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Villous chorion remodelling in term placentas following maternal COVID-19 infection: Association with the duration of the post-COVID interval

Abstract

Relevance. In placental tissue, SARS-CoV-2 targets cells characterised by the expression of angiotensin-converting enzyme 2 (ACE2), particularly endothelial cells, syncytiotrophoblasts and telocytes. Damage to these cells causes pyroptosis, inflammation and the development of arteriolosclerosis. Telocyte injury is associated with the loss of intercellular signalling, which leads to pathomorphological changes in the placenta.

Aim. To investigate the remodelling of the villous chorion in pregnant women with coronavirus disease COVID-19.

Materials and methods. A total of 152 placentas from term deliveries in women with COVID-19 were examined and divided into groups according to the duration of the post-COVID interval (from COVID-19 diagnosis to delivery). In Group I (n=86), the PCI was 1-4 weeks, while in Group II (n=66), it was 5-18 weeks. The control group comprised 50 placentas obtained after physiological deliveries before the onset of the COVID-19 pandemic. Microscopic, immunohistochemical and statistical research methods were used. COVID-19 in pregnant women was confirmed by a positive polymerase chain reaction (PCR) test for SARS-CoV-2 RNA, while the newborns were PCR-negative and had high Apgar scores. Quantitative differences in the stroma and vessels of the chorionic villi, as well as the percentage of stem and semi-stem chorionic villi, were determined using the ONLINE JPG TOOLS service.

Results. The placentas in Group II were characterised by an increased percentage of stem and semi-stem chorionic villi: 33 (23; 47) versus 7 (7; 9); $p < 0.001$ in Group I. Disorders of the rheological properties of blood were observed in the main groups in the form of stasis and thrombosis in 100% of cases in Group I and 79% of cases in Group II. Stromal oedema led to changes in the ratio of vessels to stroma in the chorionic villi and to a reduction in the percentage of vessels: 29 (27-33). In Group II, the vascular lumen was restored – 46 (44-47), which was explained by a decrease in stromal oedema. Arteriolar endothelial necrosis was detected in 97.7% of observations in Group I and 6.1% in Group II. In Group I, destructive changes in telocytes were identified. In Group II, telocyte-like cells expressing α -SMA were detected, which does not exclude a transition to a myofibroblast phenotype during stromal remodelling in pregnant women with COVID-19, while fibrosis of the villous stroma may indicate transition towards fibroblasts. Compensatory mechanisms in the form of focal formation of small terminal villi were observed in cases involving the birth of infants with high Apgar scores.

Keywords: placenta; SARS-CoV-2; pregnancy; telocytes; smooth muscle α -actin (α -SMA).

INTRODUCTION

The study of the pathomorphological and ultrastructural changes in the chorion associated with COVID-19 provides insight into the fundamental mechanisms underlying placental dysfunction and contributes to the

development of criteria for predicting fetal and neonatal outcomes. The causative agent of coronavirus disease (COVID-19), SARS-CoV-2, binds via its spike (S) protein to the angiotensin-converting enzyme 2 (ACE2)

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receptor with the involvement of transmembrane serine protease 2 (TMPRSS2) [1-2]. As emphasised by A.E. Abaturov *et al.* [3] and M. Klein *et al.* [4], in the placenta, ACE2 is highly expressed in syncytiotrophoblasts, which are in direct contact with maternal blood, as well as in cytotrophoblasts, endothelial cells, smooth muscle cells, and telocytes. Under physiological conditions, ACE2 converts the potent vasoconstrictor angiotensin II into angiotensin-(1-7), a peptide with pronounced vasodilatory, antiproliferative, and antiapoptotic properties. Reduced ACE2 activity leads to local accumulation of angiotensin II, initiating a cascade of pathological events including vasoconstriction, activation of pro-inflammatory cytokines, tissue injury, and thrombosis. According to J. Li *et al.* [5], virus-induced dysregulation of the renin-angiotensin-aldosterone system (RAAS) directly triggers pyroptosis, a highly inflammatory form of programmed endothelial cell death, thereby further aggravating systemic endothelial dysfunction in COVID-19. In response to the death of damaged cells, macrophages and neutrophils are activated [6]. As noted by T. Iba *et al.* [7] and R.N. Baergen *et al.* [8], endothelial dysfunction worsens blood rheology, enhances platelet activation, and contributes to tissue edema followed by microcirculatory impairment; according to S.G. Gychka *et al.* [9], these processes ultimately stimulate fibroblast activation, promoting fibrosis and arteriosclerosis. These pathological changes are reflected clinically and morphologically by disseminated intravascular coagulation (DIC), generalised microthrombus formation, inflammation, and multiorgan failure [3].

