ORIGINAL ARTICLE

ASSOCIATION BETWEEN PLACENTAL MORPHOMETRIC PARAMETERS AND BIRTH WEIGHT IN DICHORIONIC DIAMNIOTIC TWINS

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ABSTRACT

The aim: To assess morphometric parameters of placentas and to evaluate the correlation between the placental disk shape, the site of the umbilical cord insertion and the birth weight of dichorionic twins.

Materials and methods: The geometry of placentas, distances between umbilical cord insertion sites and the centroids of the disks were measured in 135 pairs of dichorionic diamniotic twins. The impact of the above-mentioned parameters on the birth weight and placental mass was analyzed.

Results: In terms of weight and geometric parameters of placentas, no proven discrepancy between different types of twins and inside pairs was found. A strong correlation was established between the placental weight and birth weight ($r = 0.71$, $p < 0.05$). Both the placental weight and birth weight showed the strong correlation with S*Circ ($r = 0.62$, $p < 0.05$). The displacement of the umbilical cord insertion site from the centroid of the placenta was negatively correlated with its mass ($r = -0.428$, $p < 0.0001$) and birth weight ($r = -0.6115$, $p < 0.0001$). The displacement along the maximum axis proved to play a significant role.

Conclusions: In dichorionic diamniotic twins, the area of the placentas plays the determining role in the functional activity of the organ, which increases when its shape approaches the circle. The area of the placenta multiplied by its circularity had the strongest correlation with birth weight and placental mass. The farther from the centre the umbilical cord is inserted, the lower the functional capacity of the placenta is.

KEY WORDS: birth weight, placental mass, dichorionic diamniotic twins, umbilical cord insertion

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INTRODUCTION

Multiple pregnancies are associated with an essentially higher risk of perinatal complications compared to singleton pregnancies: stillbirth, neonatal death and morbidity, preterm delivery, foetal growth restriction and congenital disorders [1–3]. The number of twin pregnancies has increased significantly over the past decades and, taking into account the increasing introduction of assisted reproductive technologies into clinical practice, of course, will continue to grow [4,5]. In terms of obstetric prognosis, dichorionic twins look better than monochorionic, but foetal birth discordance and growth restriction are not uncommon in them too [6,7].

Dichorionic diamniotic (DCDA) twins are unique in that both foetuses develop in the same environment and have the same or similar genetic material. The identification of differences between the fetuses suggests they occur due to the different characteristics of their placentas [1,8]. The gross assessment of placentas has attracted the attention of researchers for many decades. Most of the scientists focus on the evaluation of mass and linear size of the placenta, and the search for a correlation between them and birth weight [9,10]. Following certain standards of evaluation [11], the weight of the placenta and the linear dimensions are determined quite accurately. This cannot be said about determining the area and shape of the placental disk. The latter is usually approximated to the shape of an ellipse and an equation for calculating the area of this geometric figure is used. The symmetry of the placenta is mostly assessed in the same way as the symmetry of an ellipse by dividing the larger axis by the smaller one [1,2]. In our opinion, such calculations give a very approximate result.

It is customary to classify the umbilical cord insertion sites (UCIS) in the placenta as central (more than 90%), eccentric (> 2cm from the placental edge), marginal (7%, < 2 cm from the edge), and velamentous or membranous (1% in singletons) [12Medline, CINAHL, Scopus, Web of Science, ClinicalTrials.gov, and Cochrane Databases were searched in December 2016 (from inception to December 2016]. The last two are considered to be abnormal [13]. The umbilical cord rarely inserts in the very centre of the placental disk. The question remains open to what extent the displacement of the insertion site from the geometric centre of the placenta affects the development of the child.

THE AIM

The objective of this study was to assess morphometric parameters of placentas and to evaluate the correlation between the placental disk shape, the site of the umbilical cord insertion and the birth weight of dichorionic twins.

