Original

Assessing the Link between Placental Morphology and Morphometry and Neonatal Features at Term: Insights from a Hospital-Based Study

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Abstract
Background: The placenta serves as a crucial interface between maternal and foetal circulation, undergoing dynamic changes throughout pregnancy to attain optimal structural complexity by term. This study aimed to explore potential correlations between neonatal features (Appearance, Pulse, Grimace, Activity, Respiration - APGAR score, and birth weight) and placental morphology and morphometry at term**.**
Method: Using a hospital-based cross-sectional design and systematic sampling, we meticulously examined and measured 250 placentae post-delivery, while simultaneously recording neonatal features. Descriptive (Mean ± SD and frequency) and Inferential (ANOVA, Chi-square, and Independent t-test) statistical analyses were conducted, with a significance threshold of $p < 0.05$.
Result: Among the 250 placentae analysed, statistically significant associations were discovered between placental shape and birth weight (p=0.026), placental thickness and birth weight (p=0.001), placental weight and birth weight (p=0.001), placental diameter and birth weight (p=0.001), as well as the number of cotyledons and birth weight (p=0.01). Conversely, no substantial relationship was observed between placental parameters and neonatal APGAR scores.
Conclusion: The findings propose that placental morphometry holds potential as a more robust predictor of foetal outcomes compared to morphology. Further comprehensive research is recommended to elucidate the nuanced dynamics of this relationship, providing crucial insights for refining and advancing prenatal care strategies.
Keywords: Placental morphology, placental morphometry, term, neonates.

Introduction
The human placenta, a dynamic interface comprised of maternal and foetal components, orchestrates vital exchanges between maternal and foetal circulatory systems. These exchanges, facilitated by both passive diffusion and active transport mechanisms, are pivotal for sustaining foetal growth and development.[1] As gestation progresses, the placenta undergoes intricate

structural adaptations, intricately intertwined with foetal maturation. Its timely expulsion within approximately 30 minutes following vaginal delivery further emphasizes its dynamic role. A placenta is classified as "Term" when gestation spans from 37 weeks+0 days to 41 weeks+6 days.[2]

Prior research has intriguingly postulated the placenta as a reflective indicator of foetal development, implying that deviations in its architecture might mirror concurrent alterations in foetal progression. However, substantiating this hypothesis necessitates a rigorous inquiry into the nuanced interplay between placental parameters and neonatal outcomes.[2-4]

Characterized by its discoid morphology, the placenta frequently manifests as round or oval; aberrations from this norm have been correlated with diminished birth weight.[5] Similarly, placental weight, typically approximating one-sixth of foetal weight, has been implicated in influencing birth weight variability.[6] Furthermore, placental thickness, averaging around 2cm, has exhibited intriguing associations with maternal conditions, such as Diabetes mellitus and Chorioamnionitis, alongside foetal conditions like Hydrops foetalis.[7] These observations portend potential interventions aimed at safeguarding neonatal well-being and heighten the likelihood of atypical neonatal outcomes, encompassing subdued APGAR scores and birth weight.

In light of these considerations, this study embarked on a comprehensive exploration of the intricate links between neonatal features at term—encompassing Appearance, Pulse, Grimace, Attitude, Respiration (APGAR), and birth weight—and diverse placental parameters. By meticulously unravelling these intricate associations, this research augments our comprehension of potential early indicators of neonatal vitality. Furthermore, it underscores the pivotal role of placental health as a potential predictor of neonatal well-being, shedding light on novel avenues for optimizing neonatal outcomes.

Method

Study Setting

The study was conducted at the maternity units of Rivers State University Teaching Hospital in Port Harcourt City Local Government Area, Obio Cottage Hospital Rumubiakani located in Obio/Akpor Local Government Area, and General Hospital Omoku situated in Ogba/Egbema/Ndoni Local Government Area, all within Rivers State.

Study Design

This study was a hospital based cross sectional study.

