

INFLUENCE OF THE PLACENTAL CORD INSERTION SITE ON THE PLACENTAL MASS AND THE BIRTH WEIGHT IN DICHORIONIC DIAMNIOTIC TWINS

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Abstract

The aim of the study was to determine the effect of the displacement of the umbilical cord insertion site from the centre of the placenta on the placental mass and the birth weight of dichorionic diamniotic twins and to consider the importance of the direction of the displacement, as well as to assess the influence of the umbilical cord displacement on the placental mass and the birth weight of dichorionic diamniotic twins taking into account the direction of displacement.

Material and methods. The study was performed on 135 dichorionic diamniotic pairs: 68 opposite-sex, 35 same-sex males, and 32 same-sex females. The impact of an absolute cord displacement from the centroid of the placental disc and the direction of its shifting were compared with the birth weight and the placental mass.

Results. In the investigated group, a central insertion was revealed in 6 (2.2 %), eccentric – in 224 (83.0 %), marginal – in 31 (11.5 %), and velamentous – in 9 (3.3 %) cases. The first two types of cord insertion are considered to be normal, the third and the fourth are seen as abnormal. The placental mass was in a strong positive correlation with the birth weight ($r = 0.71, p < 0.0001$). The placentas with an eccentric cord insertion had a smaller surface area. A negative correlation was established between the displacement of the cord insertion site and the placental mass ($r = -0.4284, p < 0.0001$) as well as the birth weight ($r = -0.6115, p < 0.0001$). The shift along the long axis was of greater importance than in relation to the shorter one. The placental mass and the birth weight were higher in the new-borns with a normal cord insertion site. In the abnormal cord insertion group, 32.5 % of the infants were under the 10th birth weight percentile, in the normal cord insertion group – only 8.3 %.

Conclusions. The birth weight of dichorionic diamniotic twins and their placental mass are negatively correlated with the distance of the umbilical cord insertion site from the placental centre. The insertion site displacement along the long axis has a stronger negative effect on the birth weight and the placental mass in comparison with the shifting along the short axis. The placentas with an eccentric cord insertion have a smaller surface area.

Keywords: dichorionic diamniotic twins, placenta, placental cord insertion site, small for gestational age, new-borns' birth weight.

DOI: 10.21303/2504-5679.2021.001843

1. Introduction

The increase in multiple births is an important public health issue because of its large socio-economic, physical, and psychological impact [1].

Macroscopic assessment of placentas has been carried out by scientists over decades [2]. The growth of the placenta is directly related to its functional efficiency as the only fetal source of both nutrients and oxygen [3]. A small placental size and select features of uteroplacental malperfusion are more common in small for gestational age (SGA) neonates [4]. Gross examination of the placenta is a simple and available method that does not entail any significant costs. It is very important for accurate analysis of interrelationship between the mother and fetuses to use standardized criteria for macroscopic examination of placenta [5].

The genetic, physiological, and metabolic factors of the mother equally affect both dichorionic twins. Thus, the study of twins' placentas could reveal other factors that affect the birth weight (BW) and duration of the gestation in order to develop the criteria for improvement of fetal growth restriction screening [2, 6]. Although in the gross study of the placentas, more attention was always paid to their size and mass [7, 8], the details of the placental cord insertion (PCI) also found their place in publications [9]. Various studies have shown that abnormal PCI is associated with a low birth weight, an increased risk of placental complications, perinatal mortality, premature birth, and complications of the third stage of labour [10]. Thus, routine identification of the placental cord

insertion site should be considered [11]. In recent years, there has been an increase in the occurrence of these placental abnormalities [12]. It is considered that the non-central placental cord insertion site (PCIS) modifies the functional capacity of the placenta due to the sparse distribution of chorionic vessels [9, 13]. The popular classification of the umbilical cord insertion site includes four types: central, eccentric, marginal (MCI), and velamentous (VCI), or membranous [13]. From our point of view, the classification has several disadvantages. The umbilical cord insertion right in the centre of the placental disc is an extremely rare finding. Therefore, it would be more convenient to define the round area in the placental disc centre, within which the fixation of the umbilical cord can be considered central. In most studies, this area is not specified [13, 14]. Among found publications, only S. Brouillet et al. [15] indicated that cord fixation within 3 cm from the centre of the placenta was considered as central. There is also a disagreement in the definition of a marginal umbilical cord insertion. In the literature, three values are given – ≤ 3 cm [16], < 2 cm [13] and < 1 cm [14].

