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Placental Metrics and Gestational Markers: Predictors of Adverse Perinatal Outcomes and Fetal Growth Restriction

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Abstract

Objective: To evaluate the association between PW, F/P ratio, and gestational age with neonatal birthweight and perinatal outcomes in a mixed-risk obstetric population.

Methods: This analytical cross-sectional study was conducted over six months at the KRL Hospital in Kahuta. A total of 120 pregnant women who attended for antenatal care and/or delivery were enrolled after informed consent was obtained. Maternal demographics, parity, and gestational age were recorded. At delivery, neonatal birthweight and placental weight (after standard trimming) were measured, and the F/P ratio was calculated as birthweight (g)/placental weight (g). Placental weight was categorised as <10th, 10th–90th, and >90th percentiles, and the F/P ratio was categorised as <5 or ≥5. Descriptive statistics were generated, group differences were assessed using the χ^2 test, and correlations between PW and birthweight were examined using Pearson's correlation coefficient (SPSS v26).

Results: Placental weight was strongly associated with birthweight category: low PW (<10th percentile) was present in 45.3% of low-birthweight infants versus 10.2% of normal-birthweight infants ($p < 0.001$), whereas normal PW (10th–90th percentile) was more frequent in the normal-birthweight group (80.5% vs. 52.7%, $p = 0.002$). High PW (>90th percentile) also differed between groups (2.0% vs. 9.3%, $p = 0.03$). An F/P ratio <5 was observed in 48.5% of low-birthweight neonates compared with 12.3% of normal-birthweight neonates ($p < 0.001$); conversely, an F/P ratio ≥5 predominated among normal-birthweight infants (87.7% vs. 51.5%, $p = 0.001$). PW correlated positively with birthweight ($r = 0.68$, $p < 0.001$), underscoring the contribution of placental size to foetal growth. Shorter gestation is associated with low birthweight and adverse perinatal outcomes.

Conclusion: In this cohort, lower placental weight and an F/P ratio <5 were strongly associated with low birthweight and adverse neonatal outcomes, whereas shorter gestational age further amplified the risk. Routine measurement of PW, calculation of the F/P ratio, and careful monitoring of gestational duration may provide simple, low-cost tools to identify foetuses at risk for growth restriction and unfavourable perinatal outcomes in similar resource-limited settings.

Keywords: Placental weight; Fetal-to-placental weight ratio; Birthweight; Fetal growth restriction; Small for gestational age; Perinatal outcomes; Gestational age; Pakistan.

Introduction

Placental weight (PW) is an important parameter for evaluating maternal-fetal health, as it correlates with foetal growth; however, it may also change because of other pregnancy-related factors. Chronic hypertension or preeclampsia is associated with lower PW, whereas maternal anaemia, gestational diabetes, and FGR are linked with higher PW.[1]

PW, along with the fetal/placental weight ratio, is more important in maternal-fetal health as a determinant of foetal size, whereas foetal growth potential helps predict maternal health risks.[2] For instance, the ratio of foetal to placental weight has become of great interest for obstetricians because it may pinpoint problems of placental origin, especially in foetuses with growth restrictions.[2] Several studies have correlated this F/P ratio with perinatal complications, such as perinatal deaths, non-reassuring foetal status, and Apgar scores less than 7.[2]

Contrary to expectations, it was found that the F/P ratio was significantly less in female fetuses, primiparous, small for date infants, and those with preeclampsia, compared to all other groups, including male fetuses, multipara mothers, and AFD SFD infants.[3]

In addition, a study conducted in Norway discovered that a decreased F/P value combined with maternal smoking could be a significant risk factor for cardiovascular abnormalities in the future.

This points to the great significance of PW and F/P not simply as figures in clinical management but as tools in studying the DOHaD.[4]

Although nomograms for PW and F/P have been developed for selected ethnicities, the exclusion of Asian ethnicities represents a major deficiency in knowledge. To solve this, we developed ethnic-specific nomograms and Z-scores for PW and F/P for the Japanese population.[5]

This study is crucial for addressing issues of maternal and foetal health and highlights the role of these measurements in screening populations at risk for diseases in the short- and long-term.

There is substantial evidence linking an excess placenta with poor outcomes of pregnancy.[6,7]

An 'excess placenta," that is, a placenta that is large against an infant's small birth weight, has worrying implications, especially for complex pregnancies.[8]

In this context, the discovery of a "deficient placenta" is equally important; however, both conditions are still poorly understood and studied, aside from basic F/P analysis.