Study Population

The population for this study encompassed mothers of/and term neonates delivered in the facilities mentioned below within the period of this study

Sample size and Sampling Technique

The study sample size was derived using the formula for quantitative variables.[8]

$$n = \frac{(Z)^2\,(s)^2}{(e)^2}$$

n = minimum sample size when total population >10,000

Z = percentage of normal distribution corresponding to the 2–sided significance; 95% significance level corresponds to 1.96

s = standard deviation of outcome variable from similar study; standard deviation of placental weight among term neonates in a Nigerian study was 0.084kg.[9]

e = level of precision ± 0.01

$$n = \frac{(1.96)^2\,(0.084)^2}{(0.01)^2} = 271$$

Allowance for non-response of 10% $= \frac{n}{1-non\ response}$

Where n= minimum sample size (271)

Non-response =10% (0.1),

Thus, adjusted sample size = 301

Adjustment for population <10,000 using finite population correction

Adjusted sample size $= \frac{n}{(1+{}^{n}/_{N})}$

Where;

n =sample size determined when total population is > 10,000 =301

N= size of population from which sample is to be selected =1500

Adjusted sample size $= \frac{301}{(1+{}^{301}/_{1500})} = 250$

Hence final sample size of 250 placentae were sampled in the study

Sampling technique: proportionate to size allocation was used to determine the number of parturient to be sampled from each study centre for effective representation. A systematic random sampling method which required a sampling interval was employed. The sampling interval was obtained by dividing the estimated

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number of parturient in the facility over study period of three months by the size of the sample.

Proportionate to size allocation

$$\frac{x_i}{\sum x} X\, n$$

n is sample size (250), x_i = number of term deliveries for 3months data collection period at the facility.

Rivers State University Teaching Hospital (RSUTH) 240 = $\frac{240}{792} X\, 250 = 76$

Obio Cottage 480 = $\frac{480}{792} X\, 250 = 152$

General Hospital Omoku 72 = $\frac{72}{792} X\, 250 = 22$

Sampling interval = $\frac{x_i}{n}$

Rivers State University Teaching Hospital = $\frac{240}{76} = 3.2 \sim 3$

Obio Cottage Hospital = $\frac{480}{152} = 3.2 \sim 3$

General Hospital Omoku = $\frac{72}{22} = 3.3 \sim 3$

The sampling interval of three (3) for each of centre was therefore deduced. Hence, every 3rd term parturient was sampled. The random start was selected by simple random sampling via balloting after which the sampling interval was followed as with systematic random sampling technique

Nature/source of Data: The study involved primary data. Information was collected directly from parturient and the products of conception (foetus and placenta) assessed immediately after delivery.

Method of Data Collection/Instrumentation Samples was collected immediately after delivery, washed under running water and examined for completeness. The attached umbilical cord was cut leaving a stump of about 5cm from its insertion. Relevant maternal medical history was recorded. Sex of the baby was noted, birth weight was checked with a weighing device. APGAR score and other relevant features of the new born were noted. The following features of the placenta were observed and recorded:

1. Shape: by inspection.
2. Number of cotyledons: By inspection and palpation; the placenta was put on a flat tray with the maternal surface facing upwards with a gentle pressure on the centre of the foetal surface to make obvious the cotyledons. Counting was done from one end to the other; the total numbers of cotyledons was recorded.
3. Cord attachment: By inspection and palpation; the placenta was placed on a flat tray with the foetal surface facing upward. The cord attachment was observed and recorded.
4. Thickness: the toothpick method was used.[10] A toothpick was inserted through the placenta and measured at five points on each placenta to the nearest centimetre. Each placenta was placed on a flat tray on the foetal surface and divided arbitrarily into three zones by drawing two circles on the foetal surface. These circles cut the radius of the placenta into three equal parts. One measurement was taken from the middle of the central zone while two measurements were taken from the middle zone and another two from the peripheral zone. The mean of all five measurements were calculated and considered the thickness of the placenta.
5. Weight: after trimming with running water, the placenta was placed on a sensitive weighing scale with readings taken in kilograms.
6. Diameter: the placenta was placed on a flat tray and measured in three planes with a plastic meter rule. The mean of the three planes was considered the diameter of the placenta.

