

## MORPHOMETRIC STUDY OF THE SKELETON OF THE THORAX IN HUMAN FETUSES AGED 7-10 MONTHS

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### ABSTRACT

**Introduction.** It is necessary to clearly understand the norms of morphometric parameters of thorax during the fetal period of human ontogenesis, which is one of the main directions to solve the problem of modern normology.

**Objective.** To trace the dynamics of changes of morphometric parameters of the bony thorax in human fetuses aged 7-10 months.

**Materials and methods.** The anatomical study involved 39 human fetuses specimens of 231.0-375.0 mm of crown-rump length (CRL). The study was conducted by means of macro-microscopic preparation, morphometry and variation statistics method.

**Results.** It was found that the length of the costal cartilage increases from rib I to VII and is the longest in the rib VII. The ribs are the highest along the midclavicular line. At the same time, the height of the ribs decreases along the posterior axillary line and becomes the shortest along the scapular line. It was revealed the greatest width of the II and III intercostal spaces along the parasternal and midclavicular lines. The width of the four superior intercostal spaces along the midclavicular line on the right and on the left is larger than the height of the corresponding ribs. The width of the IIX intercostal spaces on the right and on the left

### RÉSUMÉ

**Etude morphométrique du squelette thoracique des foetus humains de 7-10 mois**

**Introduction.** À l'heure actuelle, il est nécessaire d'avoir une idée claire des normes des paramètres morphométriques de la poitrine pendant la période foetale de l'ontogenèse humaine, qui est l'une des directions de la résolution du problème de la normologie moderne.

**But.** Tracer la dynamique des changements des paramètres morphométriques du squelette thoracique.

**Matériaux et méthodes.** L'étude anatomique a été menée sur 39 préparations de foetus humains de 231,0-375,0 mm de longueur pariétale-coccygienne à l'aide de la préparation macro-microscopique, de la morphométrie et de la méthode de statistique de variation.

**Résultats.** Il a été établi que la longueur du cartilage intercostal augmentait de la I-ère à la VII-ième côte, et qu'elle était la plus grande dans la VII-ième côte. La plus haute élévation des côtes a lieu dans la ligne médiane, en même temps, la hauteur des côtes diminue le long de la ligne axillaire postérieure et est la plus petite sur la ligne des omoplates. On a révélé la plus grande largeur II et III des espaces intercostaux sur

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along the scapular lines exceeds the height of the corresponding ribs in 1.33-1.65 times. The greatest width of the II, IV and VII intercostal spaces was along the posterior axillary line both sided. The greatest width of the II, IV and X of the intercostal spaces was noted along the scapular lines.

**Conclusions.** The length of the costal cartilage increases from rib I to VII and is the largest in VII ones. The smallest value of the length of the costal cartilage was found in the rib XII. During the 7<sup>th</sup>-10<sup>th</sup> months of the intrauterine development, an intensive increase in the length of costal cartilages of the ribs I-III occurs, on average, by 1.5 times, and there is a slow increase in the length of the costal cartilage of the rib VII. The ribs along the midclavicular line are the highest. At the same time, the height of the ribs decreases along the posterior axillary line and along the scapular line it is the lowest.

**Keywords:** skeleton of the thorax, ribs, intercostal spaces, human fetuses.

## INTRODUCTION

Ribs are protective ribbon-like bony elements, normally present within the chest wall and are ones of the most imaged structures in the clinical practice<sup>1-4</sup>.

Investigation of prenatal development of structures of intercostal spaces (IS) in a chronological sequence allows to establish both general biological laws of morphogenesis of the skeleton and muscles of the thorax, vascular-neural formations of the IS, variations of their structure and topography, and morphological preconditions of the possible development of congenital malformations of the components of the IS, which are formed under the influence of exogenous and endogenous factors in the critical periods of intrauterine life<sup>5</sup>. In humans, an increasing body of evidence has linked the frequency of cervical ribs to stillbirths, other malformations and early childhood cancers. However, the frequency of cervical ribs in a putatively healthy fetal population is not sufficiently known to assess the actual medical risks of these prenatal findings<sup>6-8</sup>.

Globally, the proportion of premature infants, children with perinatal pathology, and children born with very low body weight increases annually<sup>9</sup>.

les lignes parasternale et médio-claviculaire. La largeur des quatre espaces intercostaux supérieurs le long de la ligne médiane à droite et à gauche est dominée par la hauteur des côtes correspondantes. La largeur des espaces intercostaux II-X à droite et à gauche le long des lignes d'omoplate dépasse la hauteur des côtes correspondantes de 1,33-1,65 fois. A été notée la plus grande largeur des espaces intercostaux II, IV et VII sur la ligne axillaire postérieure à droite et à gauche, et aux lignes d'omoplate des espaces intercostaux II, IV et X.

