UDC 616-053.13-07:618.177-089.888.11
DOI: 10.56871/RBR.2025.17.33.005

FETOMETRY PARAMETERS IN PREGNANCY AFTER *IN VITRO* FERTILIZATION

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For citation: Mitrofanova IV, Lutsai ED. Fetometry parameters in pregnancy after *in vitro* fertilization. Russian Biomedical Research. 2025;10(1):43–50.
DOI: https://doi.org/10.56871/RBR.2025.17.33.005

Received: 02.02.2025 **Revised: 12.03.2025** **Accepted: 09.04.2025**

Abstract. ***Introduction.*** Current research supports the efficacy and safety of in vitro fertilization (IVF), but questions about pregnancy and fetal development after their use continue to be relevant. Early sources claim that there is a relationship between IVF and low birth weight, premature birth, placental abruption, congenital malformations, and perinatal mortality. More recent data show that the incidence of perinatal complications is higher in women after IVF. ***The aim of the study*** was to evaluate fetometric parameters in pregnancies resulting from in vitro fertilization in the Orenburg region. ***Material and method.*** Retrospectively we studied 1333 ultrasound protocols at 11–14, 20–22, 30–34 weeks in 462 pregnant women of the first (343) and second (119) gestational periods after IVF. When analyzing screening at 11–14 weeks, we compared the crown-rump length (CRL) and nuchal translucency (NT) of fetuses in women of two age groups. The second and third screens looked at averages the mean biparietal diameter (BPD), occipitofrontal diameter (OFD), head circumference (HC) and abdominal circumference (AC) and femur length (FL) in fetuses from women of the two age periods and according to sex were compared, as well as the growth intensity of the above parameters depending on the sex of the fetus and the age period of the mother. ***Results.*** The study showed that at the first screening, the mean CRL of the fetus was not statistically significantly different between the two groups, while the mean value of the nuchal NT was significantly higher in fetuses of second gestational age women. When comparing the fetometric parameters obtained at the second screening, there was a significant difference in OFD in fetuses of women of the two age periods. When comparing the studied fetometric parameters depending on the sex of the fetus, significant differences were found in a greater direction for male fetuses. ***Conclusion.*** Thus, fetometry revealed uneven growth of the studied parameters from the intermediate to late fetal period, including depending on the sex of the fetus and the age of the mother.

Keywords: fetus, fetometry, *in vitro* fertilization, growth intensity

DOI: 10.56871/RBR.2025.17.33.005

ПОКАЗАТЕЛИ ФЕТОМЕТРИИ ПРИ БЕРЕМЕННОСТИ ПОСЛЕ ЭКСТРАКОРПОРАЛЬНОГО ОПЛОДОТВОРЕНИЯ

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Для цитирования: Митрофанова И.В., Луцай Е.Д. Показатели фетометрии при беременности после экстракорпорального оплодотворения. Российские биомедицинские исследования. 2025;10(1):43–50. DOI: https://doi.org/10.56871/RBR.2025.17.33.005

Поступила: 02.02.2025 **Одобрена: 12.03.2025** **Принята к печати: 09.04.2025**

Резюме. ***Введение.*** Современные исследования подтверждают эффективность и безопасность экстракорпорального оплодотворения (ЭКО), однако продолжают оставаться актуальными вопросы о течении беременности и развитии плода после их применения. Ранние источники утверждают о существовании взаимосвязи между процедурой ЭКО и низким весом при рождении, преждевременными родами, отслойкой плаценты, врожденными аномалиями развития, перинатальной смертностью. Поздние данные показывают, что частота перинатальных осложнений выше у женщин после ЭКО. ***Цель исследования*** — дать оценку фетометрическим показателям при беременности, наступившей в результате экстракорпорального оплодотворения, в Оренбургской области. ***Материалы и методы.*** Ретроспективно были изучены 1333 протокола ультразвукового исследования в сроки 11–14, 20–22, 30–34 недели у 462 беременных первого (343) и второго (119) периодов зрелого возраста после применения вспомогательных репродуктивных технологий (ВРТ). При анализе скрининга в 11–14 недель сравнивали копчико-теменной размер (КТР) и толщину воротникового пространства (ТВП) плодов у женщин двух возрастных групп. Во втором и третьем скрининге сравнили средние значения бипариетального (БПР), лобно-затылочного размеров (ЛЗР), окружности головы (ОГ) и живота (ОЖ) и длины бедра (ДБ) у плодов от женщин двух возрастных периодов и в зависимости от пола, а также интенсивность роста вышеперечисленных параметров в зависимости от пола плода и возрастного периода матери. ***Результаты.*** Исследование показало, что при первом скрининге среднее значение КТР плода не имело статистически значимых различий у женщин двух групп, а среднее значение ТВП у плодов женщин второго периода зрелого возраста было значимо больше. При сравнении фетометрических показателей, полученных при втором скрининге, выявлено значимое различие ЛЗР у плодов женщин двух возрастных периодов. При сравнении исследуемых фетометрических параметров в зависимости от пола плода выявлены значимые различия в большую сторону для плодов мужского пола. ***Заключение.*** Таким образом, фетометрия выявила неравномерный рост исследуемых параметров от промежуточного к позднему плодному периоду, в том числе в зависимости от пола плода и возраста матери.