In a recent study, published in 2020, on an improved technique of placental evaluation using digital photography, the authors measured the distance from the insertion point to the margin of the disc and the length of its long and short axes. The PCIS was classified into central, eccentric, and marginal based on the ratio of the distance from the insertion point to its closest disc margin to the average length of the long and short axes [17].

It remains unclear whether the direction of cord displacement was taken into account.

The aim of the study was to assess the influence of the umbilical cord displacement on the placental mass and the birth weight of dichorionic diamniotic twins considering the direction of the displacement.

2. Materials and methods

In the study, that was performed in the Department of Obstetrics and Gynecology No. 1 of Shupyk National Healthcare University of Ukraine on the basis of the Kyiv Regional Perinatal Centre in 2017–2021, were involved 135 dichorionic diamniotic (DCDA) pairs of twins. Among them, 68 pairs were opposite-sex, 35 – same-sex males and 32 – same-sex females.

This study was approved by the Ethics Committee of Shupyk National Healthcare University of Ukraine on 6th November, 2017, Ref. Nr. 9.

The pregnant women involved in the study signed an informed consent to participate in it. All potential benefits and possible risks, associated with participation in the study, as well as the ability to withdraw from it at any time were explained to them. One copy of the consent was provided to the patient. The study design complies with the Helsinki Declaration.

The assessment of the PCIS influence on the placental mass (PM) and the birth weight (BW) was included in the gross study of the placentas. The fetal-side images were taken using digital camera Panasonic DMX LC 15, which was located strictly vertically above and parallel to the object. To calibrate the camera, photographing was performed with a ruler located in the disc fetal side plane. As well as in our previous studies [18], further image processing was performed using the ImageJ/Fiji 1.46r software package (<http://imagej.nih.gov/ij/docs/guide>). The placenta is usually irregular in shape. Comparing it with a circle or an ellipse immediately introduces an error in the measurements. Thus, the question arises where the centre of this irregular geometric figure is. After manually tracing the outer contours of the placenta, the program calculates the coordinates of the centroid, which is the centre point of the selection. This is the average of the X and Y coordinates of all pixels in a selection. This place was marked with a dot. Absolute cord displacement (ACD) from the centroid of the placental disc was measured as the planar distance between them. Then, using the above-mentioned software the maximum diameter of the placental disc (MaxA) (command Feret's diameter) was determined. It served as the X-axis. The placental breadth or minimum diameter (MinA) was measured as the longest diameter on the perpendicular Y-axis. The Y-axis is not always at the midpoint of the major one. Not in all cases the centroid is located on the indicated axes. To clarify the question of whether the vector of the insertion site displacement matters, the differences in its coordinates and the coordinates of the centroid on the X- and Y-axes were determined. Projections of the site displacement on the X-axis (XCD) and the Y-axis (YCD) were measured in centimeters and presented as a percentage of half the length of the corresponding axis (**Fig. 1**).

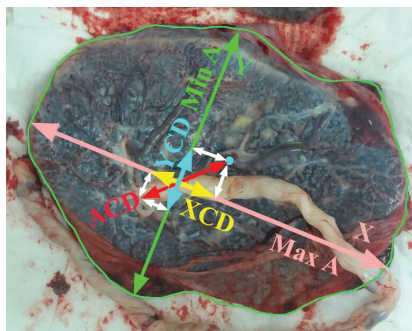


Fig. 1. Measurement of cord displacement along the diameters of the placental disc. Green line – the outside boundary of the placenta; ● – centroid of the placental disc; \longleftrightarrow – absolute cord displacement (ACD); \longleftrightarrow – maximum diameter of the placental disc (MaxA); \longleftrightarrow – minimum diameter of the placental disc (MinA); \longleftrightarrow – projections of the site displacement on the X-axis (XCD); \longleftrightarrow – projections of the site displacement on the Y-axis (YCD)

The area and the perimeter of the fetal side of the placental disc were calculated by the software. The placentas and new-borns were weighed and the correlation between the eccentricity of the PCIS and the PM as well as the new-borns' BW and the placental area were determined.

