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SPATIAL ORGANIZATION OF EXTRAORGAN ANGIOARCHITECTONICS OF THE HUMAN PLACENTA IN NORMAL CONDITIONS: A PILOT MORPHOLOGICAL STUDY USING INJECTION-CORROSION METHODS

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Background. Despite extensive research on the placenta, the spatial organization of its vascular bed, particularly the extraorgan compartment which influences fetal blood flow distribution and intraplacental hemodynamics, remains insufficiently understood. Elucidation of normal placental angioarchitectonics is essential for understanding the mechanisms of obstetric complications.

Aim. To investigate the features of the spatial organization of the extraorganic angioarchitecture of the normal human placenta.

Materials and Methods. The study was performed on 10 intact human placental specimens with attached umbilical cords obtained after physiological deliveries at 38–40 weeks of gestation. A polychrome injection technique using self-curing acrylic plastic ("Protakryl") was applied, followed by corrosion casting of the placental and umbilical cord vascular beds. The obtained casts were used for direct visual, topographic, and morphometric analysis and were documented by digital photography. Descriptive frequency analysis was used to summarize the observed anatomical variants. The study was a fragment of the research topic of the Department of Human Anatomy of Poltava State Medical University (Ukraine) with a state registration number 0125U002785.

Research Ethics. The study was performed on anonymized human placental specimens in accordance with the legislation of Ukraine, including Resolution of the Cabinet of Ministers of Ukraine No.999 of August 30, 2024, on the collection and use of human biological samples for research purposes.

Results. In the area of umbilical cord attachment, a short arterial anastomosis (Hyrtl's anastomosis) is often found between the umbilical arteries, which equalizes hemodynamic load and blood flow distribution in the initial segments of the arterial bed. First-order placental arteries course radially toward the periphery but lack strict topographic correspondence with veins at the same level: veins predominantly run centrally within the lobules, whereas arteries are located more laterally and often extend into adjacent cotyledons. The main vessels then transition into the vessels of anchoring villi – a transitional segment between the main bed and the hemomicrocirculatory network of the villous chorion – from which the axial vessels of stem villi arise for blood redistribution within the cotyledons.

Conclusions. The human placenta's extraorgan angioarchitectonics shows regular arterial/venous spatial organization with compensatory interarterial anastomoses at the cord insertion. Arterial and venous topography differs within lobules. Anchoring villus vessels bridge the main and microcirculatory beds. These preliminary results provide a descriptive morphological basis for future studies of placental pathology, though confirmation on a larger sample is required.

Keywords: *obstetrics, experimental medicine, placenta, blood vessels, arteriovenous anastomoses, angioarchitecture.*

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Introduction

It is well established that the structural and functional basis of interaction between the maternal organism and the fetus, starting from the zygote stage, is formed through complex processes of cell proliferation, migration, differentiation, and tissue specialization. These processes drive the divergent development of both the embryo proper and the accessory provisional structures. The latter subsequently enable the formation of a unique temporary organ – the placenta – which mediates integration between the endometrium and the fetal organism [1–3]. The placenta is a key component of the mother–fetus system, performing transport, trophic, respiratory, barrier, immunological, and endocrine functions, thereby ensuring adequate conditions for intrauterine development.

Disruptions of these processes can occur at any stage of gestation under the influence of various adverse endogenous and exogenous factors. In this regard, several researchers have identified so-called critical periods of embryo- and fetogenesis, during which the developing organism is characterized by particularly high sensitivity to damaging influences. Consequently, such disturbances affect not only the fetal condition but also the morphological organization of the placenta, its vascularization, and its compensatory and adaptive capacity [4–6].

The range of deviations from the physiological course of pregnancy, childbirth, and the early neonatal period constitutes the subject matter of perinatal pathology. Elucidating the genesis of many pathological conditions often requires a comprehensive pathological examination of the placenta as one of the most informative biological substrates of pregnancy. At the same time, the correct interpretation of pathological changes, the identification of morphological markers of injury, and a deeper understanding of the mechanisms underlying their formation necessitate a thorough knowledge of the variants of normal placental structure [5; 6].

