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Placental thickness and imaging biomarkers as predictors of neonatal outcomes in term singleton pregnancies in a tertiary hospital in Uyo

Iniobong Gabriel Abah[1], *Mgbe Emeka Kelvin*[2], *Dianabasi Eduwem*[1]

[1]*Department of Radiology, University of Uyo, Akwa Ibom State, Nigeria*
[2]*Department of Radiation Medicine, University of Nigeria Nsukka, Enugu, Nigeria*

Abstract

Context: Accurate antenatal prediction of neonatal outcomes remains a global clinical challenge, particularly in low-resource settings. Placental imaging biomarkers are underutilized in routine obstetric practice.
Aim: To assess placental thickness and selected ultrasound-derived placental imaging biomarkers as predictors of adverse neonatal outcomes.
Materials and Methods: This prospective cross-sectional analytical study included 320 term singleton pregnancies to evaluate the association between placental thickness, Doppler indices, and neonatal outcomes. Placental thickness, echotexture, placental lakes, uterine and umbilical artery Doppler indices were measured. Neonatal outcomes assessed included birth weight, 5-minute Apgar score, neonatal intensive care unit (NICU) admission, and early neonatal morbidity. Multivariable logistic regression identified independent associations between placental parameters and outcomes.
Results: Abnormal placental thickness (thin) was observed in 38 (64.4%) and (thick) 21 (35.6%) of abnormal placentas. Abnormal echotexture and placental lakes were seen in 67 (20.9%) and 58 (18.1%), respectively. Elevated umbilical and uterine artery resistance was noted in 51 (15.9%) and 45 (14.1%) of cases. Adverse neonatal outcomes included 20 (33.9%) low birth weight, 16 (27.1%) low Apgar score, and 23 (39.0%) NICU (Neonatal Intensive Care Unit) admissions. Multivariable analysis showed that combined placental biomarkers independently predicted adverse outcomes shown by abnormal placental thickness (AOR-7.85, P-value - <0.001, 95% CI: 4.10-15.02), Elevated umbilical resistive index (AOR-5.62, P-value - <0.001, 95% CI: 2.90-10.88) and abnormal uterine artery Doppler (AOR-4.97, P-value - <0.001, 95% CI: 2.45-10.10)
Conclusion: Placental thickness combined with imaging biomarkers such as echotexture, lakes, and Doppler indices provides a practical, non-invasive approach to predict neonatal outcomes, supporting comprehensive placental evaluation in antenatal care.

Keywords: Placental thickness; Placental imaging biomarkers; Neonatal outcomes; Obstetric ultrasound; Doppler ultrasonography

Introduction

Despite advances in obstetric care, adverse neonatal outcomes remain a significant contributor to perinatal morbidity and mortality worldwide, particularly in low- and middle-income countries.[1,2] Early identification of pregnancies at risk is essential for optimizing antenatal surveillance and guiding timely obstetric intervention. Current fetal assessment strategies rely predominantly on biometric parameters and Doppler evaluation; however, these measures may not fully capture

Corresponding Author:

Dr. Abah I.G
Department of Radiology, University of Uyo, Akwa Ibom, Nigeria.

iniobonggabah@uniuyo.edu.ng

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placental dysfunction, which underlies many adverse pregnancy outcomes.[3,4]

The placenta plays a central role in fetal growth, oxygenation, and metabolic exchange. Structural and functional alterations of the placenta often precede clinically evident fetal compromise[4,5]. Sonographically assessed placental thickness has been proposed as a surrogate marker of placental health, with both abnormally thin and thick placentas associated with fetal growth restriction, maternal diabetes, hypertensive disorders of pregnancy, and adverse perinatal outcomes.[6–10]

Beyond placental thickness, several ultrasound-derived placental imaging biomarkers—including placental echotexture, placental lakes, and uteroplacental Doppler indices—provide additional insight into placental structure and perfusion[5,11–12]. Abnormal placental echotexture has been associated with placental insufficiency, while altered uterine and umbilical artery Doppler indices reflect impaired placental vascular resistance and are linked to adverse perinatal outcomes[12-15]. Integrating multiple placental imaging biomarkers into a unified assessment may enhance antenatal risk stratification beyond conventional fetal biometric evaluation alone[13,14].