Ключевые слова: плод, фетометрия, экстракорпоральное оплодотворение, интенсивность роста

INTRODUCTION

Since the first in vitro fertilization (IVF) procedure was performed, extensive experience has been accumulated in the use of assisted reproductive technologies (ART). Numerous randomized controlled trials have demonstrated the efficacy and safety of ART [1]. However, the study of pregnancy outcomes following IVF, including fetal development, remains relevant. The fundamental question remains unresolved: whether to consider IVF-conceived pregnancy as physiological (i.e., identical to spontaneous conception) or to regard it as a pregnancy with an inherently higher risk of perinatal complications [2].

On one hand, IVF success is conventionally determined by ultrasound-confirmed intrauterine pregnancy.

On the other hand, current practice places greater importance on evaluating outcomes through the birth of a healthy term infant with preserved maternal health.

Early studies suggested an association between IVF procedures and adverse perinatal outcomes, including low birth weight, preterm delivery, placental abruption, congenital anomalies, and perinatal mortality [3]. More recent data indicate that women who conceive through IVF experience higher rates of perinatal complications compared to the general population [4]. Currently, IVF is increasingly being utilized by women of advanced maternal age.

Consequently, a critical priority for obstetric-gynecologic care is to enhance the quality and efficacy of medical management during pregnancy, delivery, and the postpartum period [3], as well as to optimize prenatal fetal diagnostics — particularly standard ultrasound fetal biometry [5].

Fetal ultrasound screening holds a pivotal position in prenatal diagnostics [6]. Standard screening examinations were traditionally performed at 11–14, 18–21, and 30–34 gestational weeks. Retrospective analysis demonstrates the feasibility of fetal assessment in women with IVF-conceived pregnancies during intermediate and late fetal development stages.

AIM

The aim of the study was to evaluate fetometric parameters in pregnancies resulting from in vitro fertilization in the Orenburg region.

MATERIALS AND METHODS

The study sample comprised 462 electronic pregnancy and delivery records following IVF between 2016–2022. All cases were stratified by maternal age: first period of mature age (FPA, 20–34 years) and second period of mature age (SPA, 35–45 years) — 343 and 119 cases, respectively. For the second and third trimester screenings, the sample was equally divided by fetal sex (50% male and 50% female). Inclusion criteria were: women with singleton IVF pregnancies, term deliveries, and without severe extragenital pathology.

Using retrospective analysis of electronic pregnancy and delivery records, we analyzed standardized fetal biometry data obtained during routine ultrasound screenings at 11–14, 18–22, and 30–34 gestational weeks[1]. It should be noted that the third (mandatory) screening was discontinued as of January 1, 2021[2].

We analyzed 1,333 ultrasound examination protocols across different pregnancy trimesters. For first-trimester screening (450 scans), we measured crown-rump length (CRL) and nuchal translucency (NT). Second-trimester screening (456 scans) included assessment of biparietal diameter (BPD), occipitofrontal diameter (OFD), head circumference (HC), abdominal circumference (AC), and femur length (FL). The same parameters as the second trimester (BPD, OFD, HC, AC, FL) were evaluated in third-trimester scans (427 examinations).

All ultrasounds were performed using Voluson S10 systems with RAB6-RS transducers alongside Samsung HS70(A) machines equipped with 5–9 MHz microconvex transducers.