The structural unit of the placenta is the cotyledon, which represents the branching of a chorionic stem villus [10]. The villous chorion undergoes continuous remodelling throughout gestation, giving rise to stem, intermediate, and terminal villi. S. Soni *et al.* [11] argued that in the first two trimesters of pregnancy, immature intermediate villi constitute the main villous population and give rise to mature intermediate villi; by the third trimester, terminal villi predominate. Throughout its development, the placenta records and retains structural alterations induced by adverse factors, which may be reflected in quantitative and qualitative changes in the chorionic villi and their components [12]. T.V. Savchuk *et al.* [13] concluded that changes in blood rheology contribute to both maternal and fetal vascular malperfusion, which may subsequently lead to placental insufficiency. Previous studies of placentas from pregnancies complicated by COVID-19, including those by S. Jaiman *et al.* [14] and T.V. Savchuk *et al.* [12], demonstrated placental insufficiency and impaired chorionic morphogenesis, which contributed to adverse perinatal outcomes, including perinatal loss. However, the need for further investigation of chorionic villous structures in pregnant women with coronavirus disease at different gestational ages, which may influence chorionic remodelling, determined the relevance

of this study. The study aimed to assess the structural remodelling of the villous chorion in pregnant women affected by COVID-19.

MATERIALS AND METHODS

The study was designed as a retrospective comparative pathomorphological analysis. To achieve the aim of the study, 152 placentas from pregnancies complicated by COVID-19 in mothers who delivered a live full-term infant were examined. Depending on the duration of the post-COVID interval (PI) – the time between maternal COVID-19 diagnosis and delivery – the main study groups were formed. The PI in Group I (n = 86) ranged from 1 to 4 weeks, while in Group II (n = 66) it ranged from 5 to 18 weeks. For comparison, placentas (n = 50) from physiological term deliveries before the COVID-19 pandemic were studied. To minimise the influence of confounding factors on the placenta, the exclusion criteria were: preeclampsia, chronic arterial hypertension, diabetes mellitus, multiple pregnancy, congenital fetal malformations, fetal growth restriction, acute infectious diseases of other etiology, severe extra-genital pathology, and caesarean delivery. The material was obtained under a cooperation agreement with the Department of Pediatric Pathological Anatomy of the State Nonprofit Enterprise “National Children’s Specialised Hospital “Ohmatdyt” of the Ministry of Health of Ukraine”. The study was conducted from 2020 to 2026. Placental samples were collected between 2020 and 2022, morphological examinations were performed in 2020-2026, and statistical analysis of the obtained data was conducted in 2025-2026. The study was conducted in compliance with bioethical standards regulated by the World Medical Association [15], the Convention on Human Rights and Biomedicine [16]. Written informed consent was obtained from all women. The study was approved by the Bioethics Committee of Bogomolets National Medical University, protocol No. 144 dated 29.03.2021. COVID-19 in pregnant women was confirmed by a positive polymerase chain reaction (PCR) test for SARS-CoV-2 RNA, while newborns were PCR-negative with high Apgar scores. The age of the women did not differ significantly between the study groups ($p > 0.05$): the median age in Group I was 32 [28; 36], in Group II – 31 [28; 34], and 30 [26; 34] years in the comparison group.

