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Anatomy of the ileum-intestinal tract of the human fetus at 16–22 weeks of ontogenesis

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Abstract

Aim – to obtain new data on the quantitative macromicroscopic anatomy of the iliac-intestinal region in the intermediate fetal period of human ontogenesis from the 16th to the 22nd week of development.

Material and methods. The study was performed on 30 subjects of both sexes (18 female and 12 male fetuses) using the following methods: macro- and microscopic preparation, N.I. Pirogov sawing, histotopographic method, morphometry, and variation-statistical methods. All the morphometric data obtained were subjected to variation-statistical processing in Windows XP-based Excel 2010 and Statistics 13.0 application software packages. When testing statistical hypotheses in this study, the critical level of statistical significance (p) was assumed to be 0.05. The Student's t-test was used to assess the reliability. A set of tools for macromicroscopic preparation of the fetus was used.

Results. During the period of development in question, the position of the ileum has slight vertical deviations, which affects the formation and magnitude of the angle between the ileum and the cecum, as well as between the ileum and the ascending colon. The predominant shape of the cecum is cylindrical (80%), less often conical (20%). There is an uneven growth of the walls of the cecum, where the lateral wall prevails over the medial one, which is associated with the formation of flap structures. The ileo-intestinal opening is oval in shape, the frenules are weakly pronounced, with a more pronounced ileo-colon lip. Semilunar folds are differentiated on the mucous membrane of the cecum from 16-17 weeks, and a free muscle band is also determined. The omental and mesenteric bands are not pronounced. There is no morphological boundary between the appendix and the cecum. From 19-20 weeks, the presence of 1-2 gausters is noted. The quantitative parameters of the iliac-intestinal region are characterized by a gradual twofold increase in values.

Keywords: ileocephalic intestine, cecum, human fetus, intermediate period, ileocecal angle, vermiform process.

Conflict of interest: nothing to disclose.

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Анатомия подвздошно-слепокишечного отдела кишечника плода человека на 16–22 неделе онтогенеза

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Аннотация

Цель – получить новые данные по количественной макромикроскопической анатомии подвздошно-слепокишечного отдела в промежуточном плодном периоде онтогенеза человека с 16 по 22 неделю развития.

Материал и методы. Исследование выполнено на 30 объектах обоего пола (18 плодов женского пола, 12 – мужского) с использованием методов: макро- и микроскопического препарирования, распилов по Н.И. Пирогову, гистотопографического, морфометрии, вариационно-статистических методов. Полученные морфометрические данные были подвергнуты вариационно-статистической обработке в среде Windows-XP с использованием пакета прикладных программ Excel 2010 и «Статистика 13.0». Критический уровень статистической значимости (p) при проверке статистических гипотез в данном исследовании принимали равным 0,05. Для оценки достоверности был использован критерий Стьюдента. Применен набор инструментов для макромикроскопического препарирования плода.

Результаты. В указанный период развития положение подвздошно-слепокишечного отдела имеет незначительное отклонение по вертикали, что оказывает влияние на формирование и величину угла между подвздошной кишкой и слепой, а также между подвздошной кишкой и восходящей ободочной. Преобладающей формой слепой кишки является цилиндрическая (80%), реже – конусовидная (20%). Отмечается неравномерный рост стенок слепой кишки, где латеральная стенка преобладает над медиальной, что связано с формированием структур заслонки. Определены подвздошно-кишечное отверстие овальной формы, слабо выраженные уздечки, с более выраженной подвздошно-ободочно-кишечной губой. На слизистой оболочке слепой кишки с 16–17 недели дифференцируются полулунные складки, а также определяется свободная мышечная лента. Сальниковые и брыжеечный ленты не выражены. Морфологическая граница между червеобразным отростком и слепой кишкой отсутствует. На 19–20 неделе отмечается наличие 1–2 гаустр. Количественные параметры подвздошно-слепокишечного отдела характеризуются постепенным двукратным нарастанием значений.

Ключевые слова: подвздошно-слепокишечный отдел кишечника, слепая кишка, плод человека, промежуточной период, илеоцекальный угол, червеобразный отросток.

Конфликт интересов: не заявлен.

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Список сокращений
ТР – темп роста; ТП – темп прироста; ИР – интенсивность роста.