The study was conducted at the Medical-Genetic Counseling Center of Orenburg Regional Clinical Hospital No. 2 and the Department of Human Anatomy, Orenburg State Medical University (Ministry of Health of Russian Federation. The research protocol was approved by the Local Ethics Committee of Orenburg State Medical University (Protocol No. 308, dated November 28, 2022).

For Groups 1 and 2, as well as for male and female fetuses, growth intensity rates for the aforementioned fetometric parameters were calculated from intermediate to late fetal periods using the formula (Sokolov V.V. et al., 2005):

$$GI = \frac{(D_2 - D_1)}{0{,}5 \cdot (D_1 + D_2)} \cdot 100\%.$$

where D_2 represents the parameter value in the late fetal period and D_1 and epresents the value in the intermediate fetal period.

All morphometric data underwent variation-statistical processing using MS Excel and IBM SPSS Statistics soft-

[1] Prikaz Ministerstva zdravookhraneniya Rossiyskoy Federatsii ot 28 dekabrya 2000 goda № 457 “O sovershenstvovanii prenatal’noy diagnostiki v profilaktike nasledstvennykh i vrozhdennykh zabolevaniy u detey”. Available at: https://base.garant.ru/4177325/ (accessed: 16.03.2025).

[2] Prikaz Ministerstva zdravookhraneniya Rossiyskoy Federatsii ot 20 oktyabrya 2020 goda № 1130n “Ob utverzhdenii Poryadka okazaniya meditsinskoy pomoshchi po profilyu «akusherstvo i ginekologiya»”.Available at: https://base.garant.ru/74840123/ (accessed: 16.03.2025).

ware, version 20.0. We determined the mean value (X), standard deviation (Sx), minimum (min) and maximum (max) values. The significance of differences between compared parameters was assessed using Student's t-test, with the statistical significance level (p) set at 0.05 as the critical threshold in our study.

RESULTS

Ultrasound scanning provides detailed images of nearly all fetal structures and enables their qualitative and quantitative assessment. Ultrasound fetometry serves as a prenatal diagnostic method that forms the basis for establishing regional standards of fetal growth evaluation.

Fetometry data at different gestational timepoints in IVF-conceived pregnancies are presented in Table 1.

During first-trimester screening, analysis of women in first and second mature age periods revealed mean CRL values of 63.6±6.6 mm (FPA group) and 64.7±7.8 mm (SPA group). These measurements showed no statistically significant intergroup difference (p=0.246).

Mean NT measurements were 1.6±0.3 mm in the FPA group compared to 1.7±0.3 mm in the SPA group, demonstrating statistically significant differences (p=0.045), with higher values observed in women of SPA.

During second-trimester screening (without accounting for fetal sex), women in first and second mature age periods following IVF demonstrated the following mean fetal biometry values in the intermediate fetal period. For pregnant women of FPA biparietal diameter, occipitofrontal diameter, head circumference, abdominal circumference, and femur length measured 48.7±3.5 mm, 64.1±3.9 mm, 181.9±10 mm, 156.2±9.6 mm, and 33.7±2.5 mm, respectively. For pregnant women of SPA, these parameters were 48.8±2.8 mm, 65.1±3.8 mm, 183.7±9.2 mm, 157.4±10.5 mm, and 34.1±3.1 mm, respectively.

Comparative analysis revealed no significant differences in BPD, HC, AC, or FL between age groups, while

Table 1

Fetal parameters in pregnancy after in vitro fertilization

Таблица 1

Фетометрические параметры при беременности после экстракорпорального оплодотворения

Первый скрининг / First screening (n=450)			
Параметр / Parameter	X±Sx	min	max
КТР, мм / CRL, mm	63,9±6,9	48	83
ТВП, мм / NT, mm	1,6±0,3	0,8	3,2
Срок беременности, недель / Gestational age, weeks	12,6±0,5	11	14
Второй скрининг / Second screening (n=456)			
БПР, мм / BPD, mm	49±3,3	43	54
ЛЗР, мм / OFD, mm	65±3,9	56	73
ОГ, мм / HC, mm	183,3±9,9	160	205
ОЖ, мм / AC, mm	158,1±9,9	134	178
ДБ, мм / FL, mm	34±2,6	30	41
Срок беременности, недель / Gestational age, weeks	20,7±0,8	19,1	22,6
Третий скрининг / Third screening (n=427)			
БПР, мм / BPD, mm	80,2±3,7	74	89
ЛЗР, мм / OFD, mm	99,8±4,8	87	111
ОГ, мм / HC, mm	287±12,3	256	315
ОЖ, мм / AC, mm	272±14,3	228	296
ДБ, мм / FL, mm	60,5±4	53	66
Срок беременности, недель / Gestational age, weeks	31,3±1,1	29	33,6

Note: BPD — biparietal diameter of the head; FL — femur length; CRL — coccygeal-parietal size; NT — nuchal translucency thickness; OFD — occipitofrontal diameter; HC — head circumference; AC — abdominal circumference.