**Conclusions.** La longueur du cartilage des côtes augmente de I à VII et la plus grande est dans la côte VII. La plus petite valeur de la longueur du cartilage intercostal a été trouvée dans la côte XII. A partir du septième au dixième mois du développement du fœtus se produit une augmentation intensive de la longueur des cartilages intercostaux des côtes I-III en moyenne de 1,5 fois et on observe le ralentissement d'augmentation de la longueur du cartilage intercostal de la VII-ième côte. Les côtes ont la plus grande hauteur le long de la ligne médio-claviculaire. En même temps, la hauteur des côtes diminue le long de la ligne axillaire postérieure et elle est la plus petite sur la ligne des omoplates.

**Mots-clés:** squelette de poitrine, côtes, espaces intercostaux, fœtus humains.

Performing medical diagnostic manipulations in premature infants requires anatomical specification.

Ribs and IS constitute an important part of the skeleton of the thorax. These structural elements in the prenatal period of human ontogenesis are of particular interest because they develop in the neighborhood with non-functioning lungs, huge liver and adrenal glands, and large thymus<sup>10</sup>.

It is necessary to have a clear knowledge of the normative morphometric parameters of the thorax during the fetal period of human ontogenesis<sup>10</sup>, which is one of the directions of solving the problem of modern normology. In scientific references, there are few reports about the age-related anatomy of the skeleton of the thorax and ribs at different stages of prenatal ontogenesis and in newborns<sup>11-14</sup>.

A study of the skeleton of the thorax in 40 human fetuses of 16-22 weeks of gestation revealed the predominance of the pyramidal form of the thorax, with the base directed downwards, above the conical shape<sup>15</sup>. In 90% of the examined fetuses there was a parallel, and in 10% of cases – inclined arrangement of the ribs<sup>15</sup>. The authors also drew attention to the broad IS, in the coincidence of the serial number of the rib with the number of vertebrae of the same level along the parasternal, midclavicular and the anterior axillary lines<sup>15</sup>. It has been established that in the

fetuses of the aforementioned age, ribs VII, VIII and IX are already involved in the formation of the costal arch, but rib X does not join the above placed one with its cartilaginous edge<sup>16</sup>.

This study is a continuation of our research dealing with the morphometric parameters of the skeleton of the thorax in human fetuses. The investigation of the peculiarities of the fetal anatomy of the skeleton of the thorax in the fetuses of 4-6 months revealed that three superior IS were the widest, their width exceeds the height of the corresponding ribs along the parasternal line. The smallest value of the length of the costal cartilage was found in the rib I. The length of the bony part of the rib along the parasternal line, beginning with the rib II, gradually increases and the maximum value of the length of the bony part is observed in the rib VI<sup>17</sup>.

However, the sources of literature contain no information on the morphometric parameters of the skeleton of the thorax in 7-10-month-old human fetuses.

**THE OBJECTIVE OF THE STUDY** was to trace the dynamics of changes of the morphometric parameters of the skeleton of the thorax in human fetuses aged 7-10 months.

#### **MATERIALS AND METHODS**

The anatomical study involved 39 specimens of human fetuses, of 231.0-375.0 mm of crown-rump length (CRL), without external signs of anatomical impairments or abnormalities of the development of the skeleton of the thorax by means of macro-microscopic preparation, morphometry and the method of variation statistics. Specimens of fetuses were studied directly in Chernivtsi Regional Pediatric Pathology and Anatomy Bureau, Ukraine, in accordance with the cooperation agreement. Specimens of fetuses from the Museum of the Department of Human Anatomy named after M.H. Turkevych and the Department of Histology, Cytology and Embryology, HSEI of Ukraine „Bukovinian State Medical University“ were also involved in the study<sup>18</sup>. The method of macro-microscopic preparation for the study of fetal anatomy of the skeleton of the thorax implies holding to certain conditions: 1) to exclude the error in the numbering of vertebrae, ribs and IS at the stage of fixation of specimens of fetuses in 5% of the formalin solution, it is necessary to fix the body in a straightened position; 2) the initial stage is the preparation of the spinal processes of the thoracic vertebrae, their verification, followed by the designation of the ribs and vertebrae; 3) during the study, all stages of preparation should be photographed due to

the fact that each stage contains morphological data and is important for the research.

In order to establish the individual and age anatomical variability of the bony thorax in the human fetuses from the 7<sup>th</sup> to the 10<sup>th</sup> month of intrauterine development, we determined the height of the ribs by the midclavicular, posterior axillary and scapular lines on the right and on the left, the width of the IS along the parasternal, midclavicular, posterior axillary and scapular lines on the right and on the left, the length of the costal cartilages and the length of the bony part of the ribs I-XII. In the course of statistical calculations, the built-in MS Excel functions were applied. The arithmetic mean and its error were calculated. The critical level of statistical significance was adopted at  $p \leq 0.05$ .