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INTRODUCTION

The morphological basis for many pathologies of the ileocecal intestinal region is established during prenatal ontogenesis [1, 2]. Congenital intestinal malformations (malrotation, intestinal volvulus, cecocolic intussusception, intestinal obstruction, and atresias) account for 3–6% of cases, with malformations of the colon being predominant. Modern diagnostic techniques enable clear visualization of the human fetal intestine and allow for early endoscopic diagnosis in newborns and young children [3, 4].

The current scientific data mainly concern the formation of components of the ileocecal intestinal region individually, anatomy and morphometry of the cecum and the vermiform appendix in the fetal period of development, as well as the anatomy of the ileocecal angle in newborns, children, and persons of advanced age. Studies comprehensively addressing the anatomical features of the ileocecal intestinal region during the fetal period of human ontogenesis are virtually absent in scientific literature. Meanwhile, the processes of its formation and migration, with the small intestine moving (from right to left, behind the superior mesenteric artery) and the large intestine moving (from left to right relative to the same artery), collectively termed intestinal rotation, are completed during the intermediate fetal period of ontogenesis [5]. The gastrointestinal tract of the fetus, as the digestive organ, starts functioning from 16th-20th week [6], which opens an opportunity of prevention of many of its congenital damages. It is known that the ileocecal region of the intestine represents a transitional zone between the small and large intestines, connecting the terminal segment of the ileum, the cecum with its vermiform appendix, and the ileocecal valve (Bauhin's valve), as well as the initial portion of the ascending colon [7]. This region is frequently associated with congenital developmental anomalies.

AIM

To obtain new data on the quantitative macromicroscopic anatomy of the iliac-intestinal region in the intermediate fetal period of human ontogenesis from the 16th to the 22nd week of development.

MATERIAL AND METHODS

This study was conducted at the Department of Human Anatomy, Orenburg State Medical University, from 2019 to 2024. An approval (No. 237, dated 16.10.2019) was obtained from the Local Ethics Committee of OSMU. The research utilized cadaveric material (human fetal torsos from the fetal collection of the Department of Human Anatomy, OSMU) obtained following termination of normally progressing physiological pregnancies for social reasons, with full compliance with all relevant deontological, ethical, and legal standards.

The study was conducted on 30 specimens of both sexes (18 female and 12 male fetuses). The specimens were divided into 3 age groups: 16-17 weeks (n=10), 18-19 weeks (n=10), and 20-22 weeks (n=10). The selected age range virtually fully corresponds to the second trimester of pregnancy and the intermediate fetal period of human ontogenesis.

The study utilized the following research methods: macro- and microscopic dissection method, N.I. Pirogov's sectioning method in three mutually perpendicular planes, histotopographic method, morphometric method, and variational-statistical methods of data processing (mean value (X), standard error of the mean (Sx), standard deviation (σ), minimum parameter value (min), maximum parameter value (max), growth rate (GR), growth increment rate (GIR), and growth intensity (GI)).

The obtained morphometric data were processed in Windows XP using the Excel 2010 and Statistica 13.3 software suites. Given the obtained normal distribution of sample data, parametric methods were used for statistical analysis. The critical level of statistical significance (p) when testing statistical hypotheses in this study was set at 0.05. Student's t-test was used to assess reliability. The study employed a set of tools and devices for macromicroscopic dissection of fetal torsos (fetal torso dissection stand, magnifying loupe and illuminated eyepieces, digital caliper, set of microscopic instruments (microscissors, forceps, scalpel, and bayonet medical probe)).

RESULTS

During macroscopic examination of the ileocecal intestinal region in fetuses with opened anterior abdominal wall, the transition zone between the terminal ileum and cecum, the cecum with its vermiform appendix, and the ileocecal orifice were clearly identifiable (**Fig. 1**).

The position of the ileocecal region shows a slight vertical deviation (with some lateral inclination). The area of the ileocecal (cecocolic) angle is clearly identifiable for macroscopic examination and measurements.

In most cases (80%), the ileum enters the cecal lumen obliquely in a craniomedial direction, while in 20% of observations the entry orientation is horizontal, forming a 90° angle. At the fundus region, the cecum continues into the vermiform appendix either medially (75% of cases) or laterally (15%), without a distinct demarcation boundary.

