defects, or dysplasia. (Garcia et al., 1998, Duval et al. 1998, Aruga et al. (1999) and Huang et al. (2000)

The results of the present work were similar to Weaver, Schoell and Stilzer (2014) who mentioned that rib cage morphology changed with age and sex were expected to affect thoracic injury mechanisms and tolerance, particularly for vulnerable populations such as pediatrics and the elderly. They analyzed the size and shape of the external variation of the external geometry of the ribs characterized for males and females aged from 0-100 years. Computed tomography (CT) scans from 339 subjects were analyzed to collect between 2700 and 10400 homologous landmarks from each rib. Rib landmarks were analyzed using the geometric morphometric technique known as Procrustes superimposition. Age and sex specific functions of 3Drib morphology were produced representing the size and shape variation and the isolated shape variation. Statistically significant changes in the size and shape variation ($P<0.0001$) and shape variation ($P<0.0053$) of all 24 ribs were found to occur with age in males and females. Rib geometry, location, and orientation varied according to rib level. From birth through adolescence, the rib cage experienced an increase in size, a decrease in thoracic kephosis, and inferior rotation of the ribs relative to the spine within the sagittal plane. From young adult hood into elderly age, the rib cage experienced increased thoracic kephosis and superior rotation of the ribs relative to the spine within the sagittal plane. The increased roundedness of the rib cage and horizontal angling of the ribs relative to the spine with age influenced the biomechanical response of the thorax. With the plane of the rib oriented more horizontally loading anterior –posterior direction will result in increased deformation within the plane of the rib and increased risk for rib fractures. Thus, morphological changes might be contributing factor to the increased rib fractures in the elderly. The, morphological functions derived in that study captured substantially more information on thoracic skeleton morphology variation with age and sex than in currently available in the literature. They conclude that their developed models of rib cage anatomy could be used to study age and sex variations in thoracic patterns due to motor crashes or falls, and clinically relevant changes due to chronic obstructive pulmonary disease or other diseases evidence by structural and anatomic changes to the chest.

The results of the present work coincided with Antona-Makosh et al. (2015) who developed a new thorax finite element model from medical images of 71-year-old average Japanese male elderly size (161cm,60kg) postmortem human subject (PMHS). The model was validated at component and assembled levels against original series of published test data obtained from the same elderly specimen. The model was completed extremities and head of model previously developed. The rib cage and the thoracic flesh materials were assigned age dependent properties and the model geometry was scaled up to simulate a 50th percentile male. She after the model was validated against existing biomechanical data from younger and elderly subjects, including hub-to thorax impacts and frontal impact sled PMHS test data. Finally, a parametric study was conducted with the new models to understand the effect of size and aging factors on thoracic response and risk of rib fractures. They found that the model behaved in agreement with table top test experiments in intact denuded, and eviscerated tissue conditions. ln frontal impact sled conditions, the model showed good 3-dimentional head and spine kinematics, as well as rib cage multipoint differences. When properties representative of an aging person was simulated, both the rib cage deformation and the predicted number of rib fracture had increased. The effects of age factors such as rib cortical thickness, mechanical properties, and failure threshold on the model responses were consistent with literature. Aged and thereby softened flesh reduced load transferee between ribs the coupling of rib cage had reduced. Aged costal cartilage increased the severity of the diagonal belt loading sustained by the lower loaded rib cage. They concluded that when age specific parameters were implemented in a finite element FE model of the thorax, the rib cage kinematics and thorax injury risk increased, when effect of size was isolated,2 factors in addition to rib material properties, were identified to affect rib cage deformation mechanisms and might increase the risk of rib fractures.

However, Standing et al. (2016) mentioned that unlike all the other sternocostal joints, the joint between the manubrium and the first costal cartilage was fibrous syndrthrosis. It lied 1cm below and 1cm lateral to the medial end of the clavicle and was difficult to palpate.

In the present work the ribs of the human cage was formed of twelve ribs, the first two and lower two presented special features. Whereas the remainder conformed to common plan. That agreed with Asfahani who explained the word (atraba) that pointed to the repeated similar characters and features of women in Jannah suret al wakia (ATRABA) as the chest repeated simulating typica ribs from the third till the seventh ribs.

. In the present work the ribs were separated by inter costal space. The ribs increased in length to the seventh and thereafter diminished. They decreased in breadth downwards. The first two ribs presented special features. Whereas the remainder conformed to common plan the present work of the present work agreed with Standring et al. (2016) mentioned that the ribs were separated by the inter costal spaces, which were deeper in front and between the upper ribs. The latter were less oblique than the lower ribs. Obliquity was maximal at the ninth rib, Ribs increased in length to the seventh and thereafter diminished. They decreased in breadth downwards; in the upper ten the greatest was anterior. The first two and the last three ribs presented special features. Whereas, the remainder conformed to common plan. The typical rib had a shaft with anterior and posterior ends. The anterior costal end had a small concave end to its vartilage. The shaft had an external and internal convexity and was grooved internally near its lower border, which was sharp. Whereas it's upper border was rounded. The posterior vertebral end had a head, neck and tubercle. The head bearded two facets separated by a transverse crest. The shaft was thin and flat, and had external and internal surfaces and superior and inferior borders. It was curved, bent at the posterior angle 3-6 cm from the tubercle, and twisted about its long axis. The part behind the angle incined superomsdially and so its external surface was poster-inferior.

