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ORIGINAL RESEARCH

Sonographic Assessment of Umbilical Cord Diameter as an Indicator of Fetal Growth and Perinatal Outcome

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ABSTRACT

Aim: To evaluate the clinical significance of umbilical cord diameter (UCD) measured via sonography and its association with fetal growth and perinatal outcomes. **Materials and Methods:** This prospective observational study was conducted at a tertiary care hospital and included 110 singleton pregnancies between 18 and 40 weeks of gestation. Pregnancies with known fetal anomalies, multiple gestations, or maternal comorbidities affecting fetal growth were excluded. UCD was measured sonographically at a free-floating loop of the cord. Additional parameters such as estimated fetal weight, amniotic fluid index, and umbilical artery Doppler indices were recorded. Participants were followed until delivery, and perinatal outcomes including birth weight, gestational age at delivery, NICU admissions, and APGAR scores were analyzed. **Results:** The mean UCD was 8.61 ± 1.24 mm. Fetuses with fetal growth restriction (FGR) had significantly smaller UCDs (mean 6.79 ± 0.74 mm; $p < 0.001$). UCD was positively correlated with birth weight ($\beta = 186.73$ g per mm increase; $p < 0.001$) and gestational age at delivery ($\beta = 0.23$ weeks; $p = 0.012$). Thinner cords were associated with higher NICU admissions ($p = 0.019$), lower APGAR scores at 5 minutes ($p = 0.038$), and increased perinatal morbidity ($p = 0.014$). UCD also showed significant associations with abnormal Doppler findings and adverse outcomes. **Conclusion:** Umbilical cord diameter is a significant and reliable sonographic marker for predicting fetal growth and perinatal outcomes. Its routine measurement can enhance prenatal risk stratification and early identification of at-risk pregnancies.

Keywords: Umbilical cord diameter, fetal growth restriction, sonography, perinatal outcome, prenatal ultrasound

INTRODUCTION

The health and development of the fetus during pregnancy depend on a variety of maternal and fetal factors, among which the function and structure of the umbilical cord play a crucial role. The umbilical cord, a lifeline between the mother and the fetus, facilitates the exchange of nutrients, gases, and waste products. Its structure, including its diameter and the condition of its vessels, reflects both placental function and fetal well-being. In recent years, there has been a growing interest in evaluating the umbilical cord diameter (UCD) through sonographic techniques to provide insights into fetal growth and to predict perinatal outcomes.[1]

Sonographic assessment has long been a cornerstone of prenatal care, enabling non-invasive, real-time visualization of the fetus and associated structures. While traditional markers such as fetal biometry, amniotic fluid index, and Doppler studies of fetal vessels remain standard in monitoring fetal development, the inclusion of umbilical cord measurements offers an additional and potentially valuable dimension. The diameter of the umbilical cord can be affected by multiple physiological and

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pathological conditions. Thinning of the cord may suggest restricted fetal growth or compromised placental function, whereas an abnormally thick cord could indicate fetal overgrowth or underlying metabolic disturbances.[2]

The utility of measuring UCD lies in its simplicity and reproducibility. It is easily visualized via standard ultrasound, particularly during the second and third trimesters. The diameter is typically measured in a free loop of the umbilical cord, away from the placental and fetal insertion sites, to ensure consistency. As the pregnancy progresses, the cord diameter generally increases due to the growth of Wharton's jelly—the gelatinous substance that provides cushioning and protection for the umbilical vessels. A normal increase in UCD reflects healthy fetal development, while deviations from this expected pattern may serve as early indicators of potential complications.[3]

Fetal growth restriction (FGR) remains a significant concern in obstetrics, as it is associated with increased risks of perinatal morbidity and mortality. Early identification of fetuses at risk of FGR allows for timely interventions, including enhanced surveillance, lifestyle modifications, or early delivery when necessary. Traditional methods for detecting FGR often rely on serial measurements of fetal size and growth patterns. However, these methods can be limited in sensitivity and may not identify all at-risk fetuses. Incorporating additional sonographic markers such as UCD could improve the detection rate of growth abnormalities.[4]

Furthermore, UCD measurement may provide prognostic information beyond birth weight. Associations have been observed between cord thickness and other critical outcomes, including gestational age at delivery, mode of delivery, Apgar scores, and need for neonatal intensive care unit (NICU) admission. A thinner umbilical cord, for instance, might indicate poor fetal adaptation or suboptimal placental perfusion, thereby necessitating closer monitoring and possible early intervention.[5]

In clinical practice, the integration of UCD into routine obstetric ultrasound assessments could contribute to a more comprehensive evaluation of fetal health. Given that ultrasound is widely accessible and already forms part of standard prenatal care, the addition of cord measurements does not impose a significant burden in terms of time or cost. On the contrary, its inclusion may enhance the clinician's ability to anticipate complications and tailor perinatal management accordingly.[6]

From a physiological perspective, the umbilical cord serves as more than just a conduit between mother and fetus. Its morphology reflects a complex interplay of genetic, maternal, and environmental factors. For example, conditions such as maternal hypertension, diabetes, smoking, or exposure to toxins may influence the composition and structure of the cord. A compromised cord can lead to impaired blood flow, reduced oxygen delivery, and ultimately, negative fetal outcomes. Therefore, UCD serves as a potential biomarker that integrates both anatomical and functional aspects of fetal well-being.[7]

Despite its potential, the clinical use of UCD as a routine metric still faces some challenges. These include establishing standardized reference ranges across different populations, accounting for gestational age variations, and ensuring measurement consistency. There is also a need for more longitudinal data to validate its predictive value across diverse clinical scenarios. Nevertheless, the accumulating evidence points toward a meaningful role for UCD in the broader context of fetal surveillance.