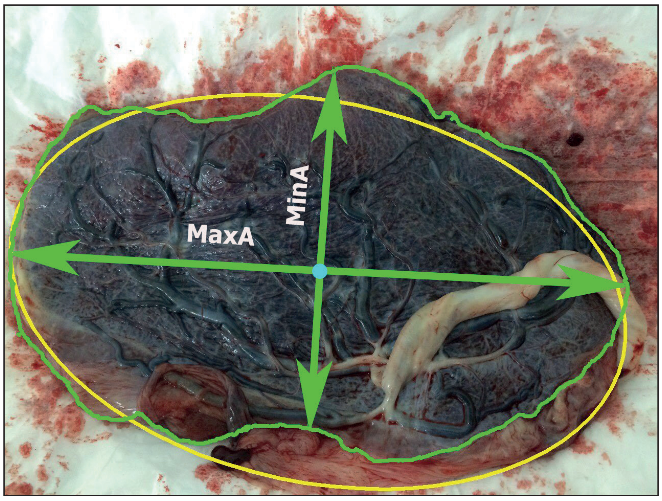

Fig. 1. The outside boundary of the placenta is outlined (green) and the program determined the centroid (●); yellow line – approximation of the shape of the placenta to the ellipse

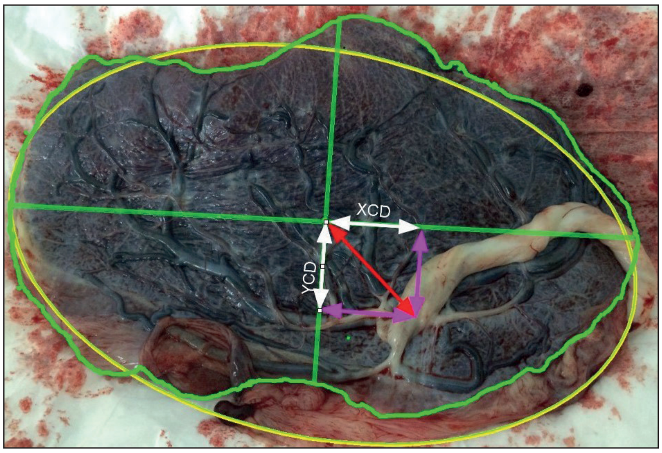

Fig. 3. Measurement of the cord insertion site displacement along the diameters of the placental disk

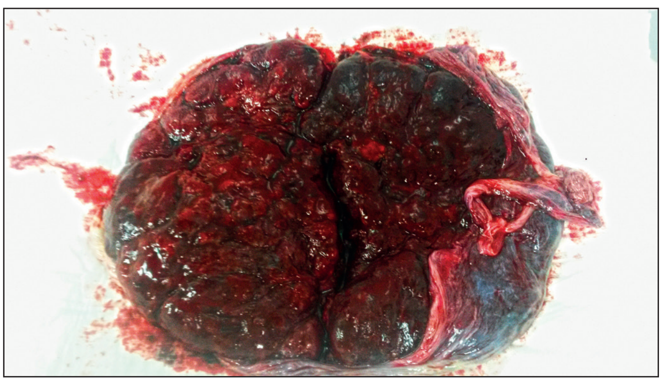

Fig. 5. Partial fusion of two placentas, inter-placental anastomoses were not verified.

MATERIALS AND METHODS

The placentas of 135 pairs of DCDA twins were examined prospectively. Sixty-eight of them were opposite-sex, 32 same-sex females and 35 same-sex males. The gestational age in these groups ranged from 28.5 to 39.5 weeks. Gross examination was performed following a consensus-determined protocol

Fig. 2. Absolute cord displacement measurement (red arrows)

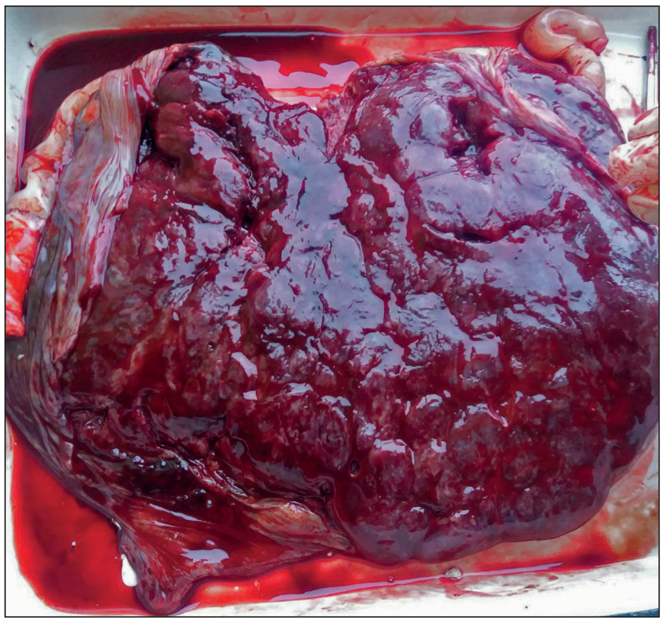

Fig. 4. The fused dichorionic diamniotic opposite-sex twins' placentas that look like one placental mass

developed by the Amsterdam Placental Workshop Group [11]. First of all, the digital pictures of both sides of the horizontally located placental disk were taken by the commercially available digital camera Panasonic DMX LC 15, with the camera located strictly vertically above the object and parallel to it. A ruler or centimetre tape was placed in the area of the upper surface of the placental disk for further calibration of the camera. Further image transformations and measurements were performed using the program ImageJ/Fiji 1.46r, inspired by NIH Image 9 (the latest version can always be obtained from http://imagej.