The neonates were classified as small for gestational age (SGA), appropriate for gestational age (AGA), and large for gestational age according to international standards for assessing birth weight based on gestational age and fetal gender [19].

Statistical analysis was performed using the software Statistica 8 (Statsoft Inc., Tulsa, USA). Normally distributed samples were presented as mean and standard deviation ($M \pm \sigma$). The Pearson's correlation coefficient (r) was calculated to measure the strength of a linear association between two variables. Comparison of the means of three or more groups was made by analysis of variance (ANOVA). When the data were not normally distributed, the samples were characterised by median (Me), first (Q1) and third (Q3) quartiles and the results were presented as Me (Q1; Q3). The differences between two normally distributed samples were evaluated by a Student's t-test for independent samples, two non-normally distributed samples – with the nonparametric Kolmogorov-Smirnov test. The statistical significance was established at $p < 0.05$.

3. Results

The gross examination of the DCDA twins' placentas revealed an insertion in the actual centre of the disc only in three cases (1.1 %). We have accepted for ourselves that an insertion at a distance of no more than 1 cm from the centroid is central. We considered insertions of < 2 cm from the edge as marginal ones. Thus, in the examined group, a central insertion was revealed in 6 (2.2 %), eccentric – in 224 (83.0 %), MCI – in 31 (11.5 %), and VCI – in 9 (3.3 %) cases. We defined the first two types of cord insertion as a normal placental cord insertion (NPCI), the third and the fourth – as an abnormal placental cord insertion (APCI).

No associations were discovered between the degree of the PCIS displacement, characterized by ACD, and mothers' age ($r = -0.0342$, $p = 0.6933$), the gravidity, weight gain during pregnancy, bad habits and gender of the new-borns.

The PM was in a strong positive correlation with the BW ($r = 0.7059$, $p < 0.0001$). No proven discrepancy was found between different types of the DCDA twin pairs and inside the pairs in the BW, PM, placental S, ACD and XCD (**Table 1**). The difference of YCD between groups was the only statistically significant one.

The placentas with an eccentric cord insertion had a smaller surface area since there was a weak negative correlation between ACD and XCD with the placental area. ($r = -0.2068$, $p = 0.0006$ and $r = -0.2471$, $p = 0.00004$ respectively). No relation between these indicators and the placental perimeter was found.

Table 1
Morphometric indicators of the placentas in different types of dichorionic diamniotic twins

No.	Indicator	Type of the twins					
		f+m M±σ		f+f M±σ		m+m M±σ	
		68		32		35	
Number of the twins							
Twins' order	I	II	I	II	I	II	
1	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
2	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
3	ACD (cm)	4.9±2.28	5.7±2.13	5.5±2.96	5.4±2.25	4.7±2.09	5.3±1.77
4	XC (%)	44.4±28.86	44.6±21.20	43.9±29.94	46.3±29.28	41.5±26.28	40.8±21.68
5	YCD* (%)	34.5±23.10*	50.4±26.50*	46.4±23.91*	46.4±21.10*	31.8±20.76*	51.0±19.94*
6	S (cm ²)	196.0±57.86	206.3±43.46	221.3±57.42	220.2±67.69	212.4±57.51	223.8±53.53

Note: * – $p = 0.00003$, ANOVA of YCD for all groups

A moderate negative correlation was established between the displacements of the PCIS and the placental mass (**Fig. 2**).

The BW was also in an inverse, even stronger, correlation with the ACD (**Fig. 3**).