This study aimed to evaluate placental thickness and selected placental imaging biomarkers as predictors of adverse neonatal outcomes in term singleton pregnancies. We hypothesized that a combined placental imaging model would demonstrate superior predictive value compared with individual placental parameters.

Materials and Methods

Study Location and Design

This prospective observational study to assess placental thickness and imaging biomarkers as predictors of neonatal outcomes in term singleton pregnancies was conducted at the Radiology department of the University of Uyo Teaching Hospital, Uyo, Akwa Ibom State, Nigeria. The University of Uyo Teaching Hospital is a tertiary healthcare facility situated in the Uyo, the capital city of Akwa Ibom state and serves the South-South geopolitical zone of Nigeria. It is a major referral centre for both Government-owned and private hospitals in Uyo and its environs.

The radiology department attends to patients referred from within the University of Uyo Teaching Hospital and its environs.

Study population

Eligible pregnant women at the University of Uyo Teaching Hospital with term singleton gestations undergoing routine antenatal ultrasound evaluation were recruited. These women were enrolled at 37 weeks of gestation and followed until delivery.

Inclusion Criteria: These include pregnant women aged 18-45 years, singleton pregnancies, gestational age at the time of assessment ≥37 weeks (term), women with uncomplicated pregnancies or pregnancies without major maternal systemic disorders (to avoid confounding effects on placental biomarkers), availability of reliable dating of pregnancy based on last menstrual period or first-trimester ultrasound, and planned delivery at the study hospital to ensure proper collection of neonatal outcome data {e.g., birth weight, APGAR scores, NICU (Neonatal Intensive Care Unit) admission}.

Exclusion Criteria: These include women with multiple gestations, preterm (<37 weeks) or post term (>41 weeks) pregnancies, major fetal congenital anomalies, chronic maternal illness affecting placental function (e.g diabetes mellitus, hypertension, preeclampsia, renal disease) and incomplete clinical or imaging data

Sample Size Determination and Sampling Technique

The minimum sample size was calculated using the single proportion formula:

$$n = Z^2pq^{(16,17)}/d^2$$

Where:

n = sample size

Z = standard normal deviate (1.96 at 95% confidence level)

p = 0.25 (In the absence of well-established local prevalence data for abnormal placental thickness, a conservative prevalence estimate of 25% was assumed to ensure adequate sample size and statistical power)

q = 1 − p
d = 0.05 @margin of error (precision)

Calculation:
$n = (1.96)^2 \times 0.25 \times 0.75 / (0.05)^2$
$n = 3.8416 \cdot 0 \times 1875 / 0.0025$
$n = 0.7203 / 0.0025 = 288.1$

Prior studies in similar populations report an incidence of 10–13% for these outcomes [2,9,10]. Assuming an effect size (odds ratio) of 2.0 for the association between abnormal placental thickness and adverse neonatal outcomes, with 80% power and a 5% significance level, the minimum required sample size was calculated to be 288 participants using standard formulas for binary outcomes 16. To account for potential incomplete data or loss to follow-up, a total of 320 women were recruited, this larger sample size ensured an adequate number of outcome events to support logistic regression modelling, consistent with the recommended minimum of 10–15 outcome events per predictor variable. Based on the observed event rates (e.g., 42 NICU admissions), this sample size permitted inclusion of approximately 2–4 predictor variables without overfitting[17].

Study Procedure

Ultrasound Protocol and Placental Assessment

Ultrasonographic evaluation was conducted using a 3.5 MHz curvilinear transducer. All ultrasound examinations were performed using standardized protocols by radiologists. Placental thickness was measured in millimeters at the level of umbilical cord insertion with the ultrasound beam oriented perpendicular to the placental surface. Care was taken to exclude the myometrium and retroplacental veins from the measurement. The readings were categorized as thin (<2.5cm), normal (2.5–4.0 cm), or thick (>4.0 cm)

Placental echotexture was assessed qualitatively and categorized as normal or abnormal based on the presence of increased heterogeneity or focal hypoechoic areas. Placental lakes were recorded as present or absent. Doppler evaluation of the uterine and umbilical arteries was performed, and resistance indices were documented according to established guidelines.

Neonatal Outcomes

Neonatal outcomes assessed included birth weight, 5-minute Apgar score, neonatal intensive care unit (NICU) admission, and early neonatal morbidity. Low birth weight was defined using standard thresholds. Adverse neonatal outcome was defined as the presence of one or more of the following: low birth weight, low Apgar score, NICU admission, or early neonatal complications.