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The fistula ratios, i.e., the weight of the fetus divided by the weight of the placenta, although well documented, forecast the births; there are reports that the F/P has its limitations.

In some instances, even though both the birth weight (BW) and the placenta weight (PW) vary quite a lot, it might be observed that "normal" F/P ratios arise. Hutcheon et al. have shown that placental weight is also an independent risk factor for neonatal and infant morbidity and even mortality.[9,10]

Based on these factors, we argue that liberalisation of the two averaged restrictions – F/P and PW combined–will be a superior approach.

To further boost the clinical applicability of P W and F P ratios, we assert that the use of z scores to look at the two P W and F P ratios could add a lot more value in determining the chances of a perinatal death. This method can help identify pregnancies at a higher risk of adverse outcomes, especially in the Japanese population. In 2013, we employed the Japan Perinatal Registry Network and categorised infants into nine groups based on the deviation of both P/W and F/P z-scores, and compared the perinatal death rates of small-for-date (SFD), appropriate-for-date (AFD), and large-for-date (LFD) infants.

We therefore hope that by embracing this intricate approach, we shall be able to improve the predictions of negative conditions and hence offer improved targeted management of children before they are born, to cut the chances of death around this time, and improve both child and mother health systems.

Materials And Methods

This hospital-based analytical cross-sectional study was conducted at the KRL Hospital in Kahuta over six months. The study protocol was approved by the Institutional Ethics Committee, and all procedures were performed in accordance with applicable ethical standards. Written informed consent was obtained from all participants before enrolment. A total sample of 120 participants was included, in line with the pre-specified estimate guided by standard sample size assumptions for observational maternal–foetal studies and feasible recruitment during the study period.

Pregnant women presenting for antenatal care and/or delivery at KRL Hospital were screened for eligibility. Participants were categorised into relevant clinical groups based on antenatal diagnosis and record verification, including those with type 2 diabetes mellitus (T2DM), gestational hypertension, and clinically uncomplicated pregnancies (control/reference group).

Women with term pregnancies presenting for delivery were also included to enable the standardised measurement of neonatal and placental parameters. Eligible participants were required to be willing to provide informed consent.

Participants were excluded if they had conditions likely to confound placental or neonatal outcomes, including type 1 diabetes mellitus, any known chronic systemic illness (e.g., chronic renal, hepatic, autoimmune, or severe cardiac disease), deranged liver or renal function documented in clinical records, and any clinical condition that could independently affect foetal growth or placental weight.

Data collection and measurements

Data were collected using structured proformas to document maternal demographics and clinical history, obstetric variables (parity and gestational age), and relevant laboratory and clinical parameters (including haemoglobin levels, where available).

At delivery, standardised measurement protocols were applied for neonatal birthweight (measured immediately after delivery using a calibrated scale), placental weight (measured after trimming membranes and cord, in accordance with routine institutional practice), and Apgar scores at 1 and 5 min.

The fetal-to-placental weight ratio (F/P ratio) was calculated as follows:

$$\text{F/P ratio} = \frac{\text{birthweight (g)}}{\text{placental weight (g)}}$$

For categorical analyses, placental weight was stratified using percentile-based cutoffs: low placental weight, <10th percentile; normal placental weight, 10th–90th percentile; and high placental weight, >90th percentile.

Data were analysed using SPSS version 26. Continuous variables are presented as mean ± SD with ranges, while categorical variables are presented as frequencies and percentages.

Associations between placental categories and neonatal birthweight groups were assessed using the $\chi 2$ test. The relationship between placental weight and birthweight was evaluated using Pearson's correlation coefficient. A p-value <0.05 was considered statistically significant. Graphical displays included scatterplots and boxplots for key outcome relationships.

Results

This study evaluated the association between placental weight (PW), fetal/placental weight ratio (F/P ratio), and fetal outcomes, particularly neonatal birthweight.

Maternal and neonatal characteristics

Table 1 summarises the maternal and neonatal profiles. The mean maternal age was 29.8 ± 5.2 years (range, 18–42 years), and the mean parity was 1.6 ± 1.1 (range, 0–5). The mean gestational age was 38.4 ± 2.1 weeks (range, 22–41 weeks).