The research has been carried out in compliance with the basic bioethical provisions of the Council of Europe Convention on Human Rights and Biomedicine (dated 04.04.1997), the Helsinki Declaration of the World Medical Association on the Ethical Principles of Scientific Medical Research with Human Participation (1964-2013), the Order of the Ministry of Health of Ukraine N° 690, dated September 23, 2009, and taking into account the methodological recommendations of the Ministry of Health of Ukraine „Procedure of exemption of biological objects from dead persons whose bodies are subject to forensic medical examination and pathological examination for scientific purposes“ (2018). The Committee on Biomedical Ethics of the HSEI of Ukraine „Bukovinian State Medical University“ has not revealed any violations of moral and legal norms during the scientific research.

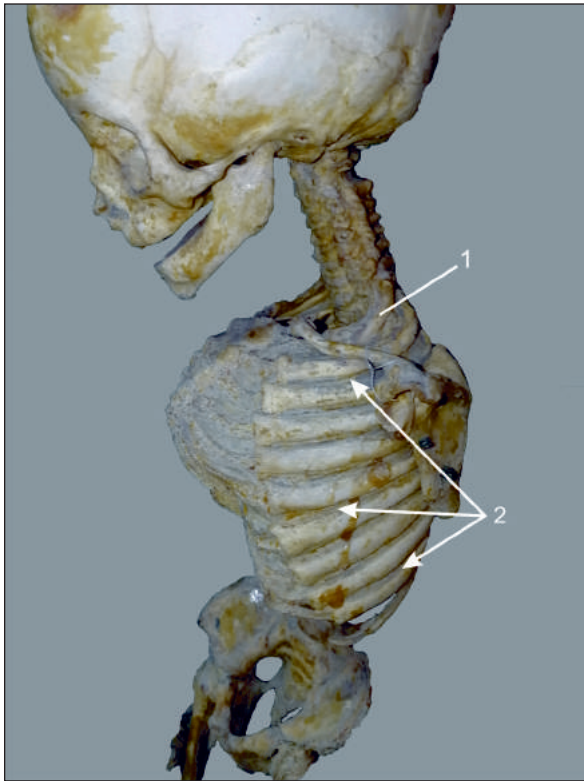
The research is a fragment of the planned comprehensive topic of the Department of Histology, Cytology and Embryology of the HSEI of Ukraine „Bukovinian State Medical University“ „Patterns of morphogenesis and structural and functional peculiarities of tissues and organs in human ontogenesis“, N° of state registration 0116U002938.

#### **RESULTS AND DISCUSSION**

In the examined fetuses the ribs are arranged with a slight inclination from the head to the angle of the rib, after that they can take a horizontal direction or continue the oblique course (Fig. 1). The ribs consist of cartilage (costal cartilage) and bone parts, between which the angle, located in the projection of the midclavicular line (Fig. 2), is determined.

In the result of the morphometric study, it was found that the length of the costal cartilage increases from rib I to VII and is the largest in the rib VII, and then gradually decreases from rib VIII to XII





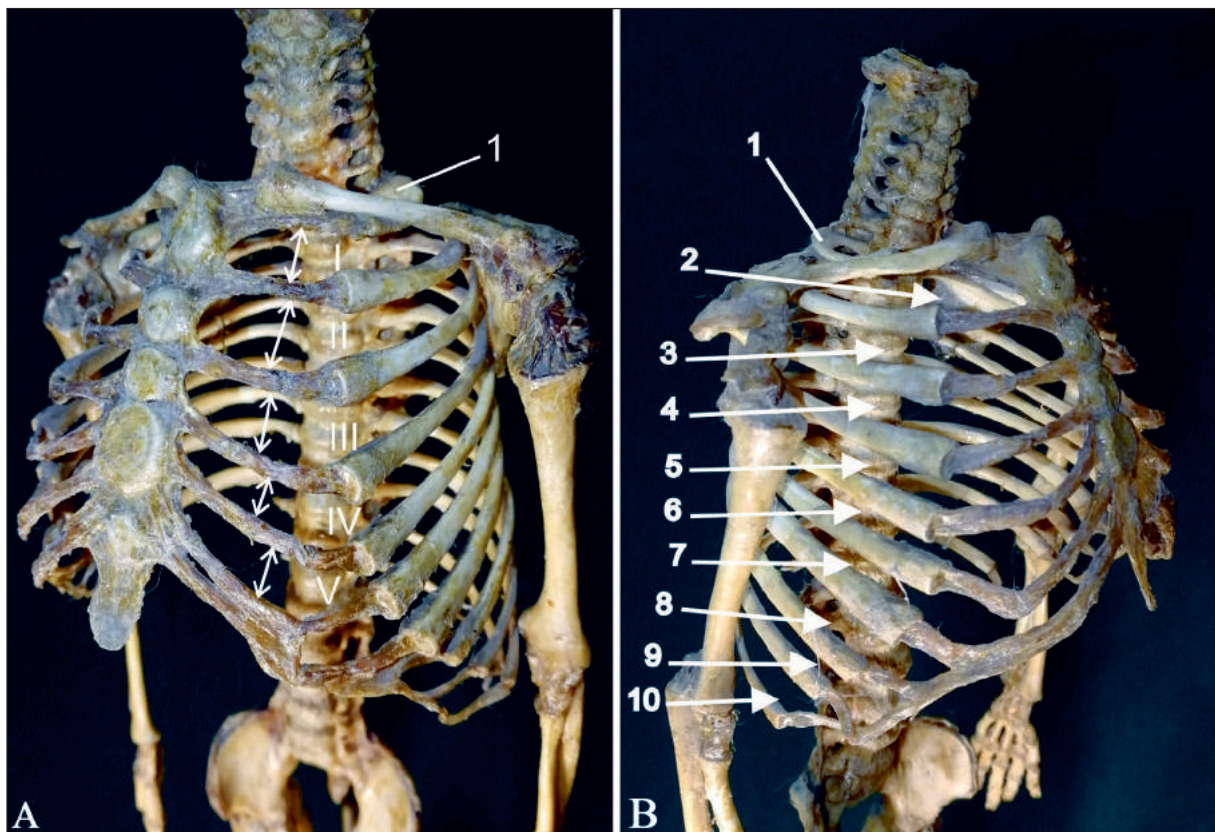
**Fig. 1.** Skeleton of the thorax in the fetus of 270.0 mm of CRL. Left view: 1 – first left rib; 2 – intercostal spaces.