Data / Statistical Analysis

Data were entered and analyzed using IBM SPSS Statistics version 25.0 (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as means with standard deviation (SD) for normally distributed data or medians with interquartile ranges (IQR) for skewed or non normally distributed data. Categorical variables were presented as frequencies and percentages.

Multivariable logistic regression analysis was performed to identify independent associations between placental imaging parameters and adverse neonatal outcomes, adjusting for relevant maternal and obstetric confounders. Predictive performance was evaluated using receiver operating characteristic curve analysis, with comparison of area under the curve values. A p value of < 0.05 was considered statistically significant.

Ethical Approval

Ethical approval for this study was obtained from the Health Research Ethics Committee of the University of Uyo Teaching Hospital, Uyo, Nigeria. The study was conducted in accordance with the principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment, and confidentiality of participant information was strictly maintained throughout the study.

Results

A total of 320 women with term singleton

Table 1: Maternal and Pregnancy Characteristics

Variable	Mean ± SD
Maternal age (years)	29.7 ± 5.3
Gestational age at ultrasound (weeks)	38.4 ± 1.2
Parity	3 ± 1.0

pregnancies were evaluated. The mean maternal age was 29.7 ± 5.3 years and mean gestational age at ultrasound was 38.4 ± 1.2 weeks. Placental thickness ranged from 18 mm to 52 mm, with 38 placentas (64.4%) classified as abnormally thin and 21 placentas (35.6%) as abnormally thick. Abnormal placental echotexture was observed in 67 participants (20.9%), while placental lakes were present in 58 participants (18.1%). Doppler assessment revealed elevated umbilical artery resistance in 51 (15.9%) participants and abnormal uterine artery indices in 45 (14.1%) participants. (Table 2).

Neonatal outcomes indicated 20 (33.9%) infants with low birth weight, 16 (27.1%) infants with low 5-minute Apgar scores, and 23 (39.0%) infants requiring NICU admission. There was a statistically significant association between abnormal placental thickness and Doppler abnormalities. Elevated umbilical artery resistance index was identified in 31 of 59 women (52.5%) with abnormal placental thickness compared with 2 of 261 women (0.8%) with normal placental thickness ($p < 0.001$), corresponding to an 18-fold increase in odds (OR = 18.7). Similarly, abnormal uterine artery Doppler indices were present in 27 of 59 women (45.8%) with abnormal placental thickness compared with 1 of 261 women (0.4%) with normal placental thickness ($p < 0.001$), yielding an odds ratio of 22.9. (Tables 4 and 5).

Neonatal outcomes were significantly associated with abnormal placental thickness. Low birth weight occurred in 20 of 59 neonates (33.9%) with abnormal placental thickness compared with 15 of 261 neonates (5.7%) with normal placenta ($\chi^2 = 39.4$, $p < 0.001$; OR = 8.41). Low 5-min Apgar was observed in 16 of 59 neonates (27.1%) with abnormal placenta versus 13 of 261 neonates (5.0%)

Table 2: Placental Imaging Findings

Parameter	Normal n (%)	Abnormal n (%)
Placental thickness	261 (81.6)	59 (18.4)
- Thin	0 (0)	38 (64.4)
- Thick	0 (0)	21 (35.6)
Echotexture	253 (79.1)	67 (20.9)
Placental lakes	262 (81.9)	58 (18.1)
Umbilical artery Doppler (elevated resistance)	269 (84.1)	51 (15.9)
Uterine artery Doppler (abnormal indices)	275 (85.9)	45 (14.1)

Table 3: Neonatal Outcomes and Correlation with Placental Biomarkers

Outcome	n (%)	Association with abnormal placental thickness (p-value)
Low birth weight	20 (33.9)	<0.001
Low 5-min Apgar	16 (27.1)	<0.001
NICU admission	23 (39,0)	<0.001

Table 4: Multivariate Logistic Regression Analysis
Outcome: Abnormal Placental Thickness

Variable	Adjusted OR (aOR)	95% CI	p-value
Elevated Umbilical Artery RI	18.7	6.5 – 53.8	<0.001
Abnormal Uterine Artery Doppler	22.9	7.2 – 72.5	<0.001