A firm contact is observed between the medial wall of the cecum and the lateral wall of the ileum, forming the so-called

ileocecal angle. This angle varies depending on the entry pattern of the terminal ileum into the cecum. The cecum and ascending colon follow a unidirectional axis deviated medially from the vertical plane. In this configuration, the ileum predominantly enters the medial wall of the cecum in a horizontal orientation, forming a 90-115° angle between the ileum and ascending colon, and a 27-40° ileocecal angle between the ileum and cecum.

The cecum and ascending colon follow a shared axis with slight lateral deviation from the vertical plane (the cecum deviates laterally), while the terminal ileum enters the cecum in a craniomedial oblique orientation through the posteromedial wall of the cecal body. This configuration forms a 70-80° angle between the ileum and ascending colon, and a 30-60° angle between the cecum and ileum.

In the fetuses of 16-17 weeks, the cecum appears as an outpouching of the intestinal tube with a cylindrical shape. It is located in the right iliac region of the fetus, between the iliopsoas muscle and anterior abdominal wall. The cecal axis continues the axis of the ascending colon. Between 16-22 weeks, the cecum adjoins the anterior surface of the ileum with its medial or posterior wall. In most observations, it shares a common mesentery with the ileum. The cecum is positioned slightly below the right fetal kidney, with its lateral or posterior wall contacting the medial portion of the anterior surface of the kidney.

During these ontogenetic periods, the shape of the cecum holds particular significance. At 16-22 weeks of the study period, the cecum appears as a moderately distended segment of the proximal colon, featuring a formed fundus and a small-sized body. By mid and late observations, the cecum becomes a well-defined structure, predominantly cylindrical in shape (80%), less commonly conical (20%) with a slightly expanded sac-like fundus. It is located in the right iliac fossa of the fetus. From 16-22 weeks of development, the cecum demonstrates a body with medial, lateral, anterior and posterior walls, along with a fundus (dome). During the study period, the cecal fundus was positioned cranially (ventrolaterally and ventromedially) in most cases (75%), or caudally (15%) (ventrolaterally and ventromedially).

The length of the cecum (from the end of the ascending colon to the orifice of the vermiform appendix) changes during the observation period from 1.0-1.50 mm (mean values 1.16±0.25 mm) to 3.0-3.60 mm (mean values 3.24±0.27 mm), with a growth rate of 2.1 times and GI of 82%. The width of the cecum changes accordingly from 0.50-0.70 mm (mean values 0.62±0.09 mm) to 2.0-2.60 mm (mean values 2.35±0.24 mm) with a growth rate of 2.1 times and GI of 135%. The conducted morphometric studies and compared parameters are statistically significant at $p<0.05$. No gender differences were identified.

During the observation period, as the fetus grows, uneven growth of the cecal walls is observed, with the lateral wall predominating over the medial wall. This is due to the medial wall being occupied by the upper and lower lips of the Bauhin's valve. It should be noted that from 16-17 weeks, semilunar folds begin to differentiate on the cecal mucosa, and a free taenia is identified on the posteromedial wall of the cecum. The omental and mesenteric taeniae are not pronounced. In the cecal wall at 19-20 weeks of development,

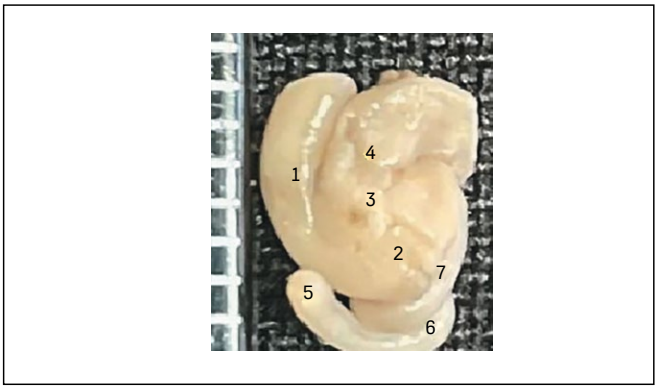

Figure 1. *Photo of a macro-preparation of the ileum-intestinal tract of the human fetus. Front view. ×7 magnification. Fetal age: 18–19 weeks, sex: male. 1 – ascending colon; 2 – dome of the cecum; 3 – ileocecal angle; 4 – ileum; 5 – tip of the appendix; 6 – third curl of the appendix; 7 – first curl of the appendix.*