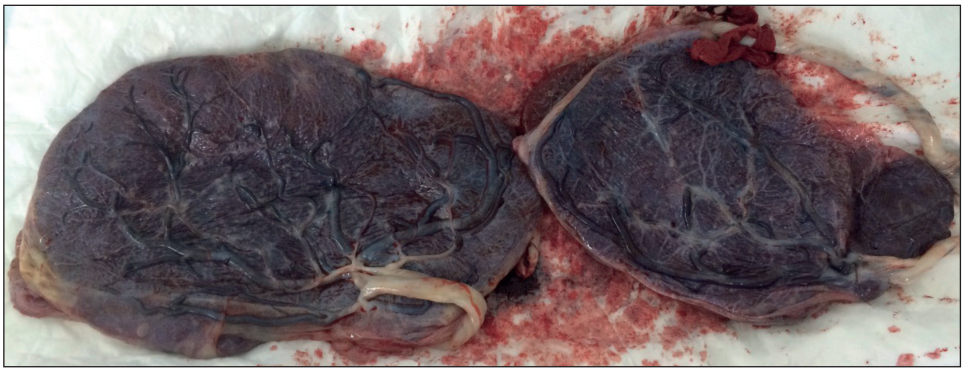

Fig. 6. Marginal cord insertion at the edges of both placentas.

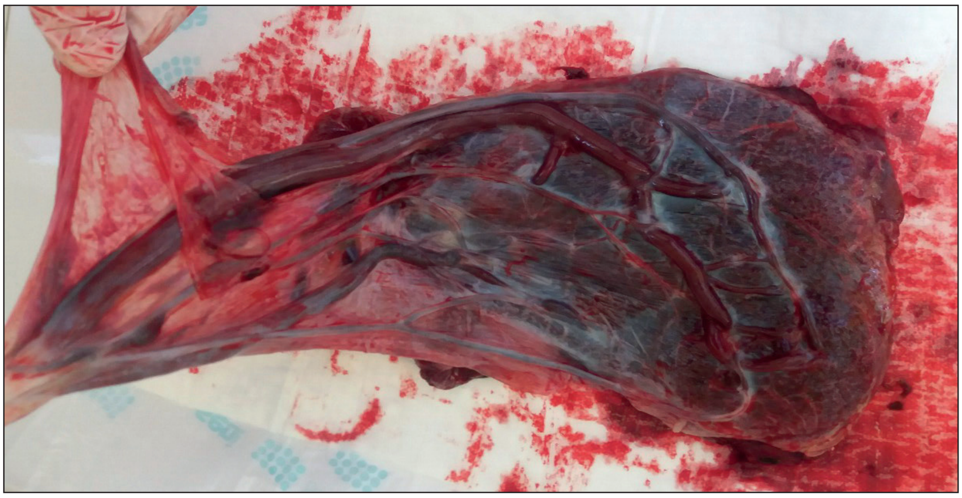

Fig. 7. Velamentous umbilical cord insertion.

nih.gov/ij/docs/guide). After performing line measurements and weighing the placentas, their geometry was assessed. Since the shape of the placentas can differ significantly from the ellipse, their outside boundaries were outlined using the above-mentioned software (Fig. 1). Then their maximum (MaxA) and minimum (MinA) diameters (command Feret's diameter), the ratio of the maximum to the minimum diameter (AR), the area of the placental disk (S), and its perimeter (Perim) were calculated. The program itself determined the coordinates of the centroid – the centre point of a geometric figure. It was manually marked by the dot.

Two shape descriptors were determined. Circularity was calculated as: . The roundness of the placental disk was estimated as: . The closer these indicators are to 1.0, the more round the placenta is. The sense of calculating both indicators is that the circularity largely depends on how smooth the edge of the placenta is, and roundness more accurately characterizes the overall shape of the disk, the ratio of large and small diameters. In the presence of additional lobes of the placenta, its area was determined as the sum of the areas of the main disk and the additional lobules.