Table 5: Multivariate Logistic Regression Analysis
Outcome: Abnormal Neonatal Outcome (Composite: Low Birth Weight / Low Apgar / NICU admission)

Variable	Adjusted OR (aOR)	95% CI	p-value
Abnormal Placental Thickness	7.85	4.10 – 15.02	<0.001
Elevated Umbilical Artery RI	5.62	2.90 – 10.88	<0.001
Abnormal Uterine Artery Doppler	4.97	2.45 – 10.10	<0.001
Maternal Age (>35 years)	1.42	0.78 – 2.58	0.24
Parity (Multiparity)	1.18	0.66 – 2.10	0.57

Table 6: Association Between Placental Thickness and Neonatal Outcomes (n = 320)

Neonatal Outcome	Abnormal Placenta (n = 59)	Normal Placenta (n = 261)	X^2 value	p-value	Odds Ratio (95% CI)
Low Birth Weight	20 (33.9%)	15 (5.7%)	39.4	<0.001	8.41 (4.0-17.6)
Low 5-min Apgar Score	16 (27.1%)	13 (5.0%)	33.3	<0.001	7.10 (3.2-15.5)
NICU Admission	23 (39.0%)	19 (7.3%)	49.2	<0.001	8.10 (4.1 – 16.0)

Table 7: Predictive Performance of Abnormal Placental Thickness

Outcome	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Low Birth Weight	57.1	86.3	33.9	94.3
Low 5-min Apgar	55.2	85.2	27.1	95.0
NICU Admission	54.8	87.1	39.0	92.7

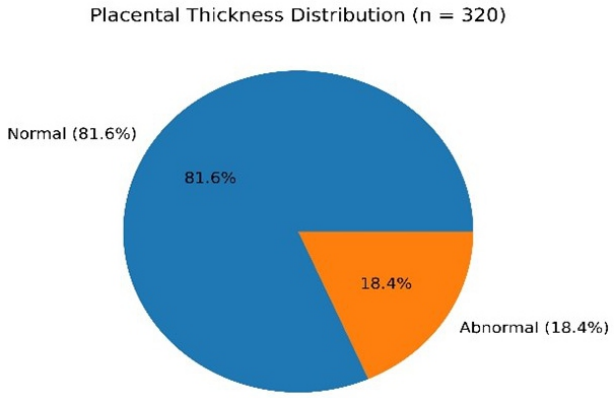

Figure 1: Pie chart demonstrating overall placental thickness distribution in the study population (n = 320)

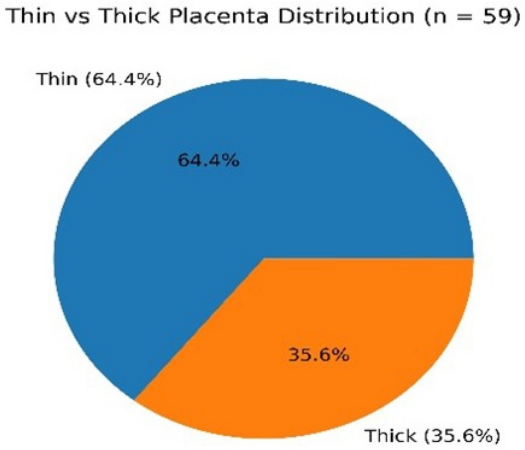

Figure 2: Pie chart showing the proportional distribution of thin and thick placentae among abnormal cases (n = 59)

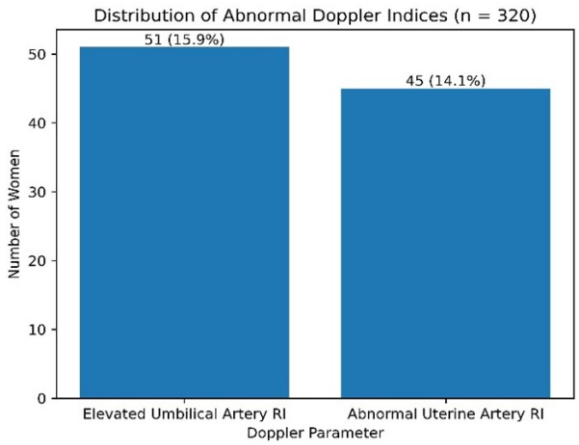

Figure 3: Bar chart illustrating the distribution of abnormal Doppler indices among 320 term singleton pregnancies. Elevated umbilical artery resistance index (RI) was observed in 51 (15.9%) women, while abnormal uterine artery Doppler indices were identified in 45 (14.1%) women.