The course of COVID-19 in Group I was classified as mild in 46 pregnant women, moderate in 34, and severe disease with bilateral polysegmental pneumonia was diagnosed in 6 women. In Group II, the course of COVID-19 was mild in 36 pregnant women, moderate in 24 cases, and severe disease with pneumonia was diagnosed in 4 women. No statistically significant differences in the severity of COVID-19 were observed between the main groups. Microscopic and immunohistochemical methods were used, including monoclonal antibodies against CD31 and smooth muscle

actin (α -SMA) (Thermo Fisher Scientific, the United States of America (USA)), as well as electron microscopy and statistical analyses. Quantitative analysis of digital images was performed on standardised microphotographs under identical magnification conditions. For each case, a defined number of fields of view ($n=6$) were analysed. Areas with artifacts were excluded from the analysis. Histological structures were visualised using digital slide scanning with the Panoramic DESK DW II scanner [17]. Quantitative differences in the stroma and vessels of chorionic villi, as well as the percentage of stem and intermediate villi, were assessed using the ONLINE JPG TOOLS service. For this purpose, qualitative pixel-by-pixel visualisation of structures or cells (endothelium, smooth muscle cells) that differed in colour after immunohistochemical staining was performed. After fixation of placental tissue samples in 10% neutral formalin, dehydration through a graded series of alcohols of increasing concentration, paraffin embedding, and preparation of 4 μ m-thick tissue sections, followed by immunohistochemical staining and microscopic imaging using a digital camera, the obtained images were saved in JPEG format and uploaded to the ONLINE JPG TOOLS service. This software was used to determine the percentage of pixel colour in the image, which corresponded to the proportion of the studied structure. For visualisation of stem chorionic villi or blood ves-

sels, they were additionally colour-coded using Microsoft Paint with a colour different from the histological staining of the structures in the image. Statistical analysis was performed using IBM SPSS v.22 (Armonk, NY, USA), licensed to Bogomolets National Medical University (license No. 128, 01.08.2016). Variational statistical methods were applied. For multiple comparisons of mean values between groups, the nonparametric Kruskal-Wallis test was used. Ranked data are presented as median with lower and upper quartiles (Me [Q1; Q3]). Categorical variables (frequencies of pathological features) were analysed using Pearson's chi-square test or Fisher's exact test when expected frequencies were small. Differences were considered statistically significant at $p < 0.05$.

RESULTS AND DISCUSSION

Placentas from COVID-19-positive pregnancies resulting in live term births were analysed. Placental weight in Group I was 539 [350; 720], in Group II – 545 [320; 750], and 536 [400; 950] in the comparison group. No statistically significant differences were found between the groups. The placentas of Group II showed an increased proportion of stem and intermediate chorionic villi – 33 (23; 47) compared with 7 (7; 9) in Group I ($p < .001$). The value in Group I did not differ from the corresponding parameter in the comparison group (Table 1; Fig. 1, A, B).

Table 1. Pathomorphological changes in the placenta in COVID-19 in pregnant women

Parameters		COVID-19 (N = 152)			p
Groups		I (n = 86)	II (n = 66)	Comparison (n = 50)	
Age of pregnant women		32 [28; 36]	31 [28; 34]	30 [26; 34]	
Placental weight (g)		539 [350; 720]	545 [320; 750]	536 [400; 950]	
COVID-19 severity, n (%) [95 % CI]	Mild	46 (53.5) [43.0-63.5]	36 (54.5) [42.5-66.1]		p = 0.90
	Moderate	34 (39.5) [29.8-50.1]	27 (40.9) [29.8-53.0]		p = 0.96
	Severe	6 (7.0) [3.2-14.4]	3 (4.5) [1.5-12.5]		p = 0.74
Percentage of stem and semi-stem chorionic villi; %		7 (7; 9)	33 (23; 47)*	7 (7; 9)	p < 0.001
Stasis, thrombosis; n (%) [95 % CI];		86 (100) [95.8-100]	52 (78.8) [67.9-89.7]		
Arteriolar endothelial necrosis; n (%) [95 % CI];		84 (97.7) [93.9-100]*	4 (6.1) [0.2-11.9]	–	–
Ultrastructural changes in telocytes; n (%) [95 % CI];		85 (98.8) [96.6-100]	57 (86.4) [78.1-94.7]	–	–
Narrowing of the lumen of terminal villus vessels, n (%) [95 % CI]; % of vessels		86 (100) [95.8-100]; 29 (27; 33)*	(92.4) [86.0-98.8]; 46 (44; 47)*	0 (0) [0,0-3,8]; 68 (65;70)	p < 0.001
Stromal edema of terminal villi, n (%) [95 % CI]; % of stroma		86 (100) [95.8-100]; 71 (67; 73)*	(92.4) [86.0-98.8]; 55 (53; 56)*	0 (0) [0,0-3,8]; 32 (30;35)	p < 0.001
Stromal fibrosis		4 (4.7) [0.1-9.3]	59 (89.4) [81.0-97.8]*	–	p < 0.001