The umbilical cord insertion in the disk was assessed visually, and then the distance between this site and the centroid of the disk was measured (Fig. 2). We termed it an absolute cord displacement (ACD).

Then the displacement of the UCIS relative to the maximum (XCD) and minimum (YCD) axes was measured and expressed as a percentage of half the length of the corresponding axis (Fig. 3).

The fused placentas before measurements were carefully separated along the line of the fusion. Birth weight was compared to the geometry of the placental disk and the UCIS. Mothers' weight, height, body mass index (BMI), bad habits and comorbidities were also registered.

Statistical data processing was performed using Statistica 8.0 (Statsoft Inc., USA) and Microsoft Office Excel 2010 statistics. The samples with normal distribution were presented as mean and standard deviation (M ± σ). The samples that do not fit normal distribution were characterised as median (Me), first (Q1) and third (Q3) quartiles and results presented as Me (Q1; Q3). The differences between two normally distributed samples were evaluated by the Student's t-test for independent samples and considered as significant at $p < 0.05$. The difference between two non-normally distributed samples was assessed with the nonparametric Kolmogorov-Smirnov test. The statistical relationship between the continuous variables was evaluated calculating the Pearson's correlation coefficient (r) and estimation of its reliability (p).

All the postpartum women involved in the study gave their informed consent before the investigation.

RESULTS

Maternal age ranged from 19 to 46 years. The mean age was 30.1 ± 5.52 years. Primiparity in women who delivered opposite-sex foetuses took place in 14 (20.6%) cases, in a group of same-sex female twins – in 9 (28.1%) and a group of same-sex male neonates – 12 (35.0%).

Table I. Geometric parameters of the placental disks depending on the type of twins

Indicator	Type of the twins					
	f + m M ± σ		f + f M ± σ		m + m M ± σ	
Number of the twins	68		32		35	
Twins' order	I	II	I	II	I	II
Birth weight (g)	2588.4 ± 471.87	2615.4 ± 478.02	2566.7 ± 510.55	2427.7 ± 620.20	2624.7 ± 392.43	2595.1 ± 492.52
Placental mass (g)	477.2 ± 109.60	482.0 ± 116.66	486.3 ± 109.29	485.8 ± 143.81	483.0 ± 99.59	485.6 ± 113.27
MaxA (cm)	18.6 ± 3.29	19.0 ± 1.73	19.5 ± 2.86	19.4 ± 3.19	19.3 ± 2.14	19.6 ± 2.32
MinA (cm)	13.2 ± 2.45	13.7 ± 2.30	14.3 ± 2.36	14.2 ± 2.34	13.8 ± 2.66	14.5 ± 2.74
AR	1.8 ± 0.53	1.4 ± 0.27	1.4 ± 0.20	1.4 ± 0.19	1.4 ± 0.23	1.4 ± 0.35
S (cm²)	196.0 ± 57.86	206.3 ± 43.46	221.3 ± 57.42	220.2 ± 67.69	212.4 ± 57.51	223.8 ± 53.53
Perim (cm)	55.9 ± 9.21	56.5 ± 5.19	60.3 ± 6.18	58.5 ± 6.22	58.9 ± 5.89	58.8 ± 5.07
Circ	0.787 ± 0.1308	0.804 ± 0.0843	0.751 ± 0.0952	0.790 ± 0.0932	0.758 ± 0.1193	0.802 ± 0.0832
Round	0.734 ± 0.1353	0.725 ± 0.1239	0.740 ± 0.1058	0.737 ± 0.0999	0.713 ± 0.1097	0.748 ± 0.1506
S*Round	144.7 ± 53.15	152.6 ± 48.95	164.6 ± 51.95	162.4 ± 52.46	155.0 ± 57.87	170.9 ± 63.11
S*Circ	155.5 ± 55.03	167.8 ± 46.14	170.0 ± 58.12	1788 ± 73.24	165.3 ± 62.19	182.8 ± 59.90

Table II. The relationship between indicators that characterize the shape of the placenta, and its weight, and the birth weight of the neonates

Indicators	Weight of the placenta		Birth weight	
	r	p	r	p
MaxA	0.47	< 0.05	0.41	< 0.05
MinA	0.47	< 0.05	0.38	< 0.05
S	0.57	< 0.05	0.49	< 0.05
AR	-0.02	> 0.05	0.02	> 0.05
Perim	0.42	< 0.05	0.26	< 0.05
Circ	0.39	< 0.05	0.51	< 0.05
Round	0.13	< 0.05	0.12	< 0.05
S*Round	0.50	< 0.05	0.47	< 0.05
S*Circ	0.62	< 0.05	0.64	< 0.05