Рисунок 1. *Фото макропрепарата подвздошно-слепокишечного отдела кишечника плода человека. Вид спереди. Увеличено в 7 раз. Возраст плода 18–19 недель, пол мужской. 1 – восходящая ободочная кишка; 2 – купол слепой кишки; 3 – илеоцекальный угол; 4 – подвздошная кишка; 5 – верхушка червеобразного отростка; 6 – третий завиток червеобразного отростка; 7 – первый завиток червеобразного отростка.*

1-2 haustra are observed. During the studied developmental period, the zone where the terminal ileum enters the cecum is identified slightly above the origin (orifice) of the vermiform appendix.

Dissection of the anterior surface of the cecum reveals its weakly folded wall, ileocolic lip (superior lip), and ileocecal lip (inferior lip), which occupy approximately two-thirds of the cecal body cavity volume and are located 3.0-5.0 mm from its fundus. The wall thickness in the cecal dome region measures 0.30-0.40 mm at 16-17 weeks, 0.4-0.60 mm at 18-19 weeks, and 0.50-0.60 mm at 20-22 weeks. The cecal wall thickness in the region of the Bauhin's valve measures 0.10-0.15 mm at 16-17 weeks, 0.15-0.17 mm at 18-19 weeks, and 0.17-0.20 mm at 20-22 weeks. The conducted morphometric studies and compared parameters are statistically significant at $p<0.05$.

On the medial wall of the cecal body lies the zone of shared ileal and cecal wall. This connection is located within the cecal wall and is not detectable upon dissection since it does not protrude into the lumen. The shared ileal-cecal wall zone forms through the union of the terminal lateral wall of the ileum with the medial wall of the cecum, visualized macroscopically as an extension of the ileocecal (inferior) lip of Bauhin's valve.

The ileum enters either the medial or anterior wall of the cecum. At the beginning of the study period, the ileum primarily enters the posterior wall of the cecum, while in later observation periods it is found to enter either the medial wall or a posteromedial portion of the cecal wall.

The structural feature of the ileocecal angle is the presence of: the ileal orifice, frenula of the ileal orifice, ileocolic lip (superior lip), and ileocecal lip (inferior lip) - collectively termed the ileocecal valve or Bauhin's valve (**Figure 2**).

Upon dissection of the anterior wall of the cecum, the terminal portion of the ileum is identified, protruding into the cecal lumen. The oval shape of the valve is characterized by the longer dimension of the ileocolic lip (superior lip).

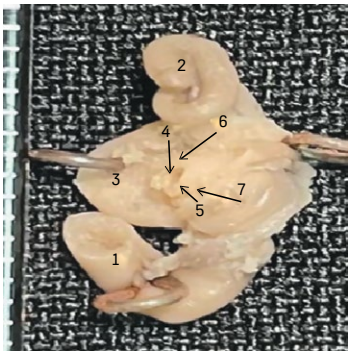

Figure 2. *Photo of the macro-preparation of the iliac-intestinal valve (bauhin's valve) of the fetus. ×5 magnification. Front view (the anterior wall of the cecum is opened). Fetal age: 18–19 weeks, sex: male. 1 – ileum; 2 – vermiform appendix; 3 – mucous membrane of the cecum; 4 – upper lip of the ileocecal valve (bauhin's valve); 5 – lower lip of the ileocecal valve (bauhin's valve); 6 – frenulum of the upper lip of the ileocecal valve; 7 – frenulum of the lower lip of the ileocecal valve.*

Рисунок 2. *Фото макропрепарата подвздошно-слепокишечного клапана (баугиниевой заслонки) плода. Вид спереди (вскрыта передняя стенка слепой кишки). Увеличено в 5 раз. Возраст плода 18–19 недель, пол мужской. 1 – подвздошная кишка; 2 – червеобразный отросток; 3 – слизистая оболочка слепой кишки; 4 – верхняя губа илеоцекального клапана (баугиниевой заслонки); 5 – нижняя губа илеоцекального клапана (баугиниевой заслонки); 6 – уздечка верхней губы илеоцекального клапана; 7 – уздечка нижней губы илеоцекального клапана.*