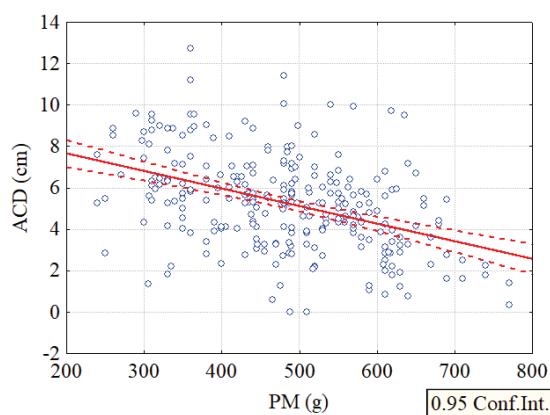


Fig. 2. Correlation between the placental mass (PM) and the absolute cord displacement (ACD) from the centroid. $ACD = 9.3 - 0.0085 \cdot PM$; Correlation: $r = -0.4284$, $p < 0.0001$

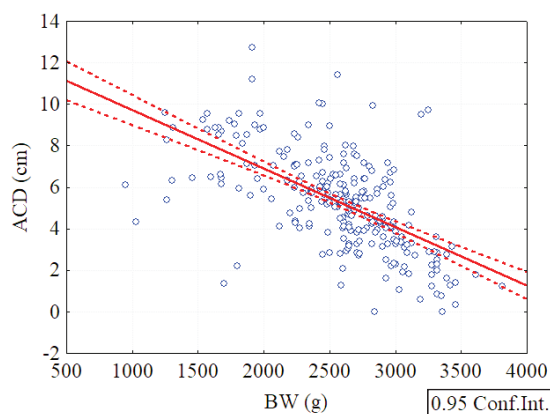


Fig. 3. Correlation between the birth weight (BW) and the absolute cord displacement (ACD) from the centroid; $ACD = 12.5 - 0.0028 \cdot BW$. Correlation: $r = -0.6115$, $p < 0.0001$

The study of the influence of the direction of the PCIS displacement on the BW showed that the shift along the long axis of the placental disc (**Fig. 4**) is much more important than the displacement in relation to the smaller axis of the latter (**Fig. 5**). A similar situation was observed with respect to the mass of the placentas. It was also more influenced by the displacement along the long axis of the placenta (**Fig. 6**) than along the short one (**Fig. 7**).

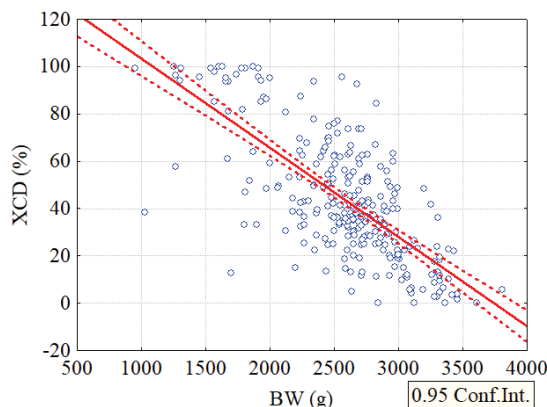


Fig. 4. Correlation between the birth weight (BW) and the displacement of the umbilical cord insertion site along the maximum diameter (XCD) of the placenta $XCD = 141.0 - 0.0377 \cdot BW$.
Correlation: $r = -0.7131$, $p < 0.0001$

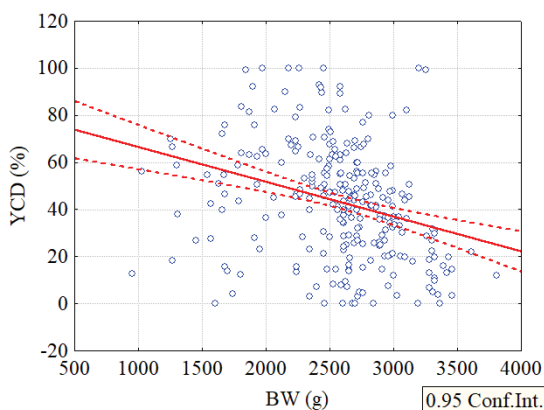


Fig. 5. Correlation between the birth weight (BW) and the displacement of the umbilical cord insertion site along the minimum diameter (YCD) of the placenta $YCD = 81.196 - 0.0148 \cdot BW$.
Correlation: $r = -0.2981$, $p < 0.0001$