(Table 1). The smallest value of the length of the costal cartilage was found in the rib XII. From the 7<sup>th</sup> to the 10<sup>th</sup> month of the intrauterine development, an intensive increase in the length of the costal cartilages of the ribs I-III occurs, on average, by 1.5 times, and there is a slow increase in the length of the costal cartilage of the rib VII.

The length of the bony part is the largest in the rib VII (Table 2). From the 7<sup>th</sup> to the 10<sup>th</sup> month of the intrauterine development, an intensive increase in the length of the bony part of the ribs III, X and XI occurs, on average, by 1.4 times, and there is a slow increase in the length of the bony part of the ribs I, VII and IX, on average by 1.26 times.

It should be noted that at the end of the fetal period of the human ontogenesis, ribs VII, VIII and IX on the right and on the left form the right and left costal arches (Fig. 3). In this case, the costal cartilage of the rib X is not yet attached to the costal cartilage of the rib IX located above.

In the result of the quantitative data obtained, it was found that the ribs are the highest along the midclavicular line. In this case, the height of the ribs decreases along the posterior axillary line and is the smallest along the scapular line (Table 3-5). A morphometry of the height of the ribs along the



**Fig. 2.** Skeleton of the thorax in the fetus of 310.0 mm of CRL. Left anterior (A) and right anterior (B) projections: A: 1 – first left rib; I-V – intercostal spaces; B: 1 – first right rib; 1-10 – intercostal spaces.

**Table 1.** Length of the costal cartilage in the fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	right	left	right	left
I	11.46±0.78	11.85±0.59	13.67±0.90	14.11±0.86	15.44±0.91	15.83±0.97	17.69±0.84	18.06±0.68
II	16.28±0.56	16.12±0.56	18.39±1.05	17.83±1.03	20.39±0.99	23.83±1.11	23.69±1.09	23.25±1.28
III	18.6±0.73	18.41±0.66	21.5±1.60	21.3±1.70	24.28±0.79	26.31±0.86	26.81±0.79	26.31±0.92
IV	21.35±1.26	21.22±1.17	24.28±1.46	24.08±1.50	26.78±0.94	26.33±1.09	29.81±1.03	29.13±0.79
V	24.58±0.89	24.85±0.92	26.89±1.71	27.5±1.62	30.17±1.03	30.30±0.90	32.19±0.70	32.63±0.44
VI	29.58±1.40	30.19±1.07	31.89±0.78	32.5±0.87	33.56±0.98	34.06±0.77	35.0±0.71	34.88±1.67
VII	37.04±0.88	36.35±0.97	37.83±0.90	37.44±0.98	39.61±0.89	39.33±0.75	40.56±1.02	40.13±0.83
VIII	28.62±1.85	28.12±1.77	31.67±1.56	31.06±1.67	33.28±1.06	32.94±0.85	34.56±0.78	34.25±0.85
IX	23.35±0.94	22.93±0.99	25.28±1.00	24.89±0.96	26.61±0.74	26.33±0.83	29.38±1.75	28.69±1.69
X	21.27±0.95	21.77±0.86	23.78±1.06	24.5±1.15	25.89±0.86	26.56±1.01	27.88±0.88	28.63±1.16
XI	14.31±0.90	13.96±0.90	15.67±0.79	15.27±0.62	16.5±0.61	16.06±0.58	17.44±0.56	17.19±0.59
XII	11.54±0.78	11.85±0.66	12.17±0.79	12.67±0.75	13.26±0.69	13.78±0.67	14.36±0.69	14.88±0.69