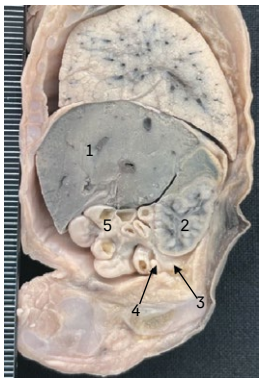

Figure 3. *Anatomy of the ileocecal intestine on the sagittal sections of the fetal torso. Sagittal sawing of the fetal torso, right view. ×2 magnification. Photos from the macro preparation. Protocol No. 143, fetal age: 18–19 weeks, sex: female. 1 – right lobe of the liver; 2 – right kidney; 3 – dome of the cecum; 4 – tip of the appendix; 5 – loops of the small intestine.*

Рисунок 3. *Анатомия подвздошно-слепокишечного отдела кишечника на сагиттальных распилах торса плода. Сагиттальный распил торса плода, вид справа. Увеличено в 2 раза. Фото с макропрепарата. Протокол №143, возраст плода 18–19 недель, пол женский. 1 – правая доля печени; 2 – правая почка; 3 – купол слепой кишки; 4 – верхушка червеобразного отростка; 5 – петли тонкой кишки.*

Between the two lips lies an oval-shaped orifice. The frenula are visualized but weakly developed.

The quantitative characteristics of the ileocecal valve structural elements are as follows: the length of the superior lip ranges from 0.50-1.10 mm to 1.50-2.0 mm. The length of the inferior lip ranges from 0.50-0.90 mm to 1.30-1.60 mm. The length of the superior lip frenulum ranges from 0.30-0.50 mm to 0.70-1.0 mm. The length of the inferior lip frenulum ranges from 0.30-0.50 mm to 0.70-1.0 mm. The conducted morphometric studies and compared parameters are statistically significant at $p<0.05$.

The lateral (right) frenulum is narrower and extends from the ileocecal valve along the inner surface of the right wall of the large intestine. The medial (left) frenulum (fold of the large intestine) extends leftward from Bauhin's valve and is somewhat wider than the lateral one. The frenula are integral components of Bauhin's valve and connect it to the wall of the large intestine. The two lips and two frenula constitute a unified anatomical structure - the ileocecal valve. Both the wall of the small intestine and the wall of the large intestine participate in the formation of the ileocecal valve lips, with each lip having both small and large intestinal aspects that transition into one another along the free edge of the lip. The superior lip of the ileocecal valve serves as a direct continuation of the lateral frenulum, while the inferior lip represents an extension of the shared ileal-cecal wall zone. Thus, a portion of the ileum resides within the cecum. The lateral cecal wall is free-standing, constituting the terminal segment of the small intestine that continues into the superior lip of the Bauhin's valve. The medial cecal wall forms the shared ileal-cecal wall zone, transitioning directly into the inferior lip of the ileocecal valve. The morphological boundary between the cecum and ascending colon is demarcated by the zone of the superior and inferior lips of the Bauhin's valve of the fetus.

At 16-22 weeks of gestation, the cecal cavity reveals a relatively wide orifice of the vermiform appendix leading into its lumen, with no apparent appendiceal valve detected. During this ontogenetic period, the vermiform appendix is already a well-formed organ possessing a rounded lumen. It is located in the right iliac fossa and along the iliac crest, extending continuously without external demarcation from the posteromedial surface of the cecal fundus (**Figure 3**).

Macroscopic examination of the fetal vermiform appendix reveals distinct proximal and distal ends. In the vast majority of cases (87%), the elongated appendix exhibits a tubular shape with variable diameter along its length (**Figure 4**).

The proximal end of the appendix originates as a continuation of the cecum, featuring a broad base, while the apical portion of the distal end is rounded and club-shaped. During weeks 16-22 of intermediate fetal development, the vermiform appendix demonstrates a tendency for spiral coiling and three-tiered folding, typically forming no more than three loops/sections of varying length and width.

The proximal, middle, and distal loops of the vermiform appendix initially occupy a more medial position and are anteriorly covered by small intestinal loops. By mid and late observation periods, the boundaries extend somewhat laterally and leftward, where the middle and distal appendiceal loops are found directly posterior to the anterior abdominal wall.