The first rib

In the present work, the first rib in all ages studied had external and internal borders, superior and inferior surfaces, anterior costal end and posterior vertebral end. The external border was convex, thick posteriorly and thin anteriorly. The anterior end of the first rib was the largest end compared with the anterior end of the other ribs, there were many features that became more prominent with age progress as scalene tubercle and shallow groves. Those features were not present on the other ribs. Those features might be the areas of muscle, tendons, pleural attachments and, vessels or nerves relation.

The results of the present work agreed with Standring et al. (2016) who mentioned that the first rib was most acutely curved and usually shortest, broad and flat, its surfaces were superior and inferior, its border were internal and external. It sloped obliquely down wards to its sternal end. The obliquity of the first rib accounted for the ingress of the pulmonary and pleural apices into the neck. The head of the first rib was small and round and bearded almost circular facet that articulated with the body of the first thoracic vertebra. The neck was round and ascended poster laterally, and the tubercles wide and prominent, was directed up and backwards. Medially an oval facet articulated with the transverse process of the first thoracic vertebra. At the tubercle the rib bent, its head turned slightly down, and so the angle and the tubercle coincided. The superior surface of the flattened shaft was crossed obliquely by two shallow grooves, separated by a slight ridge, which usually end at the internal border as small pointed projection, the scalene tubercle, to which scalenus anterior was attached. The groove anterior to scalene tubercle formed a bed for subclavian vein, and the rough area between that and the first costal cartilage gave attachment to costoclavicular ligament and, more anteriorly the subclavius. The subclavian artery and (and usually) the lower trunk of the brachisal plexus passed in the groove behind the tubercle. Behind that scalenus medius was attached as far as the costal tubercle.

The external border was convex, thick posteriorly and thin anteriorly. It was covered behind by scalenus posterior descending to the second rib. The first digitation of serratus attached to it, behind the subclavian arterial groove. The internal border was the concave and thin. The scalene tubercle was near its mid-point. The supraplueral membrane, which covered the cervical dome of the pleura, was attached to the internal border. The inferior surface was smooth and the anterior end was larger than in any other rib.

Second rib

In the present work the second prenatal developing human rib and the adult rib was curved in the similar way to the curvature of the first rib. The second rib was reported to be the most site of fructure, that's explained why we had selected the second rob for the present study. That agreed with Standring et al., 2016 mentioned that elastic recoil of the ribs that suspended the sternum was explained the rarity of sternal fractures. Despite their pliability, the ribs were much more frequently broken, the middle ribs being the most vulnerable. Because traumatic stress was often the result of compression of the thorax. The usual site of fracture was just Infront of the angle, which was the weakest point of the rib. Direct impact might fracture a rib at any point; the ends of the broken bone might be driven inwards and potentially might injure thoracic or upper abdominal viscera. The second rib was twice the length of the first rib and had a similar curvature. The non-particular area of its tubercle was small. The angle was slight and near the tubercle the shaft was not twisted, but at the tubercle was convex upward as in the first rib but less so. The external surface of the shaft was convex and superolaterally was marked centrally by rough, muscular impression that continued posteromedial towards the tubercle as a narrow-roughened ridge. The internal surface, smooth and concave faced infer medially and there was a short costal groove posteriorly. The lower part of the first two digitations of serrastus anterior were attached to a rough prominence that extended from just behind the midpoint of the external surface. The distinct lips of the upper border were widely separated behind: scalenus posterior and serrastus posterior superior were attached to the outer lip in front of the angle.

The results of the present work agreed with de Farias et al. (2020) who mentioned that the ribs were classified as true when they articulated directly to the sternum through their respective costal cartilages (synchondrosis in the first rib and synovial from the second to the seventh), false when they articulated indirectly to the sternum through the adjacent superior costal cartilage (synchondrosis), and floating when there was no anterior costal joint (i.e., when they ended at the abdominal wall). The first seven ribs were true, the eighth to the tenth were floating, and the last two were false. The third to the tenth ribs were classified as typical because they had articular facets, with an elongated body connected to the rib head by the neck and a tubercle. The head articulated with the vertebral body, forming the costovertebral joint, and the tubercle articulated with the transverse process of the vertebra, forming the costotransverse joint, both being synovial joints. The first, second, eleventh, and twelfth ribs were atypical because they did not have characteristics in common to the other ribs. The first and second ribs had characteristics of the cervicothoracic junction. The first rib was shorter and wider, with grooves related to the subclavian vessels and a tubercle for fixing the scalene muscles, whereas the second rib, thinner and longer than the first, had a tuberosity for fixing the anterior serratus muscle. The eleventh and twelfth ribs were atypical because they did not have anterior articular facets, a neck, or a tubercle. Every rib had a lower costal groove, related to the intercostal neurovascular bundle; the second to the ninth ribs had a second articular face on their head for articulation with the adjacent upper vertebral body.