Of particular importance in this regard is the study of the vascular component of the placenta, since the bloodstream provides the hemodynamic link between the fetus and placental tissue. The spatial organization of extraorgan vessels, the branching pattern of the umbilical arteries and vein, their interrelationships, the presence of anastomoses, the characteristics of umbilical cord insertion, and the architectonics of chorionic vessels are of both fundamental morphological and significant clinical importance [7; 8]. Current research indicates that even minimal deviations in placental angioarchitectonics may be associated with fetoplacental insufficiency, fetal growth restriction, preeclampsia, and other obstetric complications [9; 10].

Nevertheless, despite the undeniable relevance of these issues, questions concerning the expansion and deepening of knowledge regarding the principles of morphological orderliness and the spatial organization of the human placental vascular bed, particularly its extraorgan compartment, often remain insufficiently addressed [11]. Available literature data are fragmentary, and information on individual anatomical variability remains poorly systematized.

The above considerations provided the rationale for conducting a targeted morphological investigation, the results of which form the basis of this scientific paper.

The **aim** of the study was to provide a morphological substantiation of the features of the spatial organization of the extraorgan and initial intraplacental vascular bed of the human placenta under normal conditions.

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Materials and Methods

The study material consisted of total specimens of the human placenta together with the umbilical cord, as well as fragments within the cotyledons, obtained at the Perinatal Center of the Municipal Enterprise "1st City Clinical Hospital of Poltava City Council" within the framework of a scientific cooperation agreement with Poltava State Medical University. All stages of collection, storage, and use of biological material were carried out in accordance with current ethical and regulatory requirements governing morphological studies using human material.

The total sample included 10 total specimens of human placenta together with the umbilical cord. The studied samples were obtained from parturients with a physiological course of labor, aged 19 to 34 years, at a gestational age of 38–40 weeks. Inclusion criteria were the absence of obstetric and somatic pathology, as well as the absence of pregnancy complications that could affect the morphological characteristics of the placenta.

Initially, all total specimens underwent macroscopic anatomical examination with assessment of placental shape, dimensions, weight, type of umbilical cord insertion, and degree of eccentricity. Particular attention was paid to the topography of vessel entry into the placental surface and the features of macroscopic angioarchitectonics.

The study was descriptive in morphological nature. For selected anatomical features, a basic descriptive frequency analysis was performed, calculating their presence as a percentage. Given the pilot and descriptive design of the study, no inferential statistics (e.g., significance testing, confidence intervals) were applied.

The overall design of the work corresponds to a descriptive anatomical study with elements of qualitative morphological analysis. The study is exploratory in nature and was carried out as a pilot morphological mapping of the spatial organization of extraorgan and initial intraplacental angioarchitectonics under conditions of physiological pregnancy.

All 10 specimens that met the criteria of anatomical integrity and preservation were used to produce corrosion casts by means of vascular injection with self-curing plastics.

For polychrome vascular injection, self-curing acrylic dental plastics ("Protacryl") were used. Differentiation of the arterial and venous beds was achieved by adding dyes (ink from ballpoint pens of the respective colors) to the monomer-polymer mixture immediately prior to injection. The injection was performed manually at room temperature (20–22°C) under gentle pressure to simulate physiological perfusion, with a polymerization time of approximately 15–20 minutes before corrosion. After completion of polymerization and corrosive tissue processing, three-dimensional plastic casts of the vascular bed of the placenta and umbilical cord were obtained, enabling detailed visual and metric analysis of the spatial angioarchitectonics.