Throughout the observation period, various positions of the vermiform appendix are observed. At the beginning of the observation period (16-17 weeks of ontogenesis), ascending (cranial) position is typically found in 50% of cases, descending (caudal) position in 25%, medial position in 17%, and lateral position in 8%. Anterior position of the vermiform appendix was classified as a variant of lateral position. By

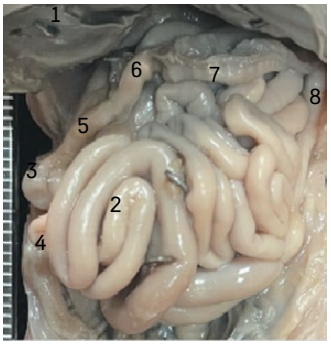

Figure 4. *Photo of a macro-preparation of the position of the ileum-intestinal tract in the abdominal cavity of a human fetus. Photos from the macro preparation. ×3 magnification. Protocol No. 186, fetal age: 18–19 weeks, sex: female. 1 – right lobe of the liver; 2 – loops of the small intestine; 3 – dome of the cecum; 4 – appendix; 5 – ascending colon; 6 – hepatic bend of the colon; 7 – transverse colon; 8 – descending colon.*

Рисунок 4. *Фото макропрепарата положения подвздошно-слепокишечного отдела кишечника в брюшной полости плода человека. Фото с макропрепарата. Увлечено в 3 раза. Протокол №186, возраст плода 18–19 недель, пол женский. 1 – правая доля печени; 2 – петли тонкой кишки; 3 – купол слепой кишки; 4 – червеобразный отросток; 5 – восходящая ободочная кишка; 6 – печеночный изгиб ободочной кишки; 7 – поперечная ободочная кишка; 8 – нисходящая ободочная кишка.*

mid-observation (18-19 weeks of intermediate ontogenesis), medial position is observed in 45% of cases, ascending (cranial) position in 36%, descending (caudal) position in 25%, anterolateral position in 10%, and descending (caudal) orientation in 9%. At the end of the observation period (20-22 weeks of ontogenesis), we identified the following positional variations of the vermiform appendix: anterolateral position was observed in 38% of cases, ascending and descending positions were equally represented in 25%, and medial position of the fetal vermiform appendix was found in 12.5%.

The first (proximal) loop constitutes the segment extending from the cecal wall to the first bend, the second (middle) loop spans between the first and second bends of the appendix, while the third (distal/terminal/end) loop represents the section from the second bend to the apex of the vermiform appendix.

In the majority of observations (88%), the loops were compactly folded in a ring-like configuration and positioned in the space between the cecal segment and the terminal portion of the ileum. The second and third loops are most readily visualized. In 12% of observations, an unfolded form of the vermiform appendix occurs, where the loop segments align linearly.

It was observed that the loops of the human fetal vermiform appendix vary in length throughout their course. By week 22, the third loop shows a slight predominance in length compared to the first. The longitudinal growth of the appendix occurs primarily through elongation of the middle and terminal loops. At the beginning of the observation period (16-17 weeks), the third loop is shorter than the first and second. By the end of the study period (20-22 weeks), the third loop demonstrates a modest length advantage over the first. The loop dimensions change dynamically during the observation period, increasing to the following ranges: first loop 5.16-6.09 mm, second loop 4.56-8.60 mm, and third loop 4.05-7.82 mm. No gender differences were identified.

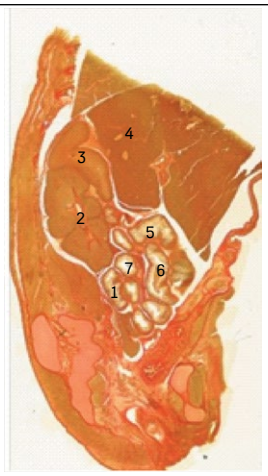

Figure 5. *Anatomy of the ileocecal angle of the human fetus. Photo histotopogram for MBS-10 (sagittal section). Van Gieson staining. 2×14 magnification. Protocol No. 200, fetal age: 22 weeks, sex: female. 1 – ileocecal angle; 2 – right kidney; 3 – right adrenal gland; 4 – liver; 5 – transverse colon; 6 – descending colon; 7 – loop of the small intestine.*