**Table 2.** Length of the bony part of the ribs in the human fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

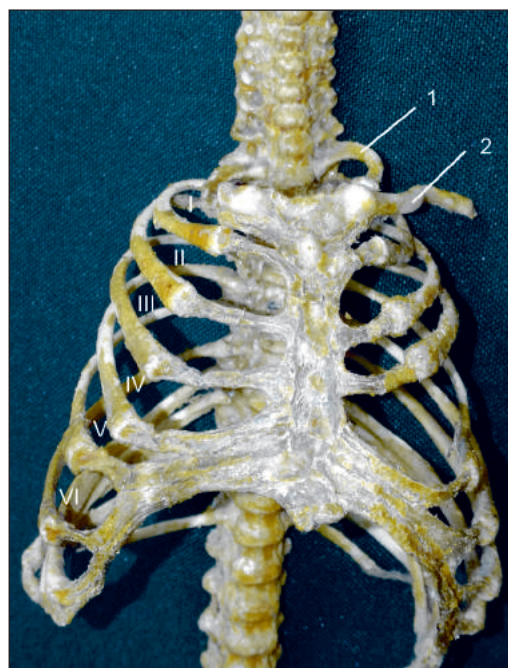
Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	right	left	right	left
I	40.96±1.1	41.46±1.79	45.61±2.10	46.22±1.87	48.39±1.17	48.89±1.08	51.56±1.02	51.94±1.11
II	45.96±1.81	46.58±1.74	52.22±2.44	52.83±2.48	57.77±1.71	58.0±1.69	61.56±1.61	62.2±1.64
III	52.62±1.19	53.12±1.23	56.94±1.01	57.56±2.02	65.94±2.57	66.61±2.42	73.18±2.60	73.81±2.49
IV	58.46±1.44	59.23±1.39	63.78±2.67	64.56±2.76	72.89±2.81	73.61±2.70	79.81±2.37	80.56±2.26
V	63.95±1.32	64.77±1.36	72.17±3.15	72.89±2.90	79.83±2.29	80.44±2.25	87.38±3.24	88.25±3.29
VI	70.92±3.19	71.65±1.68	78.0±3.44	78.72±3.36	86.83±2.54	87.5±2.30	94.75±3.33	95.5±3.43
VII	83.96±3.19	84.73±3.08	91.56±3.50	92.38±3.19	96.22±4.06	97.44±3.94	105.25±3.11	106.19±2.88
VIII	69.03±2.16	69.81±2.07	76.0±2.79	71.83±2.66	83.17±3.16	83.94±3.13	89.69±3.03	90.63±2.74
IX	61.62±1.77	61.96±2.02	65.94±3.03	66.94±2.86	73.44±2.31	74.28±2.02	78.38±1.27	79.5±1.67
X	46.62±2.54	47.21±2.24	53.22±2.39	54.11±2.41	59.5±3.03	60.5±3.08	66.75±1.81	67.81±1.89
XI	31.23±1.81	32.11±1.72	36.33±1.95	37.22±1.52	42.0±1.92	42.83±1.89	44.25±1.13	45.0±1.64
XII	23.85±2.18	23.23±2.11	27.11±1.11	26.44±1.21	29.22±0.67	25.44±8.82	31.19±1.03	30.56±1.08

midclavicular line on the right and on the left allowed to establish that the ribs III and VII are the highest. At the same time, from the 7<sup>th</sup> to the 10<sup>th</sup> month of the intrauterine development, the height of the rib III increases most intensively (almost by 2 times). In determining the height of the ribs along the posterior axillary line, the ribs VII and VI were found to be the highest, and the ribs IV and VII are the highest along the scapular line.

The morphometry of the IS width along the projection lines on the right and on the left allows to obtain quantitative data concerning this parameter. The greatest width of II and III IS was detected along the parasternal and midclavicular lines (Table 6, 7). The width of the four superior IS along the midclavicular line on the right and on the left dominates over the height of the corresponding ribs. Thus, the width of the II IS on the right and on the left is



**Fig. 3.** Skeleton of the thorax in the fetus of 290.0 mm of CRL. Front view: 1 – first right rib; I-VII – intercostal spaces.



**Fig. 4.** Skeleton of the thorax in the fetus of 265.0 mm of CRL. Front view: 1 – first left rib; 2 – left clavicle; I-VI – intercostal spaces.