However, de Farias et al. (2020) announced that although it was not clinically significant, rib foramen should be included in the differential diagnosis of bone lesions, together with aneurysmal bone cyst and enchondrom. On MDCT, a rib foramen presented as a rounded image of a well-corticated defect centered in the bony component of the rib. de Farias etal., illustrated that rib notching were deformities that affected the upper surface of the rib, the lower surface of the rib (Roesler's sign), or both. They could be related to arterial, venous, neurogenic or connective tissue diseases, or other changes that caused an increased local pressure on the rib, such as the prominent vascularization of the inferior costal groove in some cases of coarctation of the aorta

In the present study, special features of the ribs studied of the prenatal developing human typical 4th typical rib, the second and second atypical ribs at the ages of 4, 5, 6,7 months and full term and newborn infant: (4 months (13-16wks-CRL 9-14cm., 5—months old fetuses, :(17 -20weeks) CRL 15-19cm, 6-months old fetus:(21 -24weeks) CRL 20-23cm, 7 months fetus:(25-28weeks) CRL 24-27cm old fetuses. human full-term :(33-36 weeks) CRL 31-34cm) and newborn infant (37-38 weeks) CRL 35-36cm). agreed with Omar et al.,2022 who mentioned that typically, the ribs had the following anatomical components: Head with two articular facets, tubercle, neck, shaft, costal groove. Most of the ribs were typical ribs; they had all these features. The atypical ribs did not have all these features were: First rib, Second rib, Tenth rib, Eleventh rib, Twelfth rib. The first rib was atypical because it was wide and short, had two costal grooves, and one particular facet. The second rib was thin, long, and had a tuberosity on its superior surface for the attachment of the serratus anterior muscle. The tenth rib had only one particular facet. The eleventh and twelfth ribs have only one particular facet with no neck.

Discussion of Histological results

In the present study histological examination of part of TS of part of the developing prenatal 4th typical human rib at the age of 6 months:(21 -24weeks) CRL 20-23cm fetus at the costochondral junction CCI showed the presence of few Chondroblasts, present in matrix stood on the cancellous bone of the rib. Blood vessels were seen in the matrix. The chondroblasts were regularly arranged in simple columns of one cell rows whick became complex columns with age progress.

In the present study histological examination of part of TS of part of the developing prenatal human rib at the age of full term :(33-36 weeks) CRL 31-34cm) human rib at the costochondral junction CCJ showed that the periphysis, was encircling the metaphysis and depicting the wedge-shaped groove of Ranvier and the thin layer of intramembranous bone (bone collar, bone bark or an outer layer made of dense white fibrous tissue consisted of blood vessels, and an inner layer consisted of loose tissue containing osteoblasts. The inner layer was the osteogenic or osteoblastic layer which formed new bones cells(germinative). The periosteuim was more adherent to under lying bone where tendons became inserted in the bone. At these sites the coarse collagenous fibers extended from the periosteum to enter the bone and acted as nails to fix them together. Cancellous bone of the prenatal developing rib was seen full of trabeculea, osteoblasts and osteoclasts. (Normal growth plate). Regular columns of chondrocytes, without penetrating vessels were observed arranged in two zones. Distinction between the first (I) and second (II) zones of the cartilage was seen. Cancellous bone of the developing rib was formed of trabeculea and osteoblasts.

The results of the present study agreed with E Rakawy 1971 who mentioned that osteoclasts could not divide. Osteoblsts were more basophilic (blue) cytoplasm due to excess RNA in the cytoplasm the periosteum was fibrous sheath surrounded the outer surface of the prenatal developing human rib. It composed of two layers: an outer layer made of dense white fibrous tissue consisted of blood vessels., and an inner layer consisted of loose tissue containing osteoblasts. The inner layer was the osteogenic or osteoblastic layer which formed new cells (germinative). The periosteuim was more adherent to under lying bone where tendons become inserted in the bone. At these sites the coarse collagenous fibers extended from the periosteum to enter the bone and acted as nails to fix them together.

In the present study histological examination of part of TS of part of the developing prenatal human rib at the age of full term :(33-36 weeks) CRL 31-34cm) human rib at the costochondral junction, showed that, there were abnormal histological appearance of some ribs at the costchondral junction .as the fetuses were collected from the miscarriages or spontaneous abortion. There was irregular junctional line between the layers of cartilages in the CCJ. The marrow trabeculae of the rib cacellous bone were short and irregular. Some columns of chondroblasts, arranged in bizzar shaped like seeds in pomegrates were noted.