Рисунок 5. *Анатомия илеоцекального угла плода человека. Фото гистотопограммы под МБС-10 (сагиттальный срез). Окраска по Ван Гизону. Увеличение об. 2, ок. 14. Протокол №200, возраст плода 22 недели, пол женский. 1 – илеоцекальный угол; 2 – правая почка; 3 – правый надпочечник; 4 – печень; 5 – поперечная ободочная кишка; 6 – нисходящая ободочная кишка; 7 – петля тонкой кишки.*

The transverse dimensions of the appendix coils at 16–22 weeks of intermediate ontogenesis exhibit uneven values throughout their length. The dimensions of the third coil are smaller than those of the first and second. The transverse dimensions of the coils range from 1.62 mm to 3.26 mm for the first, 1.17 mm to 1.87 mm for the second, and 1.23 mm to 1.72 mm for the third. No sex differences were identified.

Histotopograms of different section planes (sagittal, frontal, and horizontal) allow for clear detailing of the anatomical features of the cecum and vermiform appendix in the human fetus (**Figure 5**).

The weakly folded wall, smooth mucosa of the cecum, and occasional semilunar folds are identified, along with the protruding ileocecal valve. The wall thickness can be measured both at the dome of the cecum and at the Bauhin's valve.

DISCUSSION

The study provides a morphological description and details the anatomy of the ileocecal region of the human fetus at 16–22 weeks of ontogenesis. It presents quantitative and morphofunctional characteristics of each structural component, which represents a novel contribution, as this topic is scarcely covered in the scientific literature. Only fragmentary data exist regarding the development of this specific region [8–10].

The differences in the macro-microscopic anatomy of the fetal ileocecal region are manifested in the shape of the cecum, the junction of the terminal ileum with the cecum, the morphology of the Bauhin's valve, and the quantitative parameters of the distance from the superior lip of the Bauhin's valve to the orifice of the vermiform appendix. The establishment of definitive anatomy and the transition to postnatal structural features of the ileocecal region

occur after 24 weeks of ontogenesis. This is crucial for understanding the pathogenesis of congenital malformations in this area [11].

Current literature indicates that the formation of the ileocecal angle occurs during midgut transformation through a 270° rotation, with differentiation of the ileocecal valve culminating in angle stabilization and reflux prevention by 13-20 weeks. During the studied period, the angle of ileal entry into the cecum is acute. Our findings differ from some researchers' conclusions. Specifically, P.L. Moore (2013) reports final angle stabilization by week 16 [12], whereas our results indicate a later timeframe - week 24. We also observed a wider range of ileocecal angle variations compared to classical studies.

The study by M.A. Malas *et al*. (2004) reported that between 13-16 weeks the angle measures 60° (range 50-70°), increases to 85-95° by 17-24 weeks, and the cecum becomes fixed in the iliac fossa [13]. By 25-38 weeks, the angle stabilizes (90-100°) and vascularization of the area is completed. In our study, during 16-22 weeks of ontogenesis, we observed an increase in the ileocecal angle from 27° to 60°, reflecting dynamic changes and the establishment of colonic anatomy. These findings should be considered during endoscopic evaluation of the colon in newborns, as F.F. Antonenko *et al*. (2022) suggest that one contributing factor to cecocolic intussusception in infants may be an obtuse ileocecal angle, along with an elongated, downward-projecting cecal dome and lack of fixation in the iliac fossa [1]. Meanwhile, it is known that abnormalities of the ileocecal angle (angle <60°) can lead to intestinal obstruction in newborns. Early diagnosis of such conditions is possible through ultrasound screening at 16-22 weeks of development. In our study, we determined the range of angle variation between the ileum and ascending colon in fetuses at 16-22 weeks of development (ranging from 70° to 115°), which represents a novel finding not previously reported in the scientific literature.

We established that at 16-17 weeks of fetal development, the cecum exhibits a cylindrical shape with its length exceeding its width. Throughout the study period, both length and width of the cecum demonstrate a uniform two-fold increase, with more intensive growth observed in width. During fetal development, we noted asymmetrical growth of the cecal walls - the lateral wall develops more prominently than the medial wall. This pattern can be explained by the fact that the medial wall is occupied by the superior and inferior lips of the ileocecal valve. Our findings are consistent with the data reported by Yu.T. Akhtemiychuk *et al*. (2006) [2].