There was no statistically significant difference in anthropometric indicators (height, body weight, BMI), the presence of comorbidities (diabetes, hypertension, preeclampsia and eclampsia) and bad habits (smoking, drug use) between mothers of different groups of twins during pregnancy. The percentage of vaginal delivery in the studied groups also did not differ. The median bodyweight of primiparous women was 78.0 (Q_1 – 72.0; Q_3 – 94.0) kg. It had no statistical difference from that of multiparous women – 78.0 (Q_1 – 72.5; Q_3 – 86.5) kg, Kolmogorov-Smirnov Test $p > 0.10$. The same situation was with BMI (29.7 ± 5.17 kg/m² and 29.3 ± 4.25 kg/m² respectively, $p = 0.6592$). Mean gestational age was 36.4 ± 1.74 weeks.

The mean birth weight of the neonates was 2579.1 ± 490.17 g. The comparison with international standards for assessing neonatal growth [14] revealed 25 (9.3%) newborns that were small for gestational age.

Among the entire sample, the average morphometric parameters of the placentas were as follows: surface area – 210.2 ± 55.66 cm², MaxA – 19.1 ± 2.63 cm, MinA – 13.8 ± 2.48 cm, AR – 1.5 ± 0.39. The placental weight of I and II babies in same-sex female couples, same-sex male couples and opposite-sex couples did not differ significantly ($p = 0.9891$; $p = 0.9196$ and $p = 0.8066$ respectively). Geometric parameters of placental disks demonstrate no essential difference between different types of twins (Table I).

Inside pairs, no difference between the studied indicators of the first and second foetuses, except for a significantly larger AR in the placentas of the first foetuses of the opposite-sex twins compared with placentas of the second foetuses ($p < 0.0001$) was found. The placental areas of the I opposite-sex twins were smaller than the placental area of the II foetuses of the same-sex male couples ($p = 0.0200$). The perimeters of the I opposite-sex twins' placentas were less than the perimeters of the placentas of the I same-sex female couples ($p = 0.0170$) as well as the II opposite-sex twins' placental perimeters were smaller than perimeters of the I same-sex female couples ($p = 0.0022$). The circularity of the placentas in I female same-sex was lower than that of II from same-sex male twins ($p = 0.0210$).

The indicator S*Round of the placentas of I foetuses of opposite-sex twins was also significantly lower than the similar index of II foetuses of male same-sex twins ($p = 0.0249$). The circularity of the placentas in I female same-sex placentas was lower than that of II new-borns from same-sex male twins ($p = 0.0210$).

A strong correlation was observed between the placental weight and the newborn birth weight ($r = 0.71$, $p < 0.05$). Both the weight of the placentas and the birth weight of newborn infants correlated with almost all investigated indicators of the disk shape, excluding the AR. The strongest, however, was the association with the S*Circ (Table II). A moderate correlation was found between S of the placental disks and another, proposed by us, index – S*Round.

Eccentric placentas have lesser surface area insofar as Circ showed a significant positive correlation with the area ($r = 0.4671$, $p < 0.0001$).

In the group we examined, the number of fused placentas (Fig. 4) corresponded to the results of other studies and was 59 (43.7%) cases: among 68 opposite-sex couples – 29 (42.6%), among male-male pairs – 17 (48.6%), same-sex female pairs – 13 (40.6%).

During the blunt separation, which in the majority of cases was easily done, no vascular interplacental anastomoses were found (Fig. 5).

The average mass of two separate placentas (547.5 ± 86.74) exceeded the average mass of fused placentas (398.4 ± 87.34, $p < 0.0001$). This indicates that chorionic disks implanting close to each other lead to their early fusion and serious limitation of the development.

Sometimes the UCIS almost coincided with the centroid of the placental disk. However, this was not common. In most cases, the umbilical cord was fixed eccentrically. In the group with abnormal placental cord insertion (PCI), there were included all cases of velamentous and marginal (< 2 cm from the edge) insertion. Totally 32 pairs (23.7% of 135 examined DCDA couples) were included. In 24 pairs one placenta had abnormal PCI, in the other 8 couples, both placentas had abnormal PCI (Fig. 6). Out of the whole abnormal PCI group, there were 16 (23.5%) opposite-sex couples, 8 females (25.0%) same-sex couples and 8 (22.9%) same-sex male couples. This means that difference in frequency of abnormal PCI was not statistically significant ($p > 0.1$), but exceeds the frequency of abnormal PCI in singleton pregnancies [12Medline, CINAHL, Scopus, Web of Science, ClinicalTrials.gov, and Cochrane Databases were searched in December 2016 (from inception to December 2016].