Note: * $p < .001$ (For quantitative variables, the Kruskal-Wallis test was used; categorical variables were compared using Pearson's χ^2 or Fisher's exact test, as appropriate)

Source: developed by the authors

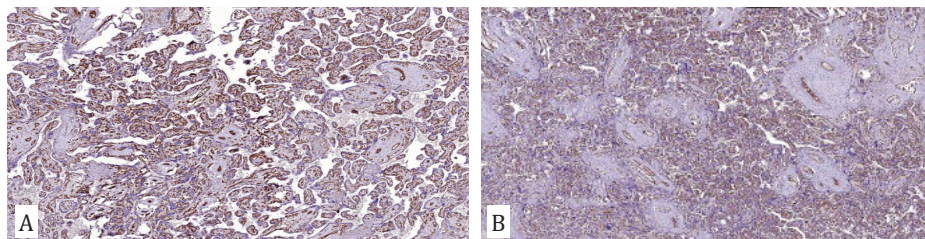


Figure 1. Structural changes of chorionic villi in pregnant women with COVID-19

Note: A – Group I; B – Group II. Expression of monoclonal antibodies against CD31 in the endothelium of chorionic villus vessels. A, B $\times 50$

Source: authors' photo

Signs of impaired blood rheology were observed in the main groups as stasis and thrombosis, occurring in 100% of cases in Group I and 79% in Group II (Table 1; Fig. 2, A-D). By electron microscopy (EM), aggregated erythrocytes obstructing the vascular lumen were detected in Group I (Fig. 3, A). The vascular lumen was

reduced in all observations (Fig. 2, A, C), leading to changes in the vessel-to-stroma ratio within the chorionic villi. The percentage of vessels decreased to 29 (27-33), while the stroma increased to 71 (67-73), compared to 68 (65-70) and 32 (30-35) in the comparison group, respectively (Fig. 2, E, F; Table 1).

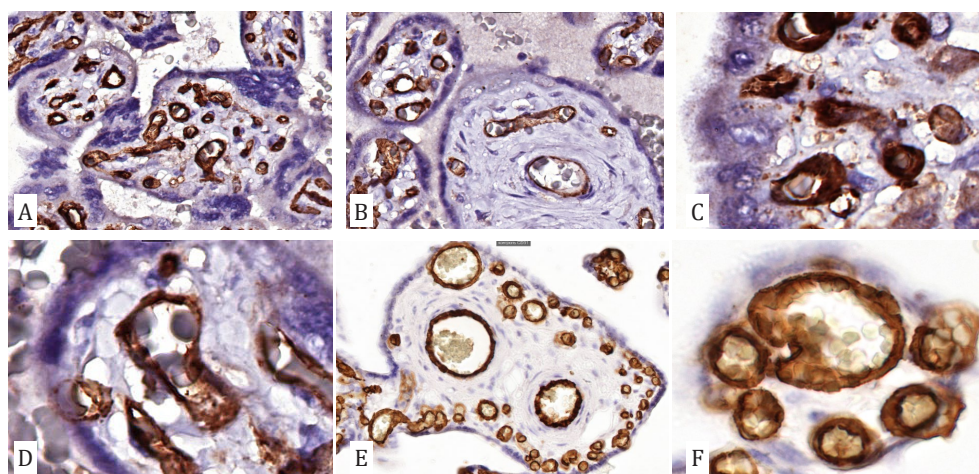


Figure 2. Structural changes of chorionic villi in pregnant women with COVID-19

Note: A, C – Group I; B, D – Group II; E, F – Group of comparison. Expression of monoclonal antibodies against CD31 in the endothelium of chorionic villus vessels. A, C, E $\times 630$; B, D, F $\times 1,800$

Source: authors' photo

Edema of the stroma in terminal villi led to a reduction in vascular lumen and a more central positioning of vessels (Fig. 2, A-D), compared to peripheral vessel location in the comparison group (Fig. 2, E, F). With an increased duration of the post-COVID interval (Group II), the vascular lumen enlarged, and the percentage of vascular area increased – 46 (44-47) (Fig. 3, B; Fig. 2, B, D), which was associated with decreased stromal edema. However, vessels remained more centrally located due to stromal fibrosis (Fig. 2, B). Thus, in Group I, the increased thickness of the vasculo-syncytial membrane was due to edema, whereas in Group II it was related to stromal fibrosis. Morphological signs of necrotic injury to arteriolar endothelium were detected in 97.7% of cases in Group I and in 6.1% of cases in Group II. In Group I, cytoplasmic edema and cytoplasmic clearing of endothelial cells were noted (Fig. 3, A).