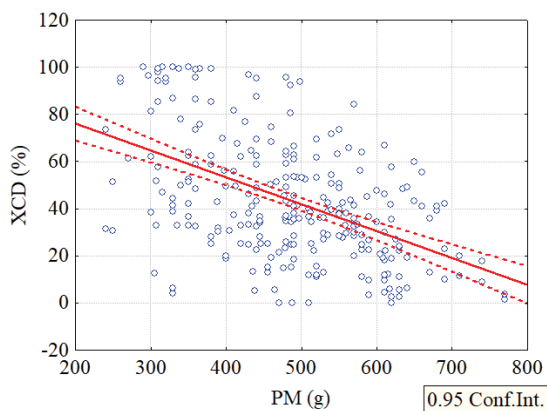


Fig. 6. Correlation between the placental mass (PM) and the displacement of the umbilical cord insertion site along the maximum diameter (XCD) of the placenta $XCD = 98.811 - 0.1141 \cdot PM$.
Correlation: $r = -0.5027$, $p < 0.0001$

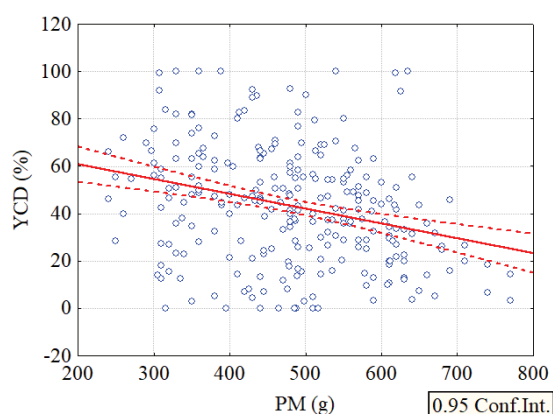


Fig. 7. Correlation between the placental mass (PM) and the displacement of the umbilical cord insertion site along the minimum diameter (YCD) of the placenta $YCD = 73.293 - 0.0626 \cdot PM$.
Correlation: $r = -0.2942$, $p < 0.0001$

However, the strength of the correlation was weaker than the effect on the birth weight.

The comparison of the PM and the BW showed their significantly higher values in the groups with NPCI than with APCI (**Table 2**). Since the samples do not follow a normal distribution, nonparametric statistics are used.

Table 2

The comparison of the birth weight and the placental mass in the groups of normal and abnormal placental cord insertion

Indicators	Neonates' birth weight Me (Q ₁ ; Q ₃) (g)	Placental mass Me (Q ₁ ; Q ₃) (g)
NPCI, $n = 230$	2690.0 (2500.0; 2930.0)	490.0 (433.0; 580.0)
APCI, $n = 40$	1810.0 (1615.0; 2165.0)	333.5 (310.0; 433.0)
p -value (Kolmogorov-Smirnov test)	$p < 0.001$	$p < 0.001$

Among the 135 DCDA twins (270 fetuses), whose placentas were macroscopically examined, there were 32 (11.9 %) SGA and 7 (2.6 %) LGA new-borns. In general, 13 (32.5 %) infants in the APCI group were under the 10th percentile: three of the 9 fetuses with the VCI (33.3 %) and 10 (32.3 %) of 31 neonates with MCI. Significantly lower ($p < 0.01$) prevalence of growth restriction was determined for gestational age in the NPCI group – 19 (8.3 %) cases.

4. Discussion

In the examined group, the frequency of a marginal and a velamentous PCI (11.5 % and 3.3 %, respectively) is quite comparable with the results obtained by the group of Rasmussen for twins (10.9 % and 6 %, respectively) [20].

In contrast to the results, obtained by S. Brouillet et al. [15], the frequency of a central fixation of the umbilical cord was significantly lower in the examined group (2.2 %). This is not surprising as the frequency of central insertion directly depends on the criterion that was used. So, in a study by the French authors [15], it is indicated that the PCIS in a distance of up to 3 cm from the disc centre was defined as central. However, in the cohort of the placentas we examined, there were some having widths of about 9 cm. This means that half of the width was 4.5 cm. Simple arithmetic calculations show that 3 cm from the centre plus 2 cm from the edge (the zone of a marginal insertion) in total will give 5 cm. This is more than half of the placental width, there is no room for an eccentric fixation. So, we chose the distance from the centre within 1 cm. With similar calculations for a paracentral/eccentric insertion of the umbilical cord, a strip with a width of 1.5 cm remains.