To ensure the validity of the vascular connections observed, the following quality control measures were applied during injection: 1) manual injection was performed using a 20 mL syringe under direct visual control and was terminated immediately upon the first appearance of the cast material on the chorionic surface, minimizing the risk of overpressurization; 2) arterial injection was performed first, and specimens showing spontaneous retrograde filling of the venous system during arterial injection were excluded from further analysis to avoid misinterpretation of injection-induced shunting; 3) the venous system was then injected separately to confirm the integrity of the venous tree. True arteriovenous anastomoses were identified only in specimens where the injection mass entered the venous system through a clearly visible connecting branch on the corrosion cast, rather than through diffuse extravasation or signs of vascular rupture.

The obtained corrosion casts were documented using digital photography, followed by archiving of the material for morphological analysis [12].

Morphological classification criteria. To systematically describe the observed spatial patterns of the placental vascular bed, we introduced three descriptive categories based on topographic and architectural features observed on the corrosion casts. These terms are proposed to facilitate communication of the consistently identified spatial relationships, rather

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than to replace established nomenclature. Central-lobar veins – first-order venous branches that course within the central regions of the placental lobules, draining blood from the cotyledon core toward the chorionic plate. Cross-lobar arteries – first-order arterial branches that run radially toward the periphery of the cotyledons and frequently extend into the territories of adjacent cotyledons. Hilar-lobular vessels – the vessels located within the anchoring villi, representing the transitional segment between the main conducting vascular bed and the intralobular villous microcirculatory network. These definitions were applied consistently during the analysis of all specimens.

Research Ethics

The study was conducted at the Department of Human Anatomy of Poltava State Medical University in collaboration with the Laboratory of Functional Morphology and the Experimental-Biological Clinic of the university. The collection, storage, and use of biological material for research purposes were carried out in accordance with the current legislation of Ukraine, including Resolution of the Cabinet of Ministers of Ukraine No.999 of August 30, 2024, which approves the Procedure for the Collection, Storage, and Use of Human Biological Samples for Research Purposes. All samples were fully anonymized; no information allowing identification of the donors was used or stored. Biological material was used exclusively after completion of childbirth, under the condition of complete absence of patients' personal identification data, thereby ensuring confidentiality and anonymity. Material acquisition was carried out in accordance with the local ethical protocols of the healthcare institution and the principles of voluntariness and respect for patient dignity. The research protocol was reviewed and approved by the Bioethics Committee of Poltava State Medical University.

Results

Analysis of placental injection-corrosion specimens obtained by selective decompositional dissection allowed detailed characterization of the spatial organization of the extraorgan and initial intraplacental arterial bed. It was established that the arterial blood supply to the placenta is provided by two umbilical arteries, which originate from the internal iliac arteries, course along the inner surface of the anterior abdominal wall to the umbilical ring, and enter the umbilical cord.

Within the umbilical cord, the umbilical arteries and umbilical vein exhibit a stable spatial relationship: the arteries are positioned symmetrically with respect to the vein at approximately equal distances, forming a configuration close to the vertices of a hypothetical equilateral triangle. This topographic organization is maintained throughout their spiral course within the umbilical cord, indicating a high structural stability of the vascular bundle.

Metric analysis demonstrated that the total internal diameter of the two umbilical arteries exceeds the diameter of the umbilical vein by approximately 25%, reflecting the specific inflow-to-outflow ratio in the fetal hemodynamic system.

At the site of umbilical cord attachment to the chorionic (amniotic) surface of the placenta, a short arterial anastomosis, known as Hyrtl's anastomosis, was visualized between the umbilical arteries in a substantial proportion of specimens. This structure provides functional equalization of pressure and redistribution of blood flow between the arterial trunks before their entry into the placental vascular bed. Hyrtl's anastomosis between the umbilical arteries on the chorionic surface of the placenta was observed in 8 out of 10 studied specimens (80%). Given the pilot nature of this study and the limited sample size, this finding should be interpreted as a preliminary descriptive observation rather than a definitive population-based frequency estimate.