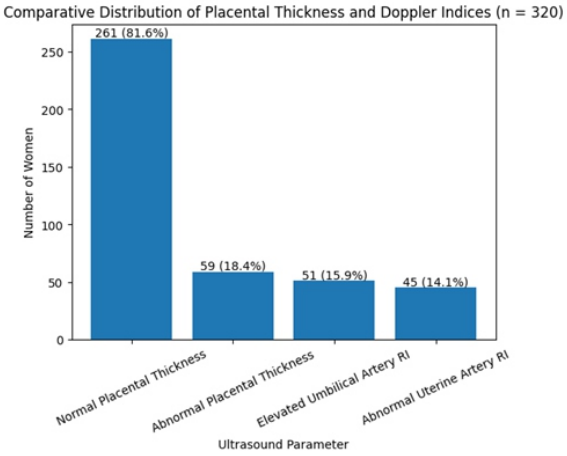

Figure 4: Composite bar chart comparing placental thickness categories and abnormal Doppler indices among 320 term singleton pregnancies. Normal placental thickness was observed in 261 (81.6%) women, while 59 (18.4%) women demonstrated abnormal placental thickness. Elevated umbilical artery resistance index was identified in 51 (15.9%) women, and abnormal uterine artery Doppler indices were present in 45 (14.1%) women.

with normal placenta ($\chi^2 = 33.3$, $p < 0.001$; OR = 7.1). NICU admission occurred in 23 of 59 neonates (39.0%) with abnormal placenta compared with 19 of 261 neonates (7.3%) with normal placenta ($\chi^2 = 49.2$, $p < 0.001$; OR = 8.1). (Table 6). Abnormal placental thickness demonstrated moderate sensitivity (≈55–57%) but high specificity (≈85–87%) for adverse neonatal outcomes, with excellent negative predictive value (>92%), supporting its utility as a predictive imaging biomarker. (Table 7)

Discussion

This study demonstrates that placental thickness, when combined with additional imaging biomarkers, is a robust predictor of adverse neonatal outcomes amongst 320 term singleton pregnancies. In this study, 59 (18.4%) of placentas were abnormal (thin and thick) with a higher prevalence of

abnormally thin placentas. This reflects similar prevalence rates reported in Nigerian and international populations[6,7,9].

Our study showed that demonstrated that both abnormally thin and thick placentas are associated with fetal growth restriction and perinatal complications like low birth weight, low 5-min Apgars scores and NICU admissions. This aligns with previous studies by Tanvi Chaudhary and Shruti Paliwal[18] who found that increased placental thickness measured at 36–40 weeks was significantly associated with low birth weight and low Apgar scores. This suggests that placental thickness could be used as a routine third-trimester surveillance marker. Gabr et al.,[19] also demonstrated that abnormal placental thickness in the second and third trimesters also significantly correlated with decreased birth weight and lower Apgar scores, thus supporting the role of placental thickness measurements in predicting adverse neonatal outcomes. Rawal et al.[20], showed significant associations between abnormal (thin or thick) placenta and outcomes like low birth weight, prematurity, and fetal growth restriction, indicating that both extremes of placental thickness may be linked to adverse outcomes. In a prospective Indian cohort study by Nagpal et al.[21], both thin and thick placentae at 32 and 36 weeks were associated with compromised neonatal outcomes (including lower birth weight). This reinforces the predictive value of placental thickness beyond routine biometric parameters and suggests that fetal compromise might begin earlier with an abnormally thin or thick placenta. This was also corroborated by a study done by Hamidi et al.[22], who reported a positive correlation between placental thickness and neonatal birthweight in routine anomaly scans. They inferred that placental thickness may reflect fetal growth potential, while not statistically significant for Apgar scores or NICU admission, this however, continues the narrative of placental thickness as a measurable correlate of neonatal outcomes.