The results of the present study agreed with EMERY and Kalpaktsoglou (1967) who mentioned that the rib was an ideal bone for studying linear growth, being probably the most rapidly growing bone in a linear fashion throughout the whole of intrauterine. The costochondral junction appeared as a column of cartilage cells sitting between regular strands of matrix and standing on bony trabeculae. Their paper was concerned with three objectives. (1). A description of the appearance of the normal costochondral junction at birth and during the latter third of intrauterine life. They summarized their histological study of the costochondral junction, which had been carried out on a large series of perinatal deaths, that the normal and abnormal appearances of the costochondral junction of the older foetuses were described As follows: Two types of deformity were found, interpreted as due to growth arrest and to a bizarre form of growth. The evidence suggested that, of children dying during labor or in the neonatal period, approximately 75%0 showed evidence of disordered growth in utero before labor had begun. The histological study of the costochondral junction was an extremely valuable part of the study of any perinatal death.

In the present study measurements of rib length and the distances and indices from ribs were used by normal measures using cm. That agreed with Bastir 2013 et al. (2013) who mentioned that the difficulties in quantifying the 3D form and spatial relationships of the skeletal components of the ribcage present a barrier to studies of the growth of the thoracic skeleton. Thus, most studies to date had relied on traditional measurements such as distances and indices from single or few ribs. It was currently known that adult-like thoracic shape was achieved early, by the end of the second postnatal year, with the circular cross-section of the newborn thorax transforming into the ovoid shape of adults; and that the ribs became inclined such that their anterior borders came to lie inferior to their posterior. They present a study that revisited growth changes using geometric morphometrics applied to extensive landmark data taken from the ribcage. They digitized 402 (semi) landmarks on 3D reconstructions to assess growth changes in 27 computed tomography-scanned modern humans representing newborns to adults of both sexes. Our analyses show a curved ontogenetic trajectory, resulting from different ontogenetic growth allometries of upper and lower thoracic units. Adult thoracic morphology was achieved later than predicted, by diverse modifications in different anatomical regions during different ontogenetic stages. Besides a marked increase in antero-posterior dimensions. They found that there was an increase in medio-lateral dimensions of the upper thorax, relative to the lower thorax. That transformed the pyramidal infant thorax into the barrel-shaped one of adults. Rib descent was produced by complex changes in 3D curvature. Developmental differences between upper and lower thoracic regions related to differential timings and rates of maturation of the respiratory and digestive systems, the spine and the locomotor system. Their findings were relevant to understanding how changes in the relative rates of growth of these systems and structures impacted on the development and evolution of modern human body shape.

The results of the present study coincided with Beresheim et al. (2020) mentioned that there was considerable variation in the gross morphology and tissue properties among the bones of human infants, children, adolescents, and adults. They studied 18 known-age individuals (n_{female} = 8, n_{male} = 9, $n_{unknown}$ = 1; birth to 21 years old), from a well-documented cemetery collection, Spitalfields Christ Church, London, UK, to explores growth-related changes in cortical and trabecular bone microstructure. Micro-CT scans of mid-shaft middle thoracic ribs were used for quantitative analysis. Results were then compared to previously quantify conventional histomorphometry of the same sample. Total area (Tt.Ar), cortical area (Ct.Ar), cortical thickness (Ct.Th), and the major (Maj.Dm) and minor (Min.Dm) diameters of the rib demonstrate positive correlations with age. Pore density (Po.Dn) increased, but age-related changes to cortical porosity (Ct.Po) appeared to be non-linear. Trabecular thickness (Tb.th) and trabecular separation (Tb.Sp) increased with age, whereas trabecular bone pattern factor (Tb.Pf), structural model index (SMI), and connectivity density (Conn. D) decreased with age. Sex-based differences were not identified for any of the variables included in their study. Some samples displayed clear evidence of diagenetic alteration without corresponding changes in radiopacity, which compromised the reliability of bone mineral density (BMD) data in the study of past populations. Cortical porosity data are not correlated with two-dimensional measures of osteon population density (OPD). They pointed that their results suggested that unfilled resorption spaces contributed more significantly to cortical porosity than did the Haversian canals of secondary osteons. Continued research using complementary imaging techniques and a wide array of histological variables would increase our understanding of age- and sex-specific ontogenetic patterns within and among human populations.

In the present study the rib growth plate and the perichondrial ring were noted close to the chondrobls columns of the developing human prenatal rib that agreed with Elisa et al. (2001) who conclude that epiphyseal changes of VDD/MBD at the growth plate were well established, and in their report, and described the associated periphyseal changes which had not been previously described. They mentioned that, the histological changes in the perichondrial ring were significantly associated with histological changes of VDD/MBD at the rib growth plate with an OR of 3.04. And such changes were widely prevalent in those under 3 months of age; hence future prospective studies should aim to explore not only the foetal but also maternal contributing factors.