It was determined that even in the early stages of the study period, the semilunar folds of the cecal mucosa are clearly differentiated, and the free taenia is present. The omental and mesocolic taeniae remain undeveloped, as their differentiation begins later, at approximately 21-22 weeks of development. According to literature sources, this process is associated with the embryogenesis of the small and large intestine, where the proximal segments of the large intestine (cecum, ascending colon) develop more slowly than the distal segments, as well as with fetal liver characteristics, as it occupies most of the abdominal cavity during this period. With the expansion of the abdominal cavity and closure of the physiological umbilical hernia, intestinal rotation occurs, after which the ileocecal angle becomes localized in the right iliac fossa and begins its intensive growth.

Our findings demonstrate that haustration begins at 19-20 weeks of prenatal ontogenesis, with approximately 1-2 haustra present throughout the entire cecal surface. In contrast, haustration of the descending colon and sigmoid colon begins earlier, with 7-15 haustra developing in these segments. M.A. Malas et al. observed that haustra and taeniae coli development initiates in the ascending colon and progresses toward the sigmoid colon [13]. According to these authors, the development of haustra and muscular bands progresses slowly during the first trimester of pregnancy, becoming more intensive during the second trimester. The mucosal thickness in both ascending and descending colon shows significant increase by mid-second trimester. C. Bardwell *et al*. (2022) reported that the length of both small and large intestine increases linearly with fetal age [14].

Our investigations revealed that during this developmental period, the following structures are clearly identifiable: the ileal orifice, the frenula of the ileal orifice, the ileocolic lip (superior lip), and the ileocecal lip (inferior lip). Both lips correspond to mucosal folds that traverse the walls of the cecum. The oval-shaped orifice is situated between the superior and inferior lips.

The fetal vermiform appendix represents a relatively long structure characterized by variable shape and position. During the studied developmental period, various anatomical positions of the appendix are being established [15-19]. Literature indicates that the ascending or descending position of the appendix in fetuses is not related to its topographic proximity to the terminal ileum. Spiralization of the appendix occurs when positioned posterior to the ileocecal junction [19-23]. We established that the vermiform appendix tends to spiralize, displaying three well-defined coils and transitioning into the cecum without a distinct boundary. Dissection specimens reveal its orifice and the absence of a valve. Valve formation occurs at later developmental stages, which aligns with data from A.A. Pujari *et al*., who report that in most newborns, a mucosal fold (appendiceal valve, Gerlach's valve) is observed near the appendiceal orifice [11].

CONCLUSION

The study yielded new data on the anatomy of the fetal ileocecal region at 16-22 weeks of development.

Since the ileocecal angle forms through complex interactions during embryonic intestinal loop rotation, its anatomical and morphological characteristics approach postnatal features by week 22. This finding has significant implications for understanding the pathogenesis of congenital malformations and their correction. The obtained data may prove valuable for endoscopic specialists, neonatologists, and pediatric surgeons [24].

ADDITIONAL INFORMATION	ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ
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Conflict of interest. The authors declare that there are no obvious or potential conflicts of interest associated with the content of this article.	***Конфликт интересов.*** Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с содержанием настоящей статьи.
Compliance with Ethical Standards. This study was conducted on the basis of the Department of Human Anatomy from 2019 to 2024. A positive conclusion of the LEK OrGMU dated 16.10.2019 No. 237 was received.	***Соответствие нормам этики.*** Исследование проведено на базе кафедры анатомии человека с 2019 г. по 2024 г. Было получено положительное заключение ЛЭК ОрГМУ от 16.10.2019 №237.
Contribution of individual authors. Vasileva T.A., Grigoreva A.A.: data analysis, writing of the text of the article. Galeeva E.N., Galiakbarova V.A.: study design, interpretation of results, editing of the article. The authors gave their final approval of the manuscript for submission, and agreed to be accountable for all aspects of the work, implying proper study and resolution of issues related to the accuracy or integrity of any part of the work.	***Участие авторов.*** Васильева Т.А., Григорьева А.А. – анализ данных, написание текста статьи. Галеева Э.Н., Галиакбарова В.А. – дизайн исследования, интерпретация результатов, редактирование статьи. Все авторы одобрили финальную версию статьи перед публикацией, выразили согласие нести ответственность за все аспекты работы, подразумевающую надлежащее изучение и решение вопросов, связанных с точностью или добросовестностью любой части работы.

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