These studies including ours, conducted in the third trimester and at term show that abnormally thin or thick placenta can be predictive of adverse fetal outcomes as they correlate with lower birth weight and poorer Apgar scores. These low birth weight and poor Apgar scores are associated with adverse neonatal outcomes. Mid-pregnancy associations between placental characteristics and neonatal birthweight further support the concept that placental growth reflects fetal growth potential. Previous studies have demonstrated that impaired placental development in the second trimester is associated with reduced fetal growth and small-for-gestational-age outcomes, highlighting the placenta's central role in nutrient transfer and fetal programming. Salafia CM et al.[11], showed that placental size and growth trajectory are key determinants of birthweight as placental morphology and function directly influence fetal growth through regulation of nutrient and oxygen exchange.

The results of our study suggest that abnormal placental thickness is strongly associated with clinically significant neonatal compromise, including low birth weight, low Apgar scores, and NICU admission. While the biomarker has moderate sensitivity, its high specificity and negative predictive value make it particularly useful for ruling out adverse outcomes in pregnancies with normal placental morphology. These findings align with prior reports highlighting placental thickness as a surrogate for uteroplacental vascular health and fetal growth potential.

The findings of this study underscore the potential clinical value of incorporating placental thickness assessment into routine obstetric ultrasound evaluation. Given that placental thickness is a simple, rapid, and reproducible measurement obtainable during standard fetal biometry, its inclusion may enhance early identification of fetuses at risk of adverse neonatal outcomes, even in the presence of apparently normal fetal growth parameters. Routine reporting of placental thickness could therefore serve as an adjunctive imaging biomarker to guide risk stratification, inform antenatal surveillance strategies, and support timely clinical decision-making. This approach is particularly relevant in resource-limited settings, where access to advanced imaging modalities or comprehensive Doppler evaluation may be constrained, and where maximizing the prognostic utility of standard ultrasound examinations is essential.

Abnormal placental echotexture found in 67 (20.9%) women and the presence of placental lakes

in 58 (18.1%) women, further indicate underlying placental dysfunction, consistent with international observations[5,11,12,23]. Doppler indices of the umbilical and uterine arteries were predictive of adverse outcomes, corroborating existing literature on impaired placental perfusion and fetal compromise[13,14,15,24]. Notably, the integration of multiple placental biomarkers improved predictive performance, supporting prior calls for comprehensive placental assessment rather than reliance on thickness alone[25,26].

A key strength of this study lies in its focus on term singleton pregnancies, thereby minimizing the confounding effects of gestational age variability and multiple gestations on placental morphology and neonatal outcomes. The use of a standardized ultrasonographic technique for placental thickness measurement enhances the reproducibility and clinical applicability of the findings. Additionally, the correlation of imaging parameters with objective neonatal outcome measures, including birth weight and immediate postnatal indices, strengthens the clinical relevance of the results. By evaluating placental thickness within a real-world clinical setting, this study provides pragmatic evidence supporting the integration of placental imaging biomarkers into routine obstetric ultrasound practice.

Several limitations of this study warrant consideration. The single-centre design may limit the generalizability of the findings to broader populations with differing demographic and obstetric characteristics. Although placental thickness measurement is relatively simple, ultrasound assessment remains inherently operator dependent, which may introduce interobserver variability. In addition, histopathological correlation of placental findings was not performed, precluding direct validation of imaging biomarkers against underlying placental pathology. Potential confounding maternal factors, such as nutritional status and subclinical anaemia, were not fully accounted for and may have influenced placental morphology. Nonetheless, these limitations reflect real-world clinical practice, and the observed associations remain clinically meaningful.

The inclusion of Nigerian data demonstrates that these imaging parameters retain predictive value across diverse populations, addressing a critical gap in obstetric imaging in low- and middle-income countries[9,10,15]. These findings have potential clinical implications: routine antenatal ultrasound could incorporate standardized placental imaging protocols to facilitate early risk stratification, timely intervention, and improved neonatal outcomes.

Conclusion

In this study of 320 term pregnancies, placental thickness combined with imaging biomarkers such as echotexture, lakes, and Doppler indices provides a practical, non-invasive approach to predict neonatal outcomes, reinforcing the value of comprehensive placental evaluation in antenatal care.

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Declaration of interest: This manuscript has not been presented at any meeting or organization

This manuscript has been read and approved by all the authors and the requirements for authorship as stated earlier in this document have been met, and that each author believes that the manuscript represents honest work.

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