Velamentous cord insertion was detected in 9 (6.7%) placentas. One of the cords inserted into the membranes 5-7 cm from the disk (Fig. 7). In this situation, vessels were not protected by Wharton's jelly.

There was no correlation between the age of women and the degree of eccentricity of umbilical cord insertion, which is displayed by ACD ($p = -0.0342$, $p > 0.05$), as well as no relationship, was found between UCIS and the number of deliveries in anamnesis, weight gain during pregnancy, smoking and gender of the children.

Sometimes the site of cord insertion almost coincided with the centroid of the placental disk. The displacement of the UCIS from the centroid of the placenta was negatively correlated with its mass ($r = -0.428$, $p < 0.0001$). A strong reverse correlation was found between the foetal BW and ACD ($r = -0.6115$, $p < 0.0001$). It turned out that the PM and foetuses' BW depend not only on the absolute displacement of the UCIS but also on the direction of this displacement. The study of the UCIS displacement from the centroid along the maximum and minimum axes of the placental disk, expressed as a percentage of the length of the corresponding semiaxis, showed a stronger correlation between BW and the distance along the maximum axis ($r = -0.7131$, $p < 0.0001$) than along the minimum one ($r = -0.2981$, $p < 0.0001$). A similar situation takes place between the displacement of the insertion site of the umbilical cord from the centroid and the mass of the placenta, but with a slightly weaker correlation (PM vs. XCD correlation: $r = -0.5027$, $p < 0.0001$; PM vs. YCD correlation: $r = -0.2942$, $p < 0.0001$). The figures demonstrate that the distance from the place of umbilical cord insertion in the placental disk along the maximum diameter of the latter was of greater importance. There is a weak negative correlation between ACD and placental disk circularity ($r = -0.315950$, $p < 0.0001$) and a moderate connection between XCD and circularity of the placenta ($r = -0.408214$, $p < 0.0001$).

DISCUSSION

When conducting this study, more accurate objective data were obtained on the relationship between the geometric shape of the placental disk and the site of the umbilical cord insertion in it with the foetuses' BW of the different types of the DCDA twins, as well as the weight of the placenta itself. The high degree of association between the mass of the placenta and the weight of the foetus at birth with the parameter we proposed – the area of the placenta multiplied by the indicator of its circularity – demonstrates that the larger the contact area of the placental disk with the uterine wall, the better the supply of nutrients and oxygen diffusion to the foetus. It can be assumed that the conditions of haemocirculation are better in the placentas, which have a round shape.

In the investigated group, 43.7% placentas were fused. This data corresponds to different publications that approximately in half DCDA twins the placentas fuse [8,14,15] The fusion of two placentas may cause their asymmetrical growth. We consider this as one of the factors contributing to the insertion of the umbilical cord not in the central part of the placental disk. The asymmetric fusion causes the placenta to occupy different areas, which may result in a discordant growth of the foetuses.

The greater weight of new-borns with placentas having central UCIS indicates that the displacement of the fixation point to the periphery leads to deterioration in the functional capacity of the placenta. Placentas with a non-central cord insertion, even though having round shape, demonstrate less metabolically effective vasculature. Our data show that the displacement along the greater axis of the placenta has a more pronounced effect on the PM and the BW than the displacement along the smallest axis. In our opinion, this occurs due to a significantly greater elongation of the placental vessels to reach the distant pole of the disk.

CONCLUSIONS

The correlation of the birth weight (r = 0.49,) as well as the placental mass (r = 0.57) with the placental area, indicates the determining role of the size of the contact zone with the uterine wall on the functional activity of the organ.

A moderate correlation between the birth weight and placental circularity (r = 0.51) indicates that its functional activity increases when the shape approaches the circle.

For a more accurate assessment of the functional suitability of the placenta, it is necessary to simultaneously assess its area and circularity, which means to calculate S*Circ (r = 0.64).

Placentas with a non-central umbilical cord insertion demonstrate less metabolically effective vasculature. The distance by which the insertion site of the umbilical cord is displaced along the maximum diameter of the placental disk is of greater importance.

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The Authors declare no conflict of interest.

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