In the present study, LS of part of the developing prenatal human rib of full term :(33-36 weeks) CRL 31-34cm) at the costochondral junction CCJ showed that the periosoteum covered both surfaces of the rib. . The periosteum was fibrous sheath surrounded the outer surface of the prenatal developing human rib. It composed of two layers: an outer layer made of dense white fibrous tissue consisted of blood vessels, and an inner layer consisted of loose tissue containing osteoblasts. That agreed with Omar et al. (2022) who mentioned that the ribs received their blood supply anteriorly; by the anterior intercostal arteries. They were supplied posteriorly; by the posterior intercostal arteries. The anterior intercostal arteries of the first seven ribs were branches of the internal thoracic artery. The anterior intercostal arteries of the eighth, ninth, and tenth ribs were branches from the musculophrenic artery. All ten of these ribs were supplied posteriorly by the posterior intercostal arteries. The first two posterior intercostal arteries were branches of the superior intercostal artery, a subsidiary of the costocervical trunk that arised from the left subclavian artery. The lower nine arteries were branches of the descending thoracic aorta. The floating ribs received vascular supply only posteriorly by the posterior intercostal arteries. The eleventh rib received vascular supply by the posterior intercostal artery and the twelfth rib by the subcostal artery.

The nomenclature of the costal veins was the same as the arteries; they differed as to where they drain blood. The anterior intercostal veins drained blood into the internal thoracic and musculophrenic veins. The posterior intercostal veins drained blood into the azygos and hemiazygos system. The subcostal vein drained the blood of the twelfth rib.

The ribs were mentioned in the Quraan suret Al nisaa(women), suret Al room (Romans) 21, suret At-Taariq7, suret al wakia (atraba). So plasts and surgical implants of the infant mandible defects or other from the rib CCJ might have a back ground from Qraan as the woman was created from the rib of first created man: Adam.

قال تعالي : وَمِنْ آيَاتِهِ أَنْ خَلَقَ لَكُمْ مِنْ أَنْفُسِكُمْ أَزْوَاجًا لِتَسْكُنُوا إِلَيْهَا وَجَعَلَ بَيْنَكُمْ مَوَدَّةً وَرَحْمَةً إِنَّ فِي ذَٰلِكَ لَآيَاتٍ لِقَوْمٍ يَتَفَكَّرُونَ (سُورَة الروم 21) suret Al room(Romans)

قال تعالي : يَا أَيُّهَا النَّاسُ اتَّقُوا رَبَّكُمُ الَّذِي خَلَقَكُمْ مِنْ نَفْسٍ وَاحِدَةٍ وَخَلَقَ مِنْهَا زَوْجَهَا وَبَثَّ مِنْهُمَا رِجَالًا كَثِيرًا وَنِسَاءً وَاتَّقُوا اللَّهَ الَّذِي تَسَاءَلُونَ بِهِ وَالْأَرْحَامَ (سُورَة النِّسَاء)suret Al nisaa(women)

قال تعالي : يخرج من بين الصلب والترائب (سورةالطارق) At-emerging from between the backbone and the Taariq ribs

The ribs were mentioned in the Ahadith as the woman was created from a rib of the man.

The Almighty said: And from his signs that he created for you from your souls, suret Al nisaa (women)

- حديث أبي هريرة ، أن رسول الله صلى الله عليه وسلم قال : " المرأة كالضلع ، إن أقمتها كسرتها ، وإن استمتعت بها استمتعت بها وفيها عوج " .
أخرجه البخاري في : 67 – كتاب النكاح : 79 – باب المدارة مع النساء.
- حديث أبي هريرة ، عن النبي صلى الله عليه وسلم قال : " من كان يؤمن بالله واليوم الآخر فلا يؤذي جاره ، واستوصوا بالنساء خيرا فإنهن خلقن من ضلع ، وإن أعوج شيء في الضلع أعلاه ، فإن ذهبت تقيمه كسرته ، وإن تركته لم يزل أعوج ، فاستوصوا بالنساء خيرا " .
أخرجه البخاري في 67 – كتاب النكاح : 80 – باب الوصاية بالنساء

The hadith of Abu Hurairah, that the Messenger of God, may God's prayers and peace be upon him, He said: A woman is like a rib. Al-Bukhari included it in: 67 - The Book of Marriage: 79 - Chapter: Manners with women. - The hadith of Abu Hurairah, on the authority of the Prophet, may God's prayers and peace be upon him, who said: "Whoever believes in God and the Last Day should not harm his neighbor, and treat women kindly, for they were created from a rib, and the most crooked thing in the rib is its upper part. Treat women kindly." PRESENT IN Bukary-Book of nikah

Summary and Conclusion:

In this study, the fourth typical ribs in all the ages studied the rib was formed of anterior end, shaft and posterior end. The rib had an angle which divided it into posterior 1/4 cylindrical part and an anterior 3/4 flattened part from side to side. The angle became more open with age progress. The rib had two borders; upper and lower and two surfaces; inner and outer. There was slight twist in the shaft of full term only and was not noted in previous fetal ages whereas there was a great clear twist in adult: The costal groove was hardly detected in full term. The lower border became sharper. The posterior end was formed of head, neck and tubercle which were not developed at age 4 and 5months old fetuses, :(17 -20weeks) CRL 15-19cm, months and were first noted at the age of 6-months old fetus (21 -24weeks) CRL 20-23cm, 7 months fetus and became more prominent with. With age progress the angle of the developing fourth typical rib was more open in the younger ages and tended to be more acute with age progress. There was no twist in the rib. Increased size and length of the ribs with age progress was noted. The change in the developing ribs was to fulfill respiratory function and grew up thoracic abe without deformeties. The fetal first rib in all ages studied was the highest, shortest, strongest, flattest and most curved and fixed rib in comparison to the other ribs. It had a broad and thick anterior end. That broadness and thickness increased with age progress. The neck of the first rib sloped obliquely. It had no true angle as its angle coincided with its tubercle. That false angle increased in depth and became more acute with age progress. The first rib was flat from above downwards, it had upper and lower surfaces and outer and inner borders. The scalene tubercle and the grooves in front and behind the tubercle were only detected at full term. They were prominent in adult rib. In all the ages studied the developing fetal second rib was two times as long as the corresponding first rib at the same age. It had upper and lower surfaces. The most characteristic of the second rib was that it developed a broad rough tubercle at the middle of its outer surface. That was first clear at the age of 5 and was more prominent with age progress. The changes in the angle of the rib with age progress were essential for the respiratory function of the developing human fetus and to allow human to sleep on his back. The changes in the rib features were necessary to provide areas for attachments of muscles, vessels and plueral and orgasm in the mediastinum to bring up normal thoracic cage with best form and shape with no defects or deformity.

Histological examination of part of the 4^{th} typical developing prenatal human rib at the age of 6-months old fetus:(21 -24weeks- 20-23cm) and full term:(33-36 weeks) CRL 31-34cm) at s costochondral junction CCJ hewed that the CCJ was formed of chondroblasts arranged in columns embedded in matrix, and stood on the cancellous bone of the ribs, few blood vessels were seen. Chondroblasts columns were regularly arranged in simple one row in the age of 6month Prenatal. Chondroblasts increased in size with age progress at full term and the Chondroblasts columns were in some sections regularly arranged, and in other sections were irregular overcrowding, bizzar arrangement according to the cause of fetal or maternal death. Periphysis, encircling the metaphysis and depicting the wedge-shaped groove of Ranvier and the thin layer of intramembranous bone (bone collar, bone bark or perichondrial ring of La Croix) were noted junctional line was straight between two zones of chobdroblasts columns. The periosteum covered both surfaces of the rib. The bone of the rib was cacellous formed of irregular trabeculae anastomosing with each other. They were covered with the osteoblasts which were bone forming cells. The periosteum was fibrous sheath surrounded the outer surface of the developing prenatal human rib. It composed of two layers: an outer layer made of dense white fibrous tissue consisted of blood vessel, and an inner layer consisted of loose tissue containing osteoblasts. The inner layer was the osteogenic or osteoblastic layer formed new bones cells. Intercostal muscles were seen. The change in the histology of CCJ with age progress was to bring up thoracic cage with no deformity, to fulfill respiratory functions, and sound mediastinal organs.

Role of the authors:

- Role of Prof dr Manal Galal Abdel wahab: The idea of the research, dissection, collecting the specimens, preparing histological sections, photographing the morphological and histological figures, writing and publishing the paper
- Role of Prof dr Sohair Sadek: collected the fetuses and revised the morphology;

The morphological part of this paper was submitted along with other nine single papers by Prof. Dr. Manal Galal Abdel Wahab at year 2000 for her promotion into Full Professor position at the Anatomy department of the Faculty of Medicine (Girls)/ Al-Azhar University/ Cairo/ Egypt.

This paper was presented as well by the physiotherapist Sarah Mohamed Mustafa Marzouk in year 2017 at the fifth conference of Al-Azhar University at Al Zagazig, faculty of Arabic language with the cooperation of the Muslim World League under the scientific miracles in the Quraan and Sunnah.

Physiotherapist Sarah Mohamed Mustafa Marzouk works as a physiotherapist at the Caring Center for children with disabilities at Ain Shams University/ Cairo/ Egypt.

Thanks to Abdel Wahab Sawsan, Gyn&Obst Consultant -Ohod Hospital –ElMadina monawara and – KSA- and Pr. Dr. Emad Awad [Prof of dinestry King Abd el Aziz university –Jeddah-KSA for financial support

References

[1]. Agadir M, Sevastik B, Sevastik Ja, Svensson L (1989) Effects of intercostal nerve resection on the longitudinal rib growth in the growing rabbit. Journal of Orthopaedic Research 7, 690-695.