**Table 3.** Height of the ribs along the midclavicular line in the human fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	right	left	right	left
Rib number I	3.00±0.45	2.88±0.42	3.78±0.22	3.64±0.24	4.76±0.37	4.60±0.33	5.48±0.32	5.29±0.25
II	3.55±0.57	3.35±0.58	4.58±0.32	4.37±0.39	5.58±0.32	5.34±0.41	6.39±0.36	6.19±0.46
III	3.91±0.68	3.75±0.67	5.09±0.33	4.90±0.44	6.37±0.48	6.09±0.59	7.54±0.43	7.20±0.57
IV	3.29±0.46	3.59±0.71	4.31±0.38	4.71±0.38	5.31±0.49	5.70±0.35	6.53±0.42	6.84±0.39
V	3.09±0.33	3.18±0.49	3.93±0.32	4.31±0.35	4.81±0.35	5.08±0.47	5.94±0.42	5.69±0.53
VI	3.68±0.49	3.85±0.66	4.64±0.47	4.74±0.87	5.22±0.44	5.61±0.49	6.06±0.49	5.75±0.71
VII	4.31±0.40	4.49±0.71	5.39±0.42	5.78±0.44	6.56±0.53	6.47±0.49	7.78±0.57	7.46±0.76
VIII	2.89±0.25	2.94±0.36	3.18±0.20	3.52±0.32	3.78±0.44	4.20±0.38	4.56±0.42	4.91±0.36

**Table 4.** Height of the ribs along the posterior axillary line in the human fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	right	left	right	left
Rib number I	1.84±1.67	1.68±0.18	2.33±0.22	2.19±0.18	2.83±0.23	2.67±0.20	3.35±0.19	3.19±0.19
II	2.02±0.19	2.18±0.23	2.68±0.31	2.89±0.31	3.48±0.21	3.29±1.03	3.93±0.16	4.13±0.22
III	2.41±0.23	2.56±0.24	3.14±0.38	3.42±0.37	4.03±0.33	4.34±0.38	4.76±0.26	4.96±0.26
IV	3.09±0.19	2.86±0.15	3.73±0.41	3.57±0.39	4.58±0.39	4.46±0.38	5.06±0.25	4.98±0.21
V	2.78±0.14	2.65±0.14	3.31±0.24	3.13±0.21	3.87±0.29	3.70±0.24	4.78±0.39	4.56±0.32
VI	3.09±0.23	2.91±0.24	3.76±0.35	3.54±0.33	4.84±0.33	4.67±0.35	5.34±0.24	5.18±0.25
VII	3.22±0.26	3.38±0.33	4.01±0.39	4.18±0.35	4.94±0.35	5.20±0.23	5.50±0.18	5.61±0.14
VIII	3.21±0.26	3.43±0.29	3.77±0.27	3.99±0.21	4.41±0.20	4.51±0.26	4.73±0.16	4.93±0.16
IX	2.71±0.14	2.84±0.14	3.33±0.30	3.58±0.25	4.0±0.32	4.21±0.32	4.69±0.31	4.83±0.35
X	2.51±0.13	2.66±0.17	3.01±0.33	3.16±0.30	3.63±0.20	3.77±0.22	4.35±0.34	4.46±0.39



**Table 5.** Height of the ribs along the scapular line in the human fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	right	left	right	left
I	1.53±0.17	1.43±0.13	1.80±0.10	1.66±0.12	2.08±0.16	1.97±0.16	2.30±0.19	2.21±0.20
II	2.40±0.22	2.46±0.31	2.80±0.16	2.91±0.19	3.04±0.14	3.17±0.16	3.29±0.16	3.43±0.18
III	2.81±0.21	2.68±0.22	3.17±0.16	3.06±0.17	3.40±0.12	3.26±0.29	3.55±0.09	3.49±0.13
IV	2.91±0.21	3.05±0.22	3.21±0.16	3.13±0.44	3.52±0.09	3.56±0.11	3.61±0.07	3.61±0.06
V	2.38±0.15	2.26±0.14	2.68±0.09	2.58±0.11	2.89±0.13	2.83±0.11	3.20±0.11	3.06±0.11
VI	2.50±0.13	2.38±0.15	2.77±0.13	2.66±0.12	3.07±0.16	2.97±0.15	3.35±0.12	3.25±0.16
VII	2.95±0.24	2.76±0.22	3.29±0.24	3.20±0.24	3.50±0.10	3.41±0.12	3.63±0.10	3.50±0.09
VIII	2.44±0.12	2.48±0.22	2.64±0.09	2.67±0.14	2.82±0.14	2.93±0.17	3.06±0.11	3.15±0.12
IX	2.26±0.19	2.39±0.27	2.61±0.13	2.83±0.13	2.96±0.15	3.04±0.22	3.14±0.14	3.26±0.21
X	2.24±0.11	2.33±0.17	2.51±0.11	2.66±0.40	2.69±0.11	2.81±0.15	2.96±0.16	3.14±0.18