Ethical Considerations: Approval for this study was sought from the Research Ethics Committee of the University of Port Harcourt. Clearance was also sought and approval obtained prior to commencement of the study from Obio Cottage Hospital Rumubiakani and Rivers State Hospitals Management Board.

Written informed consent was obtained from the mothers of the neonates before their inclusion into the study. Participation in the study was voluntary and their non-participation did not alter their medical care or treatment. Anonymity was maintained by using research numbers rather than names. Data obtained was held in confidence in keeping with ethical principles.

Data Analysis: Data analysis was with Statistical Package for Social Sciences (SPSS) version 23. Tables and charts were used for data presentation as appropriate. Categorical variables expressed as frequencies and proportions; and compared for statistical differences using Chi square test. Normally distributed data were summarized using means and standard deviation and parametric tests such as independent t- test employed for determining significant differences. Statistical significance was at p level of less than 0.05.

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Results

Table 1, highlight significant associations between different placental shapes and neonatal birth weight categories. Notably, the majority of neonates with round and oval placental shapes fell within the normal birth weight range (2.5 – 3.9kg), while triangular and irregular shapes were less common and also primarily associated with normal birth weight. Fisher's exact test yielded a statistically significant relationship between placental shape and neonatal birth weight (p = 0.026), underscoring the potential influence of placental architecture on fetal growth.

Table 2 further elucidates the impact of various placental features on neonatal birth weight. The mean thickness, weight, diameter, and number of cotyledons exhibited notable variations across different birth weight categories. Noteworthy is the statistical significance of these relationships (thickness: p = 0.0001, weight: p = 0.0001, diameter: p = 0.0001, cotyledons: p = 0.001), reinforcing the pivotal role of placental attributes in shaping neonatal outcomes.

Table 1: Descriptive statistics, age distribution and parity of mothers (N = 250)

Variables	Frequency	Percentage
Age category		
<20 years	9	3.6
20 – 24 years	20	8.0
25 – 29 years	75	30.0
30 – 34 years	92	36.8
35 – 39 years	51	20.4
≥40 years	3	1.2
Parity		
Para 1	89	35.6
Para 2 – 4	141	56.4
Para ≥5	20	8.0

Table 2: Descriptive statistics and sex distribution of neonates (N = 250)

Sex	Frequency	Percentage
Male	133	53.2
Female	117	46.8
Total	**250**	**100.0**

Table 3: Relationship between Placental shape and birth weight of neonates using chi-square

	Birth weight			
Placental shape	**Low (<2.5Kg) n (%)**	**Normal (2.5 – 3.9Kg) n (%)**	**Macrosomia (≥4.0Kg) n (%)**	**Total n (%)**
Round	1 (0.7)	123 (91.1)	11 (8.1)	135 (100.0)
Oval	2 (1.9)	106 (98.1)	0 (0.0)	108 (100.0)
Triangular	0 (0.0)	4 (100.0)	0 (0.0)	4 (100.0)
Irregular	0 (0.0)	3 (100.0)	0 (0.0)	3 (100.0_
Total	**3 (1.2)**	**236 (94.4)**	**11 (4.4)**	**250 (100.0)**

Fisher's exact test = 14.916; p-value = 0.026* *Statistically significant

Table 4: Comparison of mean of other Placental features with Neonatal birth weights using ANOVA

	Birth weight				
Placental measurements	**Low (<2.5Kg) Mean ± SD**	**Normal (2.5 – 3.9Kg) Mean ± SD**	**Macrosomia (≥4.0Kg) Mean ± SD**	**ANOVA**	**p-value**
Thickness (cm)	1.43±0.25	1.86±0.24	2.39±0.35	29.100	0.0001*
Weight (Kg)	0.43±0.06	0.61±0.13	0.91±0.17	33.352	0.0001*
Diameter (cm)	15.67±2.52	19.80±1.77	22.75±1.98	22.695	0.0001*
Number of cotyledons	17.00±1.00	17.67±1.97	20.00±2.19	7.570	0.001*

*Statistically significant ANOVA – Analysis of variance SD – Standard deviation

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Table 5: Relationship between Placental shape and APGAR score of neonates using chi-square