[2]. AGADIR M, SEVASTIK B, REINHOLT FP, PERBECK L, SEVASTIK J (1990) Vascular changes in the chest wall after unilateral resection of the intercostal nerves in the growing rabbit. Journal of Orthopaedic Research 8, 283-290.

[3]. Antona-Makoshi J, Yamamoto Y, Kato R, Sato F, Ejima S, Dokko Y, Yasuki T 2015: Age dependent factor affecting thoracic response: afinite element study focused on Japanese elderly occupants. Traffic Inj Prev. 2015: 16 Suppl 1: S66-74 doi:10.1080/15389588 2015 .1014552

[4]. Aruga J, Mizugishi K, Kosek H, Imai K, Balling H, Noda T, Mikoshiba K (1999): Zicl regulates the patterning of vertebral arches in cooperation with G1i3, Meek Dev. Dec 89 (1-2): 141-50.

[5]. Assi A , KaramM , Skalli W 2, Claudio Vergari 2, Raphael Vialle 3, Raphael Pietton 3, Aren J Bizdikian 1, Khalil Kharrat 1, Jean Dubousset 2, Ismat Ghanem 2021: A Novel Classification of 3D Rib Cage Deformity in Subjects With Adolescent Idiopathic Scoliosis Clin Spine Surg 2021 Nov 1;34(9):331-341. doi: 10.1097/BSD.0000000000001139.

[6]. Bastir M , García Martínez D, Recheis W, Barash A, Coquerelle M, Rios L, Peña- A Melián, F García Río, P O'Higgins 2013 Differential growth and development of the upper and lower human thorax-Collection-Sep 20;8(9):e75128.- doi: 10.1371/journal.pone.0075128. e 2013PMID: 24073239 PMCID: PMC3779208 - DOI: 10.1371/journal.pone.0075128

[7]. Beresheim A C , Pfeiffer S , Grynpas M. 2020 Ontogenetic changes to bone microstructure in an archaeologically derived sample of human ribs J Anat-Mar;236(3):448-462. doi: 10.1111/joa.13116. Epub 2019 Nov 15= MID: 31729033- PMCID: PMC7018627 DOI: 10.1111/joa.13116

[8]. DANIELS S, Ellis E, CARLSON DS (1987) Histological analysis of costochondral and sternoclavicular grafts in the TMJ of the juvenile monkey. Journal of Oral and Maxillofacial Surgery 45, 675-682.

[9]. de Farias L s, Meneze D s, Faé I, de Arruda P, Magalhães Santos J, and Gustavo Borges da Silva Teles[1] 2020 Anatomical variations and congenital anomalies of the ribs revisited by multidetector computed tomographyRadiol Bras. Nov-Dec; 53(6): 413–418. doi: 10.1590/0100-3984.2019.0131 - PMCID: PMC7720665 -PMID: 33304010

[10]. Duval A, Boute 0, Devisme L, Volat AS, Manovvrier (1998): New autosomal resessive syndrome of severe microcephaly and skeletal anomalies including posterior rib gab defects. Am. J. Med. Genet. Dec. 480 - 4, 429 – 3

[11]. (Drury &Walington, 1980 Carleton's Histological Technique. 5th Edition, Published

[12]. Press, London, New York, Toronto, P137- 145 by Oxford University.

a) Elisa G, Suma , Vázquez Z, Rita5 , Khairul Z, Marta C 2021: Abnormalities of the rib growth plate and the periphysis of previously healthy infants and toddlers dying suddenly and unexpectedly J Clin Pathol doi:

10.1136/jclinpath-2020-206893. Epub 2020 Dec 8. . 2021 Dec;74(12):774-779.

[13]. Emery, J. L. (1957). Proceedings of the Pathological Society of G.B. and I. J. Path. Bact., 74, 244

[14]. Emery and Pitsa K. Kalpaktsoglou 1967, The Costochondral Junction During Later Stages of Intrauterine Life, and Abnormal Growth Patterns Found in Association with Perinatal Death JOHN L. From the Taylor Research Laboratories, Children's Hospital, Western Bank, Sheffield 10 Arch. Dis. Child.

[15]. Garcia - Ramirez M, Toran N, Carrascosa A, Audi L1998 . (Down's Syndrome: altered chondrogenesis fetal ribs. Pediatr. Res:Jul. 44 (1): 93 - 8 .

[16]. Gruber H E , Lachman R S, Rimoin D L. 1990 Quantitative histology of cartilage vascular canals in the human rib. Findings in normal neonates and children and in achondrogenesis II-hypochondrogenesis J Anat-Dec;173:69-75. PMID: 2074231- PMCID: PMC1256081

[17]. HEFFEZ L, DOKU HC (1984) The Goldenhar syndrome: diagnosis and early surgical management. Oral Surgery 58, 2-9.