**Table 6.** Width of the intercostal spaces along the parasternal line in the human fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	right	left	right	left
I	3.80±0.58	3.56±0.52	4.96±0.48	4.63±0.52	5.47±0.73	5.08±0.77	6.25±0.59	5.78±0.64
II	4.47±0.66	4.22±0.63	6.64±0.72	6.21±0.78	7.79±0.74	7.37±0.71	8.69±0.92	8.14±0.93
III	4.38±0.60	4.22±0.56	6.22±1.15	5.79±1.18	7.53±0.89	7.09±0.94	8.50±1.19	7.90±1.15
IV	3.42±0.49	3.15±0.52	4.94±0.51	4.48±0.54	5.87±0.60	5.57±0.44	6.88±0.92	6.48±0.90
V	2.85±0.68	3.11±0.71	4.13±0.62	3.90±0.63	5.17±0.75	4.93±0.80	6.25±0.93	5.75±0.80
VI	2.90±0.49	2.67±0.45	3.98±0.55	3.37±0.52	4.86±0.78	4.31±0.76	5.78±0.64	5.23±0.65

**Table 7.** Width of the intercostal spaces along the midclavicular line in the human fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	right	left	right	left
I	4.95±0.44	4.57±0.46	5.97±0.53	5.58±0.64	6.48±0.48	6.04±0.58	6.81±0.59	6.40±0.63
II	5.65±0.43	5.34±0.44	7.24±0.88	6.88±0.91	8.33±0.79	7.89±0.74	10.0±0.80	9.58±0.82
III	5.31±0.63	4.98±0.56	7.22±1.39	6.74±1.31	8.28±1.03	7.79±1.02	8.75±1.60	8.25±1.60
IV	4.47±0.71	4.17±0.73	5.71±0.39	5.40±0.45	6.09±0.39	5.66±0.41	7.73±0.94	7.36±1.03
V	4.12±0.62	3.67±0.51	5.16±0.61	4.80±0.53	6.11±0.70	5.44±0.53	7.00±0.93	6.44±1.02
VI	3.78±0.50	3.42±0.41	4.67±0.35	4.17±0.50	5.67±0.66	5.21±0.65	6.38±0.52	5.82±0.53

larger than the height of the right and left rib II by 1.5 times.

The morphometric study of the width of the IS along the posterior axillary line on the right and on the left allowed to establish the greatest width of the II, IV and VII IS (Table 8).

In the fetus of 265.0 mm of CRL a wide IV left IS was detected, its width along the left parasternal

line was equal to 8.5 mm, and along the midclavicular line it was 14.5 mm. At the same time the width of the IV right IS along the above-mentioned lines was 5.2 and 6.5 mm respectively (Fig. 4).

The width of the II-X IS on the right and on the left along the scapular lines exceeds the height of the corresponding ribs by 1.33-1.65 times, on average, by 1.5 times; and the width of the right and left I IS

**Table 8.** Width of the intercostal spaces along the posterior axillary line in the human fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	left	right	left	right
I	2.93±0.31	2.88±0.31	3.70±0.39	3.60±0.32	4.28±0.23	4.18±0.23	4.83±0.18	4.73±0.21
II	3.83±0.28	3.70±0.27	4.59±0.19	4.44±0.22	5.43±0.21	5.29±0.24	6.00±0.27	5.84±0.24
III	3.38±0.22	3.26±0.21	3.98±0.18	3.88±0.13	4.64±0.17	4.56±0.14	5.23±0.22	5.16±0.28
IV	3.28±0.18	3.35±0.15	4.17±0.27	4.06±0.24	5.14±0.24	5.30±0.22	5.73±0.20	5.84±0.18
V	3.25±0.17	3.37±0.17	3.82±0.18	3.93±0.20	4.46±0.14	4.60±0.14	5.08±0.24	5.25±0.28
VI	3.21±0.15	3.37±0.17	3.89±0.27	3.97±0.27	4.72±0.32	4.84±0.30	4.94±0.22	5.10±0.20
VII	3.43±0.15	3.27±0.17	4.51±0.22	4.39±0.21	5.13±0.16	5.00±0.17	5.50±0.14	5.39±0.15
VIII	3.42±0.17	3.57±0.18	4.32±0.37	4.48±0.31	4.60±0.27	4.76±0.23	4.93±0.18	5.09±0.17
IX	3.38±0.13	3.25±0.16	3.97±0.18	3.84±0.19	4.37±0.13	4.19±0.15	5.00±0.24	4.86±0.24
X	3.22±0.16	3.08±0.15	3.74±0.21	3.60±0.20	4.11±0.13	3.90±0.19	4.93±0.21	4.81±0.24

**Table 9.** Width of the intercostal spaces along the scapular line in the human fetuses aged 7-10 months ( $\bar{X} \pm S\bar{x}$ , mm)