Further analysis revealed that the first generation of intraplacental main arteries is formed by vessel branching directly from the zone of arterial anastomosis. The diameter of each primary branch is, on average, approximately 25% smaller than the diameter of the umbilical artery. Given that an average of about six such branches are formed, their total cross-sectional area exceeds the total cross-sectional area of the umbilical arteries. Such a morphometric configuration creates conditions for a physiological decrease in linear blood

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flow velocity and pressure reduction in the subsequent segments of the placental arterial bed, which is an important element of hemodynamic adaptation of the fetoplacental system.

The first-generation arteries (first-order placental arteries) formed after the vessels exit the umbilical cord zone subsequently exhibit specific features of spatial distribution relative to the corresponding branches of the venous bed at an equivalent level of branching. It was established that no strict topographic correspondence exists between the arterial and venous branches throughout their intraplacental course – from the umbilical cord base region to the peripheral portions of the chorionic plate.

At the same time, a certain pattern of spatial organization is observed: first-order venous vessels are predominantly located in the central regions of the amniotic (chorionic) surface of the placental lobules, whereas arterial branches are more often shifted toward the peripheral or lateral zones of the corresponding lobules. Moreover, arterial vessels frequently cross over into the territories of adjacent lobules, forming patterns of vascular territory overlap between neighboring cotyledons.

Thus, the arterial and venous components of the placental bed demonstrate a functional-territorial asymmetry, characterized by a predominantly "central" arrangement of venous collectors and an "eccentric-crossing" course of arterial branches.

Given the identified features of spatial organization and the lack of a unified morphological classification of the placental vascular bed in the contemporary literature, it is advisable to distinguish conventional morphological categories: central-lobar veins and cross-lobar arteries, which reflect the established patterns of their topography and interrelationships within the cotyledonary structure of the placenta (*Fig.*).

The spatial organization of central-lobar veins was observed in all studied specimens (10/10), indicating their stable character as a basic element of the venous component of the cotyledonary structure. The crossing pattern of arterial branches relative to cotyledon boundaries was observed in 7 out of 10 specimens (70%), reflecting the variability in the spatial organization of the placental arterial bed.

Fig.: 1 – umbilical vein; 2 – umbilical arteries; 3 – anastomosis between the umbilical arteries; 4 – central-lobar veins; 5 – cross-lobar arteries; 6 – microvascular plexuses of the cotyledons. The oval indicates the site of arteriovenous anastomoses (explanation in the text).

During successive branching of the main placental vessels, it was found that smaller-caliber vessels transition into trabecular branches of the chorionic plate, which morphologically correspond to the so-called anchoring villi. According to macro- and microstructural analysis, the histoarchitectonics of these structures generally shows no fundamental differences from the structure of the chorionic plate, allowing them to be regarded as its densely organized derivative structures.

It was established that the surface of the anchoring villi, which is in direct contact with maternal blood, is covered by a continuous layer of syncytiotrophoblast with a superimposed fibrinoid layer, reflecting the features of the interface between the fetal and maternal components of the placenta. The central stroma of the anchoring villi typically contains two blood vessels, an artery and a vein, which form the main conducting vascular component of these structures.

At the same time, variants with more than two vessels within the connective tissue core of an anchoring villus were observed in some specimens, with the vessels having approximately the same caliber. Such morphological variants are likely due to the tortuous course of the vascular bed, as a result of which different segments of the same vessel may appear in the plane of the histological section.

According to the obtained data, these vessels should be regarded as terminal branches of the main portion of the placental vascular

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bed, while simultaneously constituting the initial link in the formation of the branched vascular network of the chorionic villi. The initial morphological elements of the latter should be considered the stem villi.

Based on the identified structural and functional features, the blood vessels of the anchoring villi are proposed to be designated as hilar-lobular vessels, which reflects their intermediate position between the main arterial-venous bed and the intralobular villous microcirculatory system (*Fig.*).

During the analysis of injection-corrosion placental specimens, it was found that the hilar-lobular arteries and veins give off numerous small branches, between which functionally significant arteriovenous anastomoses are formed. The spatial organization of these microvascular connections indicates the presence of local blood flow shunting pathways within the villous and perivillous vascular bed.