	APGAR Score		
Placental shape	**subnormal ≤6 n (%)**	**Normal >6 n (%)**	**Total n (%)**
Round	15 (11.1)	120 (88.9)	135 (100.0)
Oval	14 (13.0)	94 (87.0)	108 (100.0)
Triangular	1 (25.0)	3 (75.0)	4 (100.0)
Irregular	2 (66.7)	1 (33.3)	3 (100.0)
Total	**32 (12.8)**	**218 (87.2)**	**250 (100.0)**

Fisher's exact test = 6.953; p-value = 0.053

Table 6: Comparison of mean of other placental features with APGAR scores of neonates using independent t-test

	APGAR score			
Variables	**Subnormal ≤6 Mean ± SD**	**Normal >6 Mean ± SD**	**t test**	**p-value**
Thickness (cm)	1.87±0.38	1.89±0.25	-0.380	0.704
Weight (Kg)	0.65±0.26	0.62±0.12	1.393	0.165
Diameter (cm)	19.73±2.92	19.90±1.76	-0.475	0.635
Number of cotyledons	17.28±1.82	17.83±2.05	-1.449	0.149

SD – Standard deviation

Turning our focus to APGAR scores, Table 3 outlines the distribution of APGAR scores across different placental shapes. While no statistically significant association was found (p = 0.053), intriguing patterns emerge, warranting further exploration. Both round and oval placental shapes were prevalent among neonates with both subnormal and normal APGAR scores.

Delving into the relationship between placental features and APGAR scores (Table 4), we observe nuanced trends. Neonates with subnormal APGAR scores exhibited slightly higher mean placental thickness, weight, and diameter compared to those with normal APGAR scores. However, these differences were not statistically significant (thickness: p = 0.704, weight: p = 0.165, diameter: p = 0.635). Similarly, the mean number of cotyledons did not display a statistically significant association with APGAR scores (p = 0.149), suggesting that other factors may contribute to APGAR outcomes

Discussion

Examining the relationship between placental shape and neonatal birth weight has unveiled intriguing patterns. Notably, among neonates with low birth weight, two-thirds exhibited oval-shaped placentae, with a single instance of a round shape. However, triangular and irregular shapes were conspicuously absent in this category. In contrast, within the cohort of neonates falling within the normal birth weight range (2.5 – 3.9 kg), round-shaped placentae were predominant (123 cases), closely followed by oval-shaped placentae (106 cases). Triangular and irregular shapes were infrequent, represented by four and three instances respectively. Strikingly, all neonates classified as having macrosomia displayed round-shaped placentae. Rigorous statistical analysis, employing the chi-square test, robustly substantiated the significant disparities between various placental shapes and distinct birth weight categories.

Of note is the intriguing departure from the findings of Pathak *et al.,* whose study linked irregular placental shapes to low neonatal birth weight.[5] This discordance could potentially be attributed to the limited representation of low-birth-weight neonates (1.2%) within our study cohort, underscoring the need for cautious interpretation.

Digging deeper, our investigation unearthed a compelling correlation between the number of

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cotyledons and birth weight. Notably, an increase in birth weight correlated positively with a higher cotyledon count within the placenta. This finding resonates with established literature, affirming the functional significance of cotyledons within the placental structure. Such findings find resonance in the work of previous researchers, thereby reinforcing the validity of our observations.[11, 12, & 26]

Moreover, our exploration illuminated a significant link between birth weight and placental morphometry, a correlation consistently corroborated by earlier studies.[6, 13-20] This underscores the pivotal roles played by placental morphometry, morphology, blood flow dynamics, and nutrient transport in guiding foetal growth trajectories, particularly concerning term foetal weight. Central to this relationship is the principle that a larger placental diameter translates to an expanded surface area for efficient material exchange, consequently influencing foetal weight.[21, 22, & 26]

Intriguingly, a meticulous examination of APGAR scores at the first minute of birth in relation to diverse placental shapes (Round, Oval, Triangular, and Irregular) did not yield statistically significant results (Fisher's test = 6.953; p = 0.053). Furthermore, no substantial correlation between the number of cotyledons, placental parameters (thickness, weight, and diameter), and APGAR scores at one minute was unveiled, consistent with similar research findings.[18]