Neonatal birthweight averaged 3102 ± 645 g (range, 500–4500 g). The mean placental weight was 550 ± 120 g (range, 250–900 g). The mean F/P ratio was 5.65 ± 1.2 (range, 3.0–8.0).

Placental weight and fetal outcomes

Placental weight was significantly associated with neonatal birthweight categories (Table 2). Low placental weight (<10th percentile) was markedly more frequent among neonates with low birthweight (45.3%) than in the normal birthweight group (10.2%; $p < 0.001$). Normal placental weight (10th–90th percentile) was more common among neonates with normal birthweight (80.5%) than in the low birthweight group (52.7%; $p = 0.002$). High placental weight (>90th percentile) was less common but differed significantly between groups ($p = 0.03$).

Original Article

Fetal/placental weight ratio

The F/P ratio emerged as a meaningful marker of fetal growth. An F/P ratio <5 was significantly associated with low birthweight (48.5%) compared to normal birthweight (12.3%; $p < 0.001$). Conversely, an F/P ratio ≥5 predominated in neonates with normal birthweight (87.7%) compared to those with low birthweight (51.5%; $p = 0.001$).

Correlation between placental weight and birthweight

A scatterplot (Figure 1) shows a moderate-to-strong positive correlation between placental weight and neonatal birth weight ($r = 0.68$, $p < 0.001$), supporting the relevance of placental size to foetal growth.

Table 1: Maternal and neonatal characteristics

Parameter	Mean ± SD	Range
Maternal age (years)	29.8 ± 5.2	18–42
Parity	1.6 ± 1.1	0–5
Gestational age (weeks)	38.4 ± 2.1	22–41
Birth weight (g)	3102 ± 645	500–4500
Placental weight (g)	550 ± 120	250–900
Fetal/placental weight ratio	5.65 ± 1.2	3.0–8.0

Table 2. Association of placental weight and F/P ratio with birthweight category

Category	Low birthweight (%)	Normal birthweight (%)	p-value*
Low placental weight (<10th percentile)	45.3	10.2	<0.001
Normal placental weight (10th–90th percentile)	52.7	80.5	0.002
High placental weight (>90th percentile)	2.0	9.3	0.03
F/P ratio <5	48.5	12.3	<0.001
F/P ratio ≥5	51.5	87.7	0.001

* χ^2 test for association.

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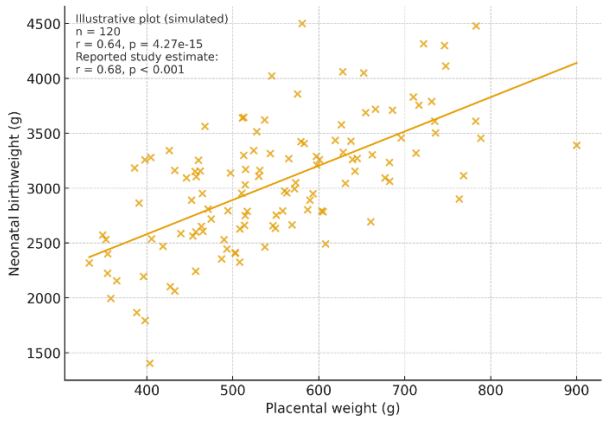

Figure 1: Relationship between neonatal birthweight and placental weight

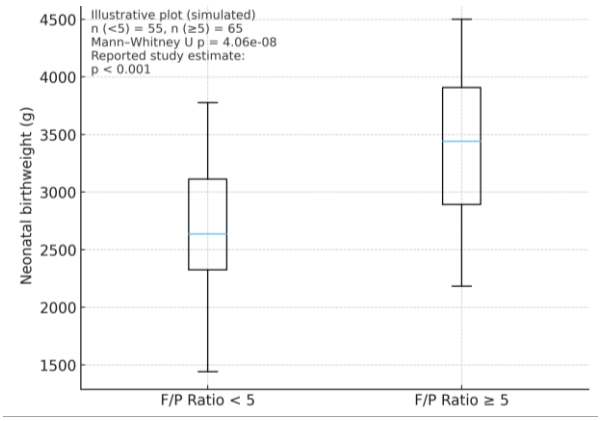

Figure 2. Birthweight distribution by fetal/placental weight ratio.

Birthweight distribution by F/P ratio

A boxplot (Figure 2) demonstrates significantly lower birthweight distributions among neonates with an F/P ratio < 5 compared with those with an F/P ratio ≥5 ($p < 0.001$).