The presence of arteriovenous anastomoses is confirmed by the results of polychrome injection with self-curing plastic "Protacryl" performed through cannulated umbilical arteries. In a number of observations, the injection mass was noted to exit not only into the arterial bed of the placenta but also to enter the venous system with subsequent filling of the umbilical vein, which indicates the presence of intraplacental arteriovenous communications and functionally active shunting mechanisms.

The obtained data confirm the existence of an integrated placental vascular network in which the arterial and venous components are not completely isolated systems but interact through anastomotic connections, providing adaptive regulation of placental hemodynamics.

Discussion

The obtained results demonstrate the complex spatial organization of the extraorgan and intraplacental vascular bed, which is consistent with current concepts of the placenta as a highly specialized dynamic organ with pronounced variability in angioarchitectonics [9; 11]. In particular, the established symmetric topography of the umbilical arteries relative to the umbilical vein within the umbilical cord corresponds to classical anatomical descriptions, according to which the vascular bundle of the umbilical cord is characterized by a stable spatial organization that minimizes mechanical and hemodynamic fluctuations during gestation [9].

The anastomosis between the umbilical arteries on the chorionic surface of the placenta (Hyrtl's anastomosis) identified in this study fully correlates with data from the contemporary morphological literature, where it is regarded as one of the key elements for equalizing arterial pressure before entry into the placental bed and as a structure that occurs in the majority of normal placenta observations [13]. Functionally, this anastomosis is considered a mechanism for stabilizing fetoplacental hemodynamics, reducing the risk of asymmetric loading on the arterial branches.

Although these findings suggest the presence of functional shunting pathways, it should be acknowledged that the corrosion casting method alone does not provide direct functional evidence. The passage of injection mass from the arterial into the venous system could theoretically result from overinjection or tissue disruption, despite our quality control measures. Furthermore, histological confirmation of these anastomoses was not possible in the same specimens due to the corrosive nature of the technique. Therefore, our observations should be interpreted as a morphological indication of potential arteriovenous connections requiring further validation using complementary approaches such as vascular casting combined with histological sectioning or micro-computed tomography in future studies.

The observed lack of strict topographic correspondence between first-order arterial and venous branches can be explained by fundamental differences in their respective morphogenetic and hemodynamic determinants. The arterial tree, branching radially from the umbilical arteries, is primarily shaped by the pulsatile fetal cardiac output and the need to distribute inflow across the entire chorionic plate, resulting in a predictable but variable radial pattern [7; 14]. In contrast, the venous system develops as a passive drainage network, with its architecture largely determined by the location of the cotyledonary venous lakes and local tissue compliance, leading to a predominantly central convergence pattern [9].

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These divergent developmental and functional constraints inevitably preclude a strict one-to-one topographic correspondence between the two systems. This interpretation is supported by recent 3D morphometric studies demonstrating significant branching variability and flow asymmetry in the placental vascular network during cotyledon formation [14].

It should be noted, however, that quantitative morphometric reference values for comparing arterial and venous topography in the normal human placenta are currently lacking in the literature. As our study was designed as a qualitative, descriptive pilot investigation, we did not perform such measurements. We acknowledge this as a limitation and suggest that future quantitative studies with larger sample sizes are needed to establish objective criteria for characterizing this spatial mismatch.

The observed tendency toward central localization of venous collectors and a crossing pattern of arterial branches is partially consistent with current concepts of "territoriality" of placental blood circulation, in which venous outflow is more stabilized, whereas the arterial component exhibits greater variability and adaptability to changes in perfusion pressure [11; 15].