Примечание: БПР — бипариетальный размер головы; ДБ — длина бедренной кости; КТР — копчико-теменной размер; ТВП — толщина воротникового пространства; ЛЗР — лобно-затылочный размер; ОГ — окружность головы; ОЖ — окружность живота.

OFD showed statistically significant greater values in the advanced maternal age cohort.

Evaluation of biparietal diameter, occipitofrontal diameter, head circumference, abdominal circumference, and femur length during third-trimester screening in the late fetal period revealed the following mean values for women of FPA: 79.4±3.7 mm, 100.2±4.8 mm, 287.3±12.3 mm, 270.1±14.3 mm, and 59.4±4 mm, respectively. For women of SPA, the corresponding fetal parameters were 79.2±3.7 mm, 100.6±4.8 mm, 287.2±12 mm, 270.2±14.9 mm, and 59.7±2.8 mm, respectively.

The results of screening examinations performed at established gestational timepoints, showing fetal size variations by maternal age and fetal sex, are presented in Table 2.

Table 2

Size of male and female fetuses

Таблица 2

Размеры плодов мужского и женского пола

Параметр / Parameter	Срок беременности, недель / Gestational age, weeks	Мужской пол / Male gender, n=231	Женский пол / Female gender, n=231	Значимость различий / Significance of differences, p
		X±Sx	X±Sx	
18–22 недели / 18–22 weeks				
ППЗВ / FPA, n=343				
БПР, мм / BPD, mm	20,8±0,8	49,7±3,7	47,7±3	<0,001
ЛЗР, мм / OFD, mm		65,2±4	63±3,5	<0,001
ОГ, мм / HC, mm		185,1±10,1	178,8±8,9	<0,001
ОЖ, мм / AC, mm		159±9	153,5±9,3	<0,001
ДБ, мм / FL, mm		34,2±2,6	33,3±2,2	0,002
ВПЗВ / SPA, n=119				
БПР, мм / BPD, mm	20,6±0,8	48,8±3,2	48,9±2,4	0,945
ЛЗР, мм / OFD, mm		65,9±4,5	64,2±2,8	0,02
ОГ, мм / HC, mm		185,1±10,5	182,2±7,2	0,099
ОЖ, мм / AC, mm		158,9±11,7	155,6±8,5	0,09
ДБ, мм / FL, mm		34±3	34,2±3,1	0,72
30–34 недели / 30–34 weeks				
ППЗВ / FPA, n=343				
БПР, мм / BPD, mm	31,6±1	80,3±3,7	78,4±3,5	<0,001
ЛЗР, мм / OFD, mm		100,6±5	99,8±4,5	0,172
ОГ, мм / HC, mm		289,8±12,7	284,9±11,4	0,001
ОЖ, мм / AC, mm		272±14,4	268,3±14	0,02
ДБ, мм / FL, mm		59,5±4,3	59,2±3,6	0,55
ВПЗВ / SPA, n=119				
БПР, мм / BPD, mm	31,1±1,2	79,8±3,9	78,5±3,1	0,05
ЛЗР, мм / OFD, mm		101,4±4,9	99,7±4,7	0,07
ОГ, мм / HC, mm		290±12,5	283,9±10,6	0,009
ОЖ, мм / AC, mm		271,8±14,5	268,2±15,4	0,2
ДБ, мм / FL, mm		59,7±3	59,8±2,6	0,79

Note: BPD — biparietal diameter of the head; SPA — second period of mature age; FL — femur length; OFD — occipitofrontal diameter; HC — head circumference; AC — abdominal circumference; FPA — first period of adulthood.

Примечание: БПР — бипариетальный размер головы; ВПЗВ — второй период зрелого возраста; ДБ — длина бедренной кости; ЛЗР — лобно-затылочный размер; ОГ — окружность головы; ОЖ — окружность живота; ППЗВ — первый период зрелого возраста.