[18]. Huang R, Zhi Q, Schmidt C, Wilting J, Brand - Saberi B, Christ B (2000): Sclerotomal origin of the ribs. Development Feb. 127(3): 527 - 32.

[19]. Kunus CA, Simpson SW, Russell KF, Hersh Kovitz 1(1999): First rib metamorphosis its possible utility for human age at death estimation Am. J .Phys. Anthropol. N°. 110 (3): 303 -23.

[20]. Langman ,J. (1975):Medical Embryology ,ed 3.Baltimore,Williams&Wilkins.

[21]. Omar A. Safarini; Bruno Bordoni Last, Update: July 112022. Anatomy, Thorax, Ribs

[22]. PELTOMAKI AND LARI HAKKINEN 1992) Growth of the ribs at the costochondral junction in the rat TIMO Institute of Dentistry, University of Turku, Finland (Accepted 20 July J. Anat. (1992) 181, pp. 259-264, with 2 figures Printed in Great Britain

[23]. Peltomäki T 1994 Histologic structure of human costochondral junction- Plast Reconstr Surg Oct;94(5):585-8. doi: PMID: 7938280 DOI: 10.1097/00006534-199410000-00003

[24]. POLITIS C, FOSION E, BOSSUYT M (1987) The use of costochondral grafts in arthroplasty of the temporomandibular joint. Journal of Craniomaxillofacial Surgery 15, 345-354.

[25]. PELTOMAKI T (1992) Growth of a costochondral graft in the rat temporomandibular joint. Journal of Oral and Maxillofacial Surgery 50, 851-857.

[26]. PELTOMAKI T, ISOTUPA K (1991) The costochondral graft: a solution or a source of facial asymmetry in growing children. A case report. Proceedings of the Finnish Dental Society 87, 167-176.

[27]. Poswillo D (1974) Experimental reconstruction of the mandibular joint. International Journal of Oral Surgery 3, 400-411.

[28]. Poswillo D (1987) Biological reconstruction of the mandibular condyle. British Journal of Oral and Maxillofacial Surgery 25, 100-104.

[29]. Romanes G.J. (2000): Cunningham, S. Manual of Practical Anatomy volume 2: Thorax and abdomen. Fifteenth edition, Oxford University Press Walton Sreet, Oxford Ox 26Dp.

[30]. Sadler TW (2012): Lang man Medical Embryology twelfth edition. Wolters Kluwer, Lippincott Williams &Wikins.

[31]. Sadler TW (2019):Lang man Medical Embryology twelfth edition . Wolters Kluwer ,

[32]. Schlager B , Krump F , Boettinger J , Jonas R, Liebsch C , Ruf M, Beer M , -Joachim Wilke H 2022 Morphological patterns of the rib cage and lung in the healthy and adolescent idiopathic scoliosis. J Anat-Jan;240(1):120-130. doi: 10.1111/joa.13528. Epub 2021 Aug 3.

[33]. Shi X, Cao L, R eed MP,Rupp JD, Hoff CN, Hu J 2014: A statistical human rib cage geometry model accounting for variation by age ,sex .stature and body mass index.Biomech 2014 Jul 18:47(10)2277-85 doi:10.1016/j.jbiomech.2014 04.045. Epub 2014 May10

[34]. Standring S et al., 2016: Gray's Anatomy. The anatomical basis of clinical practice. 41 Edition. Elsevier

[35]. Streeter, G.L. (1920): Weight,sitting ,height ,head size, foot length and menstrual age of the human embryo. Contrib Embryol 11:143-170.

[36]. WARE WH, TAYLOR RC (1966) Cartilaginous growth centers transplanted to replace mandibular condyles in monkeys. Journal of Oral Surgery 24, 33-

[37]. WARE WH, BROWN SL (1981) Growth centre transplantation to replace mandibular condyles. Journal of Maxillofacial Surgery 9, 50-58.

[38]. William P.L.; Bannister LET.; Berry M:M.; Collings PG.; Dyson M.; Dussek, J; Ferguson, M.W.T., (1995): Grays an anatomy 3- Edition churchill. Livingstone, Edinburgh, London, Melbourne and New York

[39]. Weaver AA, Schoell SL, Stilzer JD2014: Morphometric analysis of variation in the ribs with age and sex ,J Anat.A ug :225(2):245-61 doi 10.111/joa.12203.EpubJun 10.

[40]. Yousefzadeh D K , Doerger K, Sullivan C 2008 The blood supply of early, late, and nonossifying cartilage: preliminary gray-scale and Doppler assessment and their implications Pediatr Radiol Feb;38(2):146-58.PMID: 18040678
DOI: 10.1007/s00247-007-0655-2. Epub 2007 Nov 27.

i. Arabic references:

[41]. The HOLY Quraan

[42]. Al Bokary

3/25/2023