In Group II, the cytoplasm of endothelial cells formed numerous projections creating luminal microvilli and micropinocytotic vesicles, indicative of restoration of functional activity (Fig. 3, B). Telocytes were observed in close proximity to vessels (Fig. 3, E) or beneath the basal membrane of the syncytiotrophoblast (Fig. 3, C, D), characterised by spindle-shaped nuclei and long processes (telopodes) [12-14]. In Group I, telocyte nuclei exhibited apoptotic changes with irregular contours, marginalisation, and chromatin condensation, surrounded by a thin rim of cytoplasm (Fig. 3, E). Telopodes contained areas of clear cytoplasm and vacuoles (Fig. 3, C, D, E). Fragmentation, thickening, and shortening of telopodes were also noted (Fig. 3, C, E). Structural disruption of telocytes may contribute to the formation of slit-like stromal spaces (Fig. 3, E, F), resembling stromal channels in early-gestation villi.

In Group II, the number of collagen fibers around telocyte-like cells increased, suggesting possible transformation of telocytes into fibroblasts (Fig. 3, F). Structural

changes in the chorionic villi and the expression of smooth muscle actin (α -SMA) in the study groups were shown in Figure 4.

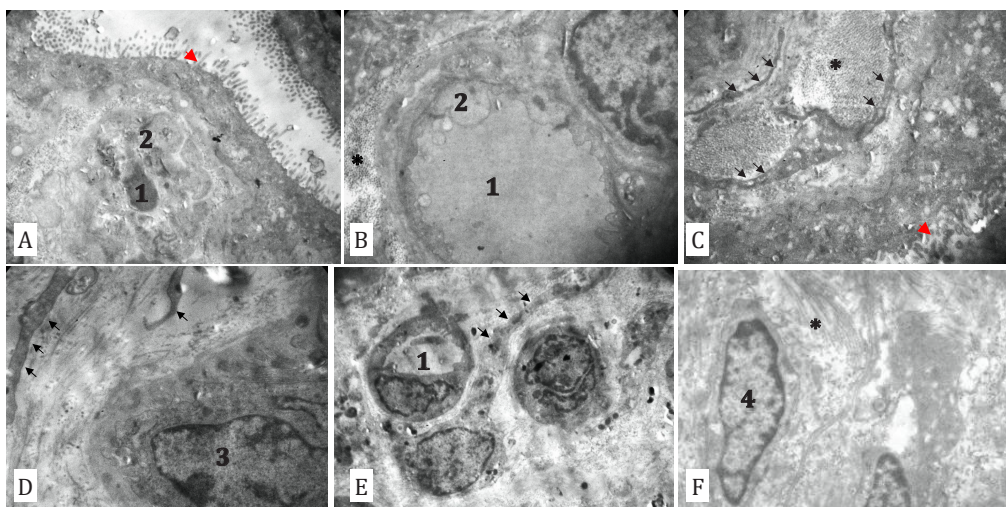


Figure 3. Electron microscopy of placental changes in pregnant women with COVID-19

Note: A, C, E – Group I; B, D, F – Group II. A – aggregated erythrocytes in the lumen of a terminal villus vessel (1) and cytoplasmic vacuolisation of the endothelium (2). B – edematous, clear endothelium (2) with numerous cytoplasmic protrusions forming luminal microvilli. C, D, E – destructive changes of telopodes (arrows), cytoplasmic vacuolisation. F – fibroblasts (4) in the stroma of a semi-stem villus. Legend: 1 – vessel lumen. 2 – endothelium. 3 – syncytiotrophoblast. Red arrow – microvilli of the syncytiotrophoblast. 4 – fibroblast. Black arrows – telopodes. Magnifications: A-C, E $\times 6,000$; D, F $\times 10,000$