Table 2 demonstrates that during 18–22-week screening, women of FPA showed significantly greater mean values for all measured parameters in male fetuses compared to female fetuses. In contrast, at 30–34-week screening during the late fetal period, no statistically significant differences were observed in mean BPD, OFD, HC, AC, or FL values between male and female fetuses across both maternal age groups.

Growth intensity analysis of fetal biometric parameters was conducted between the second and third trimester screenings.

The study revealed non-uniform changes in fetal biometric parameters during transition from intermediate to late fetal periods. Growth rates varied significantly across measured parameters, between the two maternal age groups undergoing IVF, and between fetal sexes.

The highest growth intensity was observed in FL and AC, while the lowest rates occurred in OFD and HC, with an 11.8% difference between maximum and minimum values. These findings indicate that during the intermediate fetal period, the most pronounced growth occurs in lower body segments and free lower extremities (thighs).

Growth rates (BPD, OFD, HC, AC, FL) in both maternal age groups were as follows: FPA — 48.2%, 43.4%, 44.5%, 53.4%, 55.2% and SPA — 47.7%, 43.0%, 44.0%, 52.6%, 54.7%, respectively. Comparative analysis revealed consistently higher growth intensity across all parameters in women of FPA, with the most pronounced difference observed in biparietal diameter and the smallest difference in occipitofrontal diameter.

Growth rates for BPD, OFD, HC, AC, and FL from intermediate to late fetal periods in **male fetuses** of women of **FPA** were 47.1%, 42.7%, 44.1%, 52.4%, and 54.0%, respectively (Figure 1). The highest growth intensity was recorded for femur length and abdominal circumference, while the lowest rates were observed for occipitofrontal diameter. The difference between the highest and lowest values values was 11.3%.

Growth rates for BPD, OFD, HC, AC, and FL from intermediate to late fetal periods in **female fetuses** of women of **FPA** were 48.7%, 45.2%, 45.8%, 54.4%, and 56.0%, respectively. The highest growth intensity was observed in femur length, while the lowest rates were recorded for occipitofrontal diameter. The difference between maximum and minimum values was 10.8%.

Comparative analysis between male and female fetuses of women of FPA revealed consistently higher growth rates across all parameters in female fetuses.

Growth rates for BPD, OFD, HC, AC, and FL from intermediate to late fetal periods in **male fetuses** of women of **SPA** were 48.2%, 42.4%, 44.2%, 52.4%, and 54.9%, respectively. The highest growth intensity was observed in femur length, while the lowest rates were recorded for

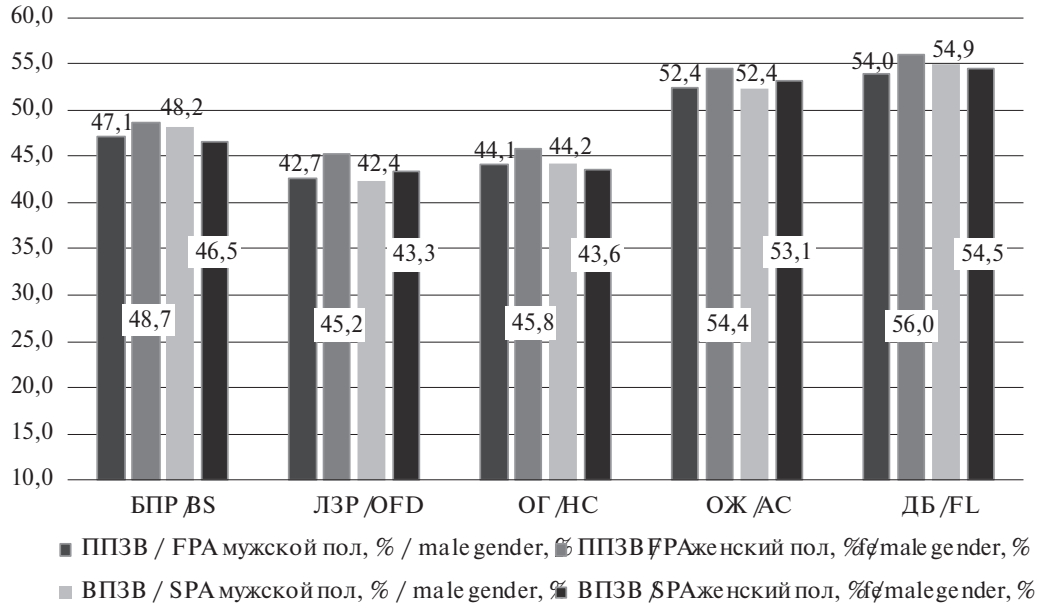

Fig. 1. Growth intensity of the main fetal parameters in first period of adulthood (FPA) and second period of mature age (SPA) women depending on the sex of the fetus (%). BPD — biparietal diameter; FL — femur length; OFD — occipitofrontal diameter; HC — head circumference; AC — abdominal circumference