We have found negative correlations between the absolute cord displacement and the newborns' BW and their PM. It means a stronger eccentricity of PCI, a lower weight of the newborns and their placentas. In this, the results obtained differ from the data of other researchers. Thus, G. Ravikumar et al. [14] did not reveal a correlation of the BW, PM or placental efficiency with the proposed cord centrality index – a distance of PCI from the centre/half of the longest diameter of the placenta. They even did not find the difference in this indicator between small for gestational age and appropriate for gestational age babies. Similar results were obtained by Haeussner et al. [21] who reported that eccentric cord insertion did not necessarily compromise efficiency of the normal human placenta.

In an earlier study by M. Yampolsky et al. [9], a strong direct correlation was found between an eccentric fixation of the umbilical cord and the placental mass. The authors regard this as a result of a decrease in the metabolic efficiency of the organ. On their opinion, these placentas grew heavier than normal to prevent underdevelopment of the fetuses. In publication of Kowsalya et al. [22] it was demonstrated that the cord insertion was more often eccentric or marginal in the group of infants with low birth weight.

We explain a greater influence of the displacement of the PCIS along the longer axis of the placenta on its mass and the BW by a significantly greater lengthening of its vessels to reach the distant pole of the disc. We have not found similar investigations yet.

Regarding an increase in the frequency of fetal growth restriction in the group of APCI, we obtained results close to the results of a group of authors from Grenoble University [15], with the difference that in our group the frequency of SGA was higher.

Study limitations. The tracing of the chorionic tree vasculature or microvasculature of the placentas to observe their relation to cord insertion were not performed.

Prospects for further research. The obtained results confirm that the peripheral PCIS should warn obstetricians of a higher risk of fetal growth restriction and a possibility of serious adverse perinatal and adult conditions.

Therefore, it is advisable to identify the insertion site of the umbilical cord during prenatal examination. The most suitable method for this is ultrasound scanning. With advancing gestation, visualisation of PCIS becomes more complicated. Further investigations are planned to improve ultrasound prenatal diagnostic approaches.

5. Conclusions

In dichorionic diamniotic twins, the birth weight is in a strong inverse relation to the distance of the umbilical cord insertion site from the centre of the placental disc ($r = -0.6115, p < 0.0001$), the correlation between the displacement of the insertion site and the mass of the placentas is somewhat weaker ($r = -0.4284, p < 0.0001$).

The displacement of the fixation site along the long axis of the placenta has a stronger negative effect on the birth weight ($r = -0.7131, p < 0.0001$) and the placental mass ($r = -0.5027, p < 0.0001$) in comparison with the shifting along the short axis ($r = -0.2981, p < 0.0001$ and $r = -0.2942, p < 0.0001$ respectively).

The placentas with an eccentric cord insertion had a smaller surface area since there is a weak negative correlation between ACD and XCD with the placental area. ($r = -0.2068, p = 0.0006$ and $r = -0.2471, p < 0.0001$ respectively).

In dichorionic pairs, the placental mass is in a strong positive correlation with the birth weight of the neonates ($r = 0.71, p < 0.0001$). The placental mass and the neonates' birth weight showed their significantly higher values in the group with a central and a paracentral cord insertion.

Conflict of interests

The authors declare that they have no conflicts of interest.

Financing

None

Acknowledgments

We are grateful to the administration of the Kyiv Regional Perinatal Centre and to the scientific supervisor – Associate professor of the Department of Obstetrics and Gynecology No. 1 of Shupyk National Healthcare University of Ukraine Andrii V. Tkachenko for assistance in organizing and conducting the study.

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Received date 31.05.2021

Accepted date 16.07.2021

Published date 30.07.2021

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How to cite: Tepla, I. (2021). *Influence of the placental cord insertion site on the placental mass and the birth weight in dichorionic diamniotic twins. EUREKA: Health Sciences*, 4, 3–11. doi: <http://doi.org/10.21303/2504-5679.2021.001843>