Source: authors' photo

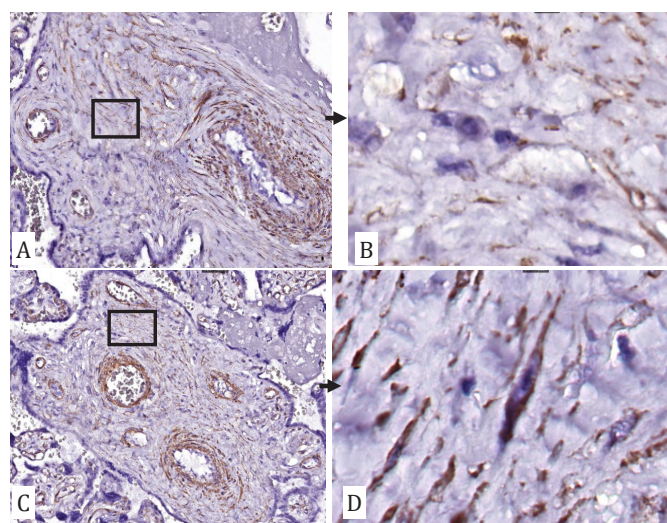


Figure 4. Structural changes of chorionic villi in pregnant women with COVID-19

Note: A, B – Group I; C, D – Group II. Expression of smooth muscle actin (α -SMA). A, C $\times 200$; B, D $\times 1,800$

Source: authors' photo

In the stroma of placentas from Group I, expression of α -SMA in long telocyte-like processes was negative or weak (Fig. 4, B). In contrast, in Group II, stromal cells exhibited α -SMA expression in the cell nucleus and proximal parts of the processes (Fig. 4, D). The present study describes and analyses placental findings in cases of maternal COVID-19 occurring at different stages of gestation and resulting in the delivery of

live-born infants. No statistically significant differences in the severity of COVID-19 were observed between the main study groups. Likewise, no statistically significant association was found between maternal COVID-19 severity and neonatal condition at birth, as all newborns demonstrated high Apgar scores, as previously reported by F. Aeffner *et al.* [18]. As previously described I. Bernard *et al.* [6], PCR-negative infants without signs

of hypoxia were born to PCR-positive mothers whose placentas showed placentitis and features of maternal vascular malperfusion. The observed findings have been linked to placental defence mechanisms that may prevent vertical viral transmission by limiting the expression and co-expression of angiotensin-converting enzyme 2 (ACE2) and transmembrane serine protease 2 (TMPRSS2) [19]. However, as previously noted J. Li *et al.* [5] and S. Beyerstedt *et al.* [20], the effect of SARS-CoV-2 on endothelial cells may result in endothelial activation and necrotic cell death, including pyroptosis. Pathomorphological changes were assessed in the stem chorionic villi, which play a key role in regulating blood flow and maintaining the mechanical stability of the villous tree, as well as in the intermediate villi, from which terminal villi are formed. As indicated S. Jaiman *et al.* [14], the latter give rise to vasculosyncytial membranes that facilitate maternal-fetal exchange of gases, nutrients, and metabolic products. In the present study, both main groups demonstrated signs of endothelial dysfunction, including microcirculatory disturbances and cytoplasmic swelling of endothelial cells (Fig. 3, A). Stromal edema resulted in narrowing of the vascular lumina and was associated with a decrease in the proportion of blood vessels within the villi to 29% (27-33), compared with 68% (65-70) in the control group (Table 1; Fig. 1). In addition, vascular thrombosis led to obliteration of the vessel lumen (Fig. 3, A), resulting in a decreased number of vessels per villus in Group I, thereby potentially impairing fetal perfusion [6].