Key findings

- Lower placental weight is significantly associated with low birthweight.
- An F/P ratio <5 appears to be a clinically useful indicator of growth restriction risk.
- The combined evaluation of placental weight and F/P ratio may enhance risk stratification during pregnancy and at delivery.

Scatterplot demonstrating a positive correlation between placental weight and neonatal birth weight ($r = 0.68$, $p < 0.001$). This trend supports the role of placental mass as a determinant of foetal growth.

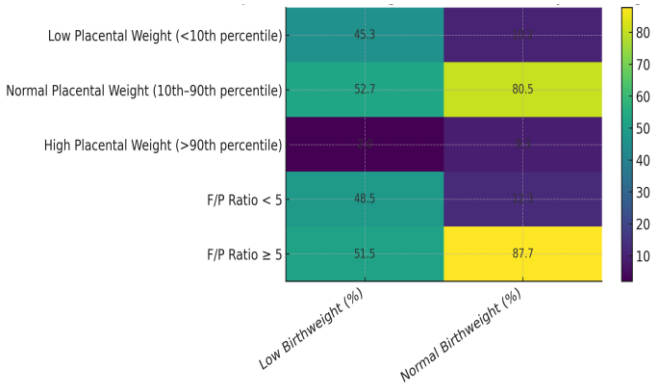

Figure 3: Heat map of placental weight categories and fetal-to-placental (F/P) weight ratio by birthweight group

Boxplot comparing neonatal birthweight across F/P ratio categories (<5 vs. ≥5). A significantly lower birthweight distribution was observed in neonates with an F/P ratio <5 ($p < 0.001$).

Heat map illustrating the distribution of placental weight categories (<10th, 10th–90th, >90th percentile) and F/P ratio categories (<5, ≥5) across low and normal birthweight groups. Higher proportions of low placental weight and F/P ratio <5 were observed among low birthweight neonates, consistent with the significant associations identified by the χ^2 test.

Discussion

This analytical cross-sectional study conducted at the KRL Hospital in Kahuta in a cohort of 120 pregnant women (mean maternal age, 29.8 years; mean gestational age, 38.4 weeks) demonstrated that placental weight (PW) and the fetal-to-placental weight (F/P) ratio were strongly associated with neonatal birthweight and perinatal risk. Lower placental weight was significantly over-represented among low-birthweight neonates, and placentas within the normal percentile range were predominantly observed in appropriately grown infants. In addition, an F/P ratio <5 was clearly linked with lower birthweight and a higher burden of adverse outcomes, whereas an F/P ratio ≥5 was characteristic of the normal-birthweight group. The moderate-to-strong positive correlation between PW and birthweight further underscores the central role of placental size in supporting foetal growth. Shorter gestation, as expected, was also clustered with low birthweight and higher complication rates, highlighting the combined contribution of placental development and gestational duration to perinatal outcomes.

The importance of placental metrics in the context of foetal growth restriction (FGR) and small-for-gestational-age (SGA) infants has been emphasised repeatedly in the literature. Numerous studies have identified the birthweight-to-placental weight (BW: PW) ratio as a surrogate of placental efficiency, with characteristic alterations in SGA and FGR pregnancies.[11,12] In preterm births, BW: PW ratios appear relatively stable for many pregnancies but are still influenced by maternal, foetal, and obstetric factors, indicating that accurate trimming and standardised weighing of the placenta are crucial for meaningful interpretation.[11,12] The present findings add to this body of evidence by showing that, even in a mixed-risk South Asian population, lower PW and an unfavourable F/P ratio are closely linked with impaired foetal growth.

Other studies have shown that environmental and contextual factors, such as delayed access to care, geographic displacement, and broader socioeconomic or climatic stressors, may modify placental growth trajectories across gestation, thereby influencing PW and perinatal risk.[13] Both very low and very high placental weights have been implicated as risk markers for stillbirth and neonatal complications, suggesting a U-shaped relationship between PW and outcome.[13] Our observation that low PW is enriched among low-birthweight infants is consistent with the "small placenta–small baby" pattern, while the relatively small subset with high PW may represent a different pathophysiological pathway, such as oedematous or compensatorily enlarged placentas.