Рис. 1. Интенсивность роста основных параметров плода у женщин первого периода зрелого возраста (ППЗВ) и второго периода зрелого возраста (ВПЗВ) в зависимости от пола плода (%). БПР — бипариетальный размер головы; ДБ — длина бедренной кости; ЛЗР — лобно-затылочный размер; ОГ — окружность головы; ОЖ — окружность живота

occipitofrontal diameter. The difference between the highest and lowest values was 12.5%.

Growth rates for BPD, OFD, HC, AC, and FL from intermediate to late fetal periods in **female fetuses** of women of **SPA** were 46.5%, 43.3%, 43.6%, 53.1%, and 54.5%, respectively. The highest growth intensity was observed in femur length, while the lowest rates were recorded for occipitofrontal diameter. The difference between maximum and minimum values was 11.2%.

DISCUSSION

This study demonstrated no significant differences in crown-rump length between fetuses of the two maternal age groups, with all mean values falling within the normal reference range at 12.6±0.5 weeks of gestation [7]. In contrast, nuchal translucency measurements showed statistically significant differences between first and second mature age period groups, being greater in the latter, though still remaining within normal physiological ranges [7, 8].

Analysis of fetal biometric parameters at 18–22 and 30–34 weeks of gestation revealed no significant differences in mean values of biparietal diameter, occipitofrontal diameter, head circumference, abdominal circumference, and femur length when compared to regional fetal growth standards [9, 10]. These findings underscore the importance of using region-specific reference norms for ultrasound assessment of fetal growth [11, 12]. Sex-based comparison demonstrated significantly larger mean biometric measurements in male fetuses, consistent with data from the population-based prospective birth cohort study (2016), which confirmed that from the second trimester onward, head circumference and abdominal circumference were consistently greater in male fetuses than in female [13].

The highest growth rates were observed for femur length and abdominal circumference, while the lowest rates were recorded for occipitofrontal diameter and head circumference. The difference between the highest and lowest values was 11.8%. These findings support our data demonstrating that "...the segments of the free lower extremity (thigh and shin) show maximal longitudinal growth during the intermediate fetal period" [14]. Growth patterns also differed significantly between sexes, corroborating findings by Z.A. Broere-Brown et al. that in singleton pregnancies, male fetuses exhibit distinct growth dynamics compared to females [13].

CONCLUSION

1. During first-trimester screening, crown-rump length and nuchal translucency measurements in IVF-conceived fetuses were within normal reference ranges.

2. Second- and third-trimester evaluations demonstrated that biparietal diameter, occipitofrontal diameter, head circumference, abdominal circumference, and femur length in IVF pregnancies conformed to both standard norms and regional nomograms. Sex-based comparisons revealed systematically larger biometric values in male fetuses.

3. Fetal biometry revealed non-uniform growth across all studied parameters from intermediate to late fetal periods, with sex-specific growth rate variations characteristic of IVF-conceived fetuses.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

Competing interests. The authors declare that they have no competing interests.

Funding source. This study was not supported by any external sources of funding.

Consent for publication. Written consent was obtained from the patient for publication of relevant medical information within the manuscript.

ДОПОЛНИТЕЛЬНАЯ ИНФОРМАЦИЯ

Вклад авторов. Все авторы внесли существенный вклад в разработку концепции, проведение исследования и подготовку статьи, прочли и одобрили финальную версию перед публикацией.

Конфликт интересов. Авторы декларируют отсутствие явных и потенциальных конфликтов интересов, связанных с публикацией настоящей статьи.

Источник финансирования. Авторы заявляют об отсутствии внешнего финансирования при проведении исследования.

Информированное согласие на публикацию. Авторы получили письменное согласие пациентов на публикацию медицинских данных.

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