With increasing duration of the post-COVID interval (Group II), swelling of endothelial cell cytoplasm and terminal villous stroma decreased (Table 1). Nevertheless, stromal edema persisted until delivery, contributing to increased thickness of the vasculosyncytial membrane. In edematous villi of both study groups, blood vessels were located closer to the centre of the terminal villous cross-section (Fig. 1), whereas in the comparison group vessels were predominantly localised in peripheral regions of terminal villi (Fig. 2). Increased thickness of the vasculosyncytial membrane has been reported to contribute to pathological endothelial activation, impaired microcirculation, hypoxia, and fibroblast activation with subsequent stromal fibrosis [7]. In Group II, a reduction in stromal edema and restoration of endothelial functional activity were observed, as evidenced by an increased number of microvilli and micropinocytic vesicles on the luminal surface of endothelial cells (Fig. 3B). This was accompanied by the gradual restoration of the functionally patent vascular lumen, reflected by an increase in the proportion of blood vessels within the terminal villi to 46% (44-47) (Fig. 3, B; Fig. 1, D, F). In Group I, isolated destructively altered cells with elongated processes consistent with telocytes (TCs) were observed adjacent to vessels whose lumina were obstructed by erythrocytes (Fig. 1A, C, E).

According to E. Erkan *et al.* [21] and B.D.A. Sanches *et al.* [22], telocytes TCs are present in the stroma of chorionic villi. In the non-innervated placenta, TCs are believed to function as mediators of intercellular communication, analogous to interstitial cells of Cajal, through their long cytoplasmic processes known as telopodes. TCs participate in signal transmission to placental myofibroblasts, which are a source of nitric oxide involved in the regulation of vascular smooth muscle tone. Furthermore, TCs contribute to tissue regeneration, angiogenesis, terminal chorionic villi formation, and protection against endothelial dysfunction [17]. As noted by B.D.A. Sanches *et al.* [22], they establish functional interactions with pericytes, endothelial cells, collagen fibres, and blood vessels. Loss of these functions due to TC injury, a reduction in their number, or their transformation into fibroblast-like cells, as reported in preeclampsia, may contribute to the development of placental dysfunction [23-24]. Thus, TCs play an essential role in regulating the contractile activity of vascular smooth muscle cells and promoting angiogenesis within terminal villi, thereby influencing the subsequent pattern of chorionic villous growth.

During the acute phase of the disease, telocytes exhibited shortened and fragmented telopodes together with cytoplasmic vacuolisation. These alterations may result either from direct SARS-CoV-2-induced injury or from secondary damage associated with vascular thrombosis (Fig. 3A). Under reversible conditions, telocytes may support regeneration of both endothelium and stromal tissue. In contrast, it has been noted M. Klein *et al.* [4] that irreversible telocyte injury may impair their angiogenic function and role in terminal villous formation, potentially contributing to delayed chorionic villous maturation, manifested by an increased proportion of stem villi. Similar placental alterations accompanied by changes in telocyte morphology and quantity have also been described in preeclampsia [21]. According to B.D.A. Sanches *et al.* [22], telocytes may differentiate into myofibroblasts and fibroblast-like cells, contributing to stromal fibrosis. Conversely, as previously reported by T.Q. Chen *et al.* [25], stromal fibrosis may also result from a reduction in telocyte number, leading to diminished regulation of fibroblast activity. In the present study, the stroma of Group II contained telocyte-like α -SMA-positive cells, suggesting a possible transition toward a myofibroblast phenotype during stromal remodelling in placentas from pregnancies complicated by COVID-19. Transformation of telocytes into fibroblast-like cells has previously been described under hypoxic conditions by S.M. Turianytsia *et al.* [19] and S. Beyerstedt *et al.* [20], which is consistent with the increased amount of collagen fibres observed in Group II (Fig. 1, D, F). In Group I, narrowing of arteriolar lumina within stem and intermediate villi was accompanied by proliferation of vascular smooth muscle cells, as evidenced

by increased α -SMA expression (Fig. 4, A). In Group II, vascular lumina were restored, vessel wall thickness decreased, and α -SMA expression was reduced. These findings suggest that destructive changes in telocytes, whether primary (direct viral injury) or secondary (associated with vascular thrombosis and stromal edema), may indirectly contribute to remodelling of the villous chorion through impaired functional activity, resulting in an increased proportion of stem and intermediate villi and stromal fibrosis. Co Focal formation of small terminal villi was interpreted as a possible compensatory morphological response.

CONCLUSIONS

1. The obtained results indicated an association between the duration of the post-COVID interval and the pattern of morphological changes in the placenta.