Of particular interest are our data regarding hilar-lobular vessels as an intermediate link between the main and terminal vascular beds. Such structures essentially correspond to the terminal villous vessels described in the literature, which form the basis of microcirculatory exchange between maternal and fetal blood [9]. At the same time, our proposed morphological interpretation emphasizes their functional role as a transition zone between macro- and microcirculation. This interpretation is consistent with classical ultrastructural descriptions of the villous tree, where the vessels of stem and anchoring villi represent the conducting compartment, while the terminal villi harbor the capillary network responsible for maternal-fetal exchange [7; 9]. Although our corrosion casting method does not allow visualization of the terminal capillary network itself, the spatial arrangement of the hilar-lobular vessels – situated between the main chorionic plate vessels and the intralobular villous microcirculatory system – strongly supports their role as a structural transition zone. We acknowledge, however, that this interpretation remains descriptive, and ultrastructural validation would be required to confirm the functional nature of this transition.

The identification of arteriovenous anastomoses between branches at the hilar-lobular level is consistent with current concepts of the presence of functional shunts in the placenta, which may enable rapid blood flow reorganization depending on perfusion conditions. Similar phenomena have been described in studies using 3D angiography of the placenta, where the existence of local zones of direct arteriovenous shunting affecting fetal blood supply efficiency has been demonstrated [14; 16].

It should be noted separately that the morphological variants of anchoring villi with multiple vessels identified in our study may be interpreted as a consequence of the complex spatial geometry of the vascular tree. This is supported by data from contemporary placental histology, where vessel tortuosity and three-dimensional variability are considered key factors contributing to artifactual multivascularity on histological sections [9].

The terms "cross-lobar arteries", "central-lobar veins", and "hilar-lobular vessels" proposed in this paper are morphofunctionally justified, as they reflect not only topographic features but also likely patterns of hemodynamic flow distribution within the cotyledonary organization of the placenta. Such an approach aligns with the current trend toward functional morphology, in which anatomical structures are interpreted through the lens of their dynamic role in the organ [11].

At the same time, certain limitations of the study should be acknowledged. The most important limitation is the small sample size (n=10), which precludes statistical generalization of the frequency data (e.g., the 80% detection rate of Hyrtl's anastomosis). As this was a pilot, descriptive morphological study, our findings should be considered preliminary and hypothesis-generating. Validation on a larger cohort is necessary before any normative conclusions can be drawn.

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Additional limitations include possible artifacts associated with the injection and polymerization technique of the plastics, which may affect the completeness of visualization of small vascular structures.

Conclusions

1. At the junction of the umbilical cord with the chorionic (amniotic) surface of the placenta, a short arterial anastomosis is observed between the umbilical arteries, which provides functional equalization and stabilization of arterial pressure prior to the formation of the first placental arterial branches.

2. First-order placental arteries, as they course radially toward the periphery of the cotyledons, do not demonstrate a strict topographic correspondence with venous branches at an equivalent level of branching. Venous vessels predominantly occupy the central regions of the placental lobules, whereas arterial branches are shifted toward the periphery and partially cross the boundaries of adjacent cotyledons. Based on these observed patterns, it is proposed to distinguish them as central-lobar veins and cross-lobar arteries.

3. The central-lobar veins and cross-lobar arteries continue into the trabecular branches of the chorionic plate, which morphologically correspond to the anchoring villi. Our observations suggest that these vessels may represent the terminal elements of the main portion of the placental vascular bed and may simultaneously form the initial link of the chorionic villi, the basic structural elements of which are the stem villi. We therefore tentatively propose designating the vessels of the anchoring villi as hilar-lobular vessels, acknowledging that this interpretation requires further validation using complementary methods (e.g., ultrastructural studies).

4. The hilar-lobular arteries and veins initiate the formation of smaller branches that precede the development of the hemomicrocirculatory bed and run along the axial part of the connective tissue stroma of the stem villi. They should be regarded as stem vessels of the placenta, participating in the regulation of blood flow distribution between individual villi and cotyledons.

Declarations

Conflict of interest is absent.

The authors of the manuscript state that in the process of conducting research, preparing, and editing this manuscript, they did not use any generative AI tools or services to perform any of the tasks listed in the Generative AI Delegation Taxonomy (GAIDeT, 2025). AI (DeepSeek v3 (DeepSeek Company, China)) assisted only with language editing, grammar, condensation, and partial translation.