Age of fetuses, months	7 months (n=13)		8 months (n=9)		9 months (n=9)		10 months (n=8)	
	right	left	right	left	right	left	right	left
I	2.90±0.28	2.64±0.26	3.57±0.37	3.30±0.29	4.03±0.34	3.94±0.31	4.59±0.37	4.33±0.38
II	3.25±0.33	3.08±0.32	4.03±0.27	3.80±0.24	4.68±0.32	4.32±0.29	5.40±0.45	5.06±0.34
III	2.88±0.15	2.70±0.19	3.69±0.26	3.56±0.29	4.36±0.26	4.09±0.26	4.83±0.27	4.54±0.29
IV	2.77±0.24	2.93±0.27	3.53±0.30	3.83±0.24	4.46±0.42	4.60±0.41	4.90±0.22	5.21±0.38
V	2.86±0.31	3.04±0.30	3.51±0.22	3.64±0.19	4.09±0.26	4.27±0.26	4.74±0.23	4.94±0.19
VI	2.71±0.20	3.91±0.21	3.37±0.32	3.56±0.22	4.00±0.27	4.17±0.24	4.60±0.19	4.86±0.19
VII	3.02±0.16	2.71±0.17	3.89±0.36	3.88±0.36	4.84±0.28	4.69±0.28	4.96±0.24	4.89±0.24
VIII	2.92±0.25	3.12±0.26	3.42±0.26	3.62±0.25	3.94±0.15	4.06±0.16	4.46±0.16	4.64±0.18
IX	3.12±0.24	2.92±0.19	3.66±0.18	3.47±0.17	4.03±0.17	3.82±0.19	4.53±0.18	4.36±0.19
X	3.28±0.27	3.05±0.26	3.74±0.18	3.58±0.17	4.22±0.27	4.03±0.25	4.91±0.25	4.74±0.26

exceeds the height of the ribs I, almost twice (Fig. 5). In the studied fetuses, the II, IV and X IS along the scapular line on the right and on the left are the widest (Table 9).

**CONCLUSIONS**

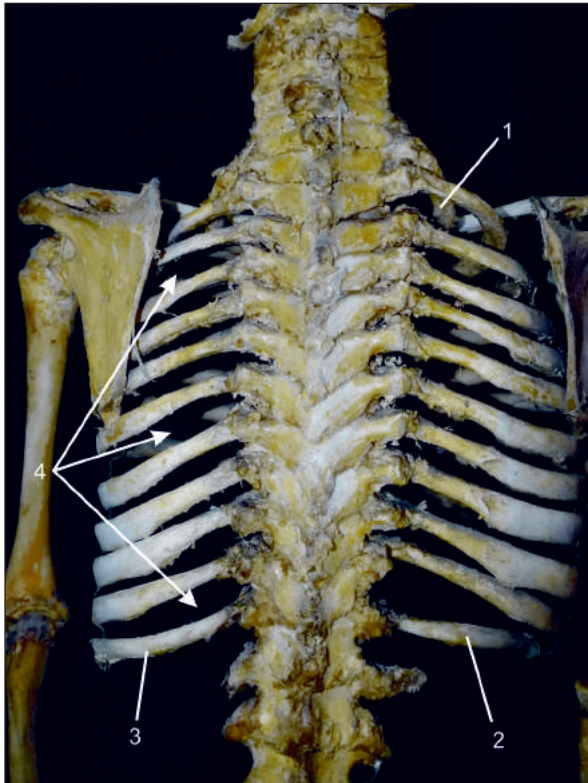
Our morphometric study has established that the length of the costal cartilage increases from rib I to VII and is the largest in the rib VII. The smallest value of the length of the costal cartilage was found in the rib XII. During the 7<sup>th</sup>-10<sup>th</sup> months of the intrauterine development an intensive increase in the length of costal cartilages of the ribs I-III occurs, on average, by 1.5 times, and there is a slow increase in the length of the costal cartilage of the rib VII.

The obtained quantitative data indicate that the ribs along the midclavicular line are the highest. At the same time, the height of the ribs decreases along the posterior axillary line and along the scapular line it is the lowest.

The analysis of the data revealed the greatest width of the II and III intercostal spaces along the parasternal and midclavicular lines. The width of the four superior intercostal spaces along the midclavicular line on the right and on the left is larger than the height of the corresponding ribs.

In the studied fetuses the greatest width of the II, IV and VII intercostal spaces along the posterior axillary line on the right and on the left, and along the scapular lines - of the II, IV and X of the intercostal spaces was noted.





**Fig. 5.** Skeleton of the thorax in the fetus of 315.0 mm of CRL. Back view: 1 – first right rib; 2 – twelfth right rib; 3 – twelfth left rib; 4 – intercostal spaces on the left.

**Prospects for further research.** The conducted research regarding the anatomical variability of the skeleton of the thorax in the fetuses aged 7-10 months indicates the need of further studies of morphometric parameters of the skeleton of the thorax in newborns.

#### Compliance with Ethics Requirements:

„The authors declare no conflict of interest regarding this article“

„The authors declare that all the procedures and experiments of this study respect the ethical standards in the Helsinki Declaration of 1975, as revised in 2008(5), as well as the national law. Informed consent was obtained from all the patients included in the study“

„No funding for this study“

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