However, as with many facets of placental research, conflicting reports persist regarding the interplay between placental weight and APGAR scores. While some studies suggest an association between heightened placental weight and diminished APGAR scores, others propose a connection between reduced placental birth weight, suboptimal APGAR scores, and instances of foetal distress.[23, 24] These nuanced discrepancies stem from the intricate interplay of variables influencing placental weight and function, encompassing factors such as race, socioeconomic status, and maternal health.[25]

Recommendation: The study emphasizes the importance of thorough placental examinations by obstetricians and paediatricians post-birth, rather than discarding them, to understand maternal and neonatal health better. Early detection and treatment of maternal conditions affecting placental morphology are crucial, requiring vigilant monitoring by healthcare workers. Collaboration between obstetricians and radiologists for in-utero placental monitoring is essential, given its significant correlation with infant weight. Maternal education on antenatal care importance is vital, with a focus on discouraging reliance on unskilled caregivers. The study contributes by establishing reference values for placental parameters in Rivers State and shedding light on maternal health's impact on placental health, emphasizing the need for early intervention. Lastly, it underscores the pivotal role of placental morphology in determining neonatal outcomes, particularly birth weight, in maternal and neonatal healthcare

Strengths and Limitations of the Study
Strengths:

- Sample Size and Data Collection: the sample size ensured a robust dataset for analysis.
- Statistical Rigor: employed appropriate statistical methods such as ANOVA, chi-square tests, and Fisher's exact test to analyse data and identify significant associations between placental characteristics and neonatal outcomes.
- Clinical Implications: the findings offer practical insights for healthcare practitioners, emphasizing the importance of placental examination in maternal and neonatal health management.
- Clear Recommendations: the study provides actionable recommendations for improving prenatal care practices, including the importance of early detection, collaborative monitoring, and maternal education.

Limitations:

- Sampling Bias: While the study examined placentae from multiple hospitals, its focus on Rivers State hospitals may limit the generalizability of the findings to other regions.
- Cross-Sectional Design: The study's cross-sectional nature provides a snapshot of placental morphology and neonatal outcomes at one point, limiting insights into temporal relationships.
- Potential Confounders: Unaccounted factors like maternal health status and environmental influences could impact the observed associations between placental parameters and neonatal outcomes.

Data Depth: While the study identifies associations, it lacks in-depth exploration of underlying mechanisms or causality, leaving potential avenues for further investigation.

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Conclusion

This study provides a deeper understanding of the intricate relationships between placental shape, birth weight, cotyledon count, placental morphometry, and APGAR scores. These findings contribute significantly to the evolving landscape of neonatal outcomes and the multifaceted dynamics of placental function. The intricate web of observations underscores the need for comprehensive research efforts aimed at unravelling the complex factors influencing foetal development and neonatal well-being. Our results shed light on potential avenues for optimizing neonatal health, while simultaneously acknowledging the intricate interplay of numerous variables within this captivating realm. As we traverse the terrain illuminated by this study, doors open to further exploration and longitudinal studies, beckoning us to fully unravel the profound implications of these captivating associations.

Declarations

Ethical consideration: Approval for this study was sought from the Research Ethics Committee of the University of Port Harcourt. Clearance was also sought and approval obtained prior to commencement of the study from Obio Cottage Hospital Rumubiakani and Rivers State Hospitals Management Board.
Written informed consent was obtained from the mothers of the neonates before their inclusion into the study. Participation in the study was voluntary and their non-participation did not alter their medical care or treatment. Anonymity was maintained by using research numbers rather than names. Data obtained was held in confidence in keeping with ethical principles.

Authors' contribution: Emeka-Ogbugo, A (conceptualized the work from inception to completion, data collection, data analysis, writing and editing and financing), Gbobie, D. J (data collection, data analysis, writing and editing), Owhorji, B. (writing and vetting of manuscript), Kua, P. L (Design of Methodology)

Conflict of interest: None

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