Authors' Contributions

Contribution / Authors	A	B	C	D	E	F
Sherstyuk O.O.	+	+			+	+
Svintsytska N.L.			+	+		+
Ustenko R.L.			+		+	+
Danylchenko S.I.		+			+	+
Serbin S.I.		+	+		+	+
Dubyna S.O.			+	+		+
Bondarenko S.V.				+	+	+

Notes:

A – concept;
B – design;
C – data collection;
D – statistical processing and interpretation of data;
E – writing or critical editing of the article;
F – approval of the final version for publication and agreement to be responsible for all aspects of the work.

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ПРОСТОРОВА ОРГАНІЗАЦІЯ ЕКСТРАОРГАННОЇ АНГІОАРХІТЕКТОНІКИ ПЛАЦЕНТИ ЛЮДИНИ В НОРМІ: ПІЛОТНЕ МОРФОЛОГІЧНЕ ДОСЛІДЖЕННЯ З ВИКОРИСТАННЯМ ІН'ЄКЦІЙНО-КОРОЗІЙНИХ МЕТОДІВ

Вступ. Незважаючи на численні дослідження плаценти, просторова організація її судинного русла, особливо екстраорганного відділу, що впливає на розподіл фетального кровотоку та внутрішньоплацентарну гемодинаміку, залишається недостатньо вивченою. Уточнення нормальної ангіоархітектоніки плаценти необхідне для розуміння механізмів акушерських ускладнень.

Мета. Вивчити особливості просторової організації екстраорганної ангіоархітектоніки плаценти людини в нормі.

Матеріали та методи. Дослідження виконано на 10 тотальних препаратах плаценти людини разом із пупковим канатиком, отриманих після фізіологічних пологів у терміні 38–40 тижнів гестації. Використано метод поліхромної ін'єкції самотвердіючої пластмаси на акриловій основі («Протакрил») з подальшим одержанням корозійних препаратів судинного русла плаценти та пупкового канатика. Отримані пластмасові зліпки використовували для прямого візуального, топографічного та морфометричного аналізу, документували цифровою фотозйомкою. Для узагальнення виявлених анатомічних варіантів використано описовий частотний аналіз.

Етика дослідження. Дослідження виконано на анонімізованих препаратах плаценти людини відповідно до законодавства України, зокрема Постанови Кабінету Міністрів України № 999 від 30.08.2024, якою затверджено Порядок збору, зберігання та використання біологічних зразків людини з дослідницькою метою.

Результати. У зоні прикріплення пупкового канатика між пупковими артеріями часто виявляється анастомоз Гіртля, який вирівнює гемодинамічне навантаження та розподіл кровотоку в початкових відділах артеріального русла. Плацентарні артерії першого порядку радіально прямують до периферії, але не мають суворої топографічної відповідності з венами аналогічного рівня: вени переважно проходять центрально в частках, а артерії розташовані латерально і нерідко переходять у сусідні котиледони. Магістральні судини далі переходять у судини якірних ворсин – перехідний сегмент між магістральним руслом і гемомікроциркуляторною мережею ворсинчастого хоріона, від яких відходять осьові судини стовбурових ворсин для перерозподілу крові в межах котиледонів.

Висновки. Екстраорганна ангіоархітектоніка плаценти людини виявляє закономірну просторову організацію артеріального та венозного компонентів із компенсаторними міжартеріальними анастомозами в місці прикріплення пупкового канатика. Артеріальна та венозна топографія відрізняється в межах часточок. Судини якірних ворсин формують перехід між магістральним і мікроциркуляторним руслами. Ці попередні результати формують описову морфологічну основу для подальших досліджень патології плаценти, однак потребують підтвердження на більшій вибірці.

Ключові слова: *акушерство, експериментальна медицина, плацента, кровоносні судини, артеріовенозні анастомози, ангіоархітектоніка.*

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