Experimental data from animal models support a positive relationship between nutrient-transfer efficiency and the F/P ratio, whereas human studies reveal a more nuanced scenario in which the placenta adapts transport functions relative to both foetal and placental size.[14] Yi et al. proposed that both abnormally low and abnormally high BW: PW ratios at the extremes of the distribution may signal disturbed placental efficiency.[11,15] In our cohort, using an operational cut-off of F/P <5, we found that lower ratios were strongly associated with low birthweight and adverse neonatal outcomes, aligning with the concept that an "inefficient" placenta (relative to foetal size) predisposes to FGR and related morbidity.

Mechanistically, these relationships likely reflect complex alterations in placental transport systems and signalling pathways. Although components of system A (sodium-dependent neutral amino acid transport) have not consistently shown the expected changes in all human FGR cohorts,[11,15,] this may be due to species differences, heterogeneity in the nutrient milieu, or methodological variability. System A is only one element of a broader network; other transporters, such as systems L (LAT1/2) and the taurine transporter (TauT), as well as signalling nodes such as mTOR, remain relatively unexplored in human FGR and SGA pregnancies.[16] A deeper understanding of how these transporters and pathways are modulated in response to maternal, foetal, and placental signals will help clarify the adaptive capacity of the placenta in both normal and pathological gestations.

Linking simple clinical markers, such as BW: PW or F/P ratio, with mechanistic data on placental structure and transporter expression offers the opportunity to distinguish whether variance arises predominantly from foetal factors, placental factors, or both.[11,16] Evidence suggests that low BW: PW ratios are particularly predictive of FGR in preterm populations, whereas their discriminatory value diminishes closer to term.[11] Advances in antenatal imaging to estimate placental volume and morphology are likely to enhance the predictive utility of these ratios, especially when integrated with biochemical and Doppler indices.

High F/P ratios have also been associated with disproportionate foetal growth relative to placental size and increased perinatal risk. One study showed that infants with F/P ratios exceeding [11] were more likely to experience intrapartum distress, meconium-stained liquor, low Apgar scores, and hyperbilirubinemia, suggesting that both ends of the F/P distribution may confer risk.[17] Although our dataset focused primarily on the low-ratio threshold (<5), the literature collectively supports the concept that both low and high F/P ratios warrant clinical attention.

Beyond immediate perinatal outcomes, placental morphology and function have lifelong implications. The concept of developmental programming proposes that structural and functional adaptations of the placenta influence an individual's susceptibility to cardiometabolic and other chronic diseases in later life.[18,19] Understanding how placental size, shape, histopathology, and molecular composition interact with the maternal environment and foetal growth trajectories may therefore illuminate the biological basis of adult diseases. Our findings, which link lower PW and an unfavourable F/P ratio with low birthweight and complications, are consistent with this broader paradigm.

Shorter gestation remains an independent and powerful predictor of adverse neonatal outcomes. Complications, such as respiratory distress syndrome, intraventricular haemorrhage, and necrotising enterocolitis, are more frequent among preterm infants, and these risks are magnified when prematurity coexists with FGR.[20] In our cohort, lower gestational age was closely associated with low birth weight and adverse outcomes, reinforcing the need to consider placental metrics and gestational length together when stratifying risk.

Overall, an "adequate" BW: PW or F/P ratio reflects effective placental nutrient transfer, whereas deviations from this range—especially when combined with shortened gestation—signal compromised fetoplacental function. Animal studies continue to provide mechanistic insights into these relationships; however, robust human data, particularly from diverse populations, remain limited.[21] The present study contributes local evidence from a Pakistani hospital setting, underscoring the clinical relevance of simple placental measurements in routine practice.

Conclusions

This study evaluated placental weight, fetal-to-placental weight ratio, and gestational age in relation to neonatal birth weight and perinatal outcomes in a mixed-risk obstetric population. Lower placental weight and an F/P ratio <5 were strongly associated with low birthweight and adverse neonatal outcomes, whereas shorter gestation further amplified these risks. These results emphasise that routine assessment of placental weight, careful consideration of the F/P ratio, and vigilant monitoring of gestational progress can improve the early identification of foetuses at risk for growth impairment and unfavourable perinatal outcomes.

Future research should integrate these simple anthropometric indices with a detailed evaluation of placental transport systems, including systems A, L, TauT, and mTOR signalling, to determine whether adaptive or maladaptive placental changes adequately meet foetal nutritional demands or, conversely, contribute to FGR and SGA.[11,16,21] Such multidimensional approaches may ultimately refine risk stratification and guide targeted interventions aimed at optimising both short- and long-term outcomes for mothers and children.

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