2. During the acute phase of COVID-19, placentas were characterised by signs of endothelial injury in 97.7% (95% CI: 93.9-100) of cases and microcirculatory disturbances in 100% (95% CI: 95.8-100). Stromal edema was associated with a reduction in the proportion of vascular lumen area to 29% (27-33) and an increase in the proportion of stromal area to 71% (67-73), compared with 32% (30-35) and 68% (65-70), respectively, in the comparison group. With increasing duration of the post-COVID interval (Group II), the vascular lumen was restored, and the proportion of vascular lumen area increased to 46% (44-47).

3. Group II demonstrated signs of chorionic villous remodelling, manifested by an increased proportion of stem and intermediate villi, reaching 33% (23-47) compared with 7% (7-9) in Group I ($p < .001$).

4. Ultrastructural alterations of telocytes were observed in 100% of cases in Group I and in 86.4% of cases in Group II. The appearance of telocyte-like α -SMA-positive cells within the villous stroma may indicate their involvement in placental fibrosis and remodelling processes.

5. Future research should focus on elucidating the role of placental telocytes in the formation of terminal villi, remodelling of the chorionic villous tree, and the mechanisms underlying placental insufficiency associated with antenatal fetal death. In particular, further studies are needed to clarify their involvement in placental vascular adaptation, maintenance of villous architecture, and cellular interactions that may contribute to adverse pregnancy outcomes.

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CONFLICT OF INTEREST

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Ремоделювання ворсин хоріона доношеної плаценти при COVID-19 у вагітної: взаємозв'язок із тривалістю постковідного проміжку

Анотація

Актуальність. У плацентарній тканині мішенню SARS-CoV-2 є клітини, що характеризуються експресією ангіотензинперетворюючого ферменту 2 (ACE2), зокрема ендотеліальні клітини, синцитіотрофобласт і телоцити. Ураження цих клітин спричиняє піроптоз, запалення та розвиток артеріосклерозу. При ушкодженні телоцитів відмічається втрата міжклітинної сингалізації, що обумовлює патоморфологічні зміни плаценти.

Мета. Дослідити ремоделювання ворсинчастого хоріона при коронавірусній хворобі COVID-19 у вагітної.

Матеріали та методи. Досліджено 152 плаценти після доношених пологів у жінок із COVID-19, розподілені на групи за тривалістю постковідного інтервалу (від діагностування COVID-19 до пологів). III в групі I (n = 86) був 1-4, в II групі (n = 66) – 5-18 тижнів. Як контрольну групу використано 50 плацент, отриманих після фізіологічних пологів до початку пандемії COVID-19. Застосовували мікроскопічний, імуногістохімічний, статистичний методи дослідження. COVID-19 у вагітної підтверджено позитивним результатом полімеразної ланцюгової реакції (ПЛР) на наявність РНК вірусу SARS-CoV-2, при цьому новонароджені були ПЛР-негативні з високими балами за шкалою Апгар. Кількісні відмінності строми та судин ворсин хоріона й відсотковий вміст стовбурових та напівстовбурових ворсин хоріона визначено за допомогою сервісу ONLINE JPG TOOLS.

Результати. Плацента групи II відрізнялася збільшенням відсотку стовбурових та напівстовбурових ворсин хоріона – 33 (23; 47) проти 7 (7; 9); $p < 0,001$ у групі I. Порушення реологічних властивостей крові спостерігалися в основних групах у вигляді стазів, тромбозів у 100 % групи I та 79 % групи II. Набряк строми призводив до зміни співвідношення судин та строми у ворсині хоріона та зменшення відсотку судин – 29 (27-33). В групі II просвіт судин відновлювався – 46 (44-47), що пояснювалося зменшенням набряку строми. Некроз ендотелію артеріол виявився в 97,7 % спостережень групи I та 6,1 % групи II. В групі I виявлялися деструктивні зміни телоцитів. В групі II виявлялися телоцитоподібні клітини з експресією α -SMA, що не виключає перехід до фенотипу міофібробластів під час ремоделювання строми при COVID-19 у вагітної, а фіброзування ворсин строми – до фібробластів. Компенсаторні механізми в вигляді вогнищового формування дрібних термінальних ворсин спостерігалися у випадках народження немовлят з високими балами за шкалою Апгар.

Ключові слова: плацента; SARS-CoV-2; вагітність; телоцити; α -актин гладких м'язів (α -SMA).