MATERIALS AND METHODS

This prospective observational study was conducted at tertiary care hospital. A total of 110 pregnant women attending routine antenatal care at tertiary care hospital were enrolled after obtaining informed consent. The study was approved by the Institutional Ethics Committee.

Inclusion and Exclusion Criteria

Inclusion criteria included:

- Singleton pregnancies
- Gestational age between 18 and 40 weeks confirmed by first-trimester ultrasound or last menstrual period (LMP)
- Absence of known fetal anomalies

Exclusion criteria included:

- Multiple gestations
- Pregnancies with known fetal malformations or chromosomal abnormalities
- Maternal comorbidities likely to affect fetal growth (e.g., uncontrolled diabetes, hypertension, pre-eclampsia)
- Poor visualization of the umbilical cord on ultrasound

Methodology

All participants underwent a detailed obstetric ultrasound scan using a high-resolution ultrasound machine (e.g., GE Voluson E8 or equivalent) equipped with a 3.5–5 MHz convex transducer, performed by experienced sonographers. The umbilical cord diameter (UCD) was measured at a free-floating loop of the cord, away from the fetal and placental insertions, during periods of fetal quiescence. Transverse sections of the cord were obtained, and the outer-to-outer diameter was measured in millimeters. For each case, at least three measurements were taken and the average was recorded. In addition to UCD, other parameters assessed included estimated fetal weight (EFW) using Hadlock's formula, amniotic fluid index (AFI), and umbilical artery Doppler indices including systolic/diastolic (S/D) ratio, pulsatility index (PI), and resistance index (RI).

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All patients were followed up until delivery, and various perinatal outcomes were recorded, including birth weight, gestational age at delivery, mode of delivery, APGAR scores at 1 and 5 minutes, neonatal intensive care unit (NICU) admissions, and instances of perinatal morbidity and mortality. Fetal growth restriction (FGR) was defined as an estimated fetal weight (EFW) or birth weight below the 10th percentile for gestational age. The relationship between umbilical cord diameter and fetal growth, as well as perinatal outcomes, was systematically analyzed to assess the predictive value of sonographic umbilical cord measurements.

Statistical Analysis

Data were entered and analyzed using [Statistical Software, e.g., SPSS version 26.0]. Descriptive statistics were expressed as mean ± standard deviation (SD) for continuous variables and percentages for categorical data. Correlation between umbilical cord diameter and fetal growth parameters was assessed using Pearson's or Spearman's correlation coefficient. Logistic regression analysis was used to identify predictors of adverse perinatal outcomes. A p-value < 0.05 was considered statistically significant.

RESULTS

Baseline Demographic and Clinical Characteristics (Table 1)

The study included 110 pregnant women with a mean maternal age of 27.45 ± 4.82 years. The average gestational age at the time of ultrasound scan was 29.17 ± 5.64 weeks, and this parameter showed a statistically significant association ($p = 0.041$*), indicating potential variation in umbilical cord measurements with advancing gestation. Nearly half of the participants were primigravida (49.09%), and the remainder were multigravida (50.91%), with no significant difference in gravidity ($p = 0.118$). The mean body mass index (BMI) was 24.84 ± 3.21 kg/m². Hemoglobin levels averaged 11.19 ± 1.28 g/dL, with 38.18% of the women classified as anemic (Hb < 11 g/dL); however, this was not statistically significant ($p = 0.089$). A history of previous miscarriage was reported by 13.64% of participants ($p = 0.337$). Importantly, exposure to smoking or tobacco was noted in 8.18% of cases and was significantly associated with adverse fetal growth parameters ($p = 0.029$*).

Sonographic Parameters (Table 2)

The mean umbilical cord diameter (UCD) was 8.61 ± 1.24 mm, ranging from 5.5 to 11.4 mm, and this was highly significant in relation to fetal growth outcomes ($p < 0.001$*). The estimated fetal weight (EFW) averaged 1,424.35 ± 483.29 g, with a statistically significant association ($p < 0.001$*), suggesting a strong correlation between UCD and fetal mass. The mean amniotic fluid index (AFI) was 13.07 ± 2.69 cm ($p = 0.027$*). Doppler indices also revealed statistically significant findings: the mean S/D ratio was 2.64 ± 0.39 ($p = 0.041$*), pulsatility index (PI) was 1.12 ± 0.18 ($p = 0.033$*), and resistance index (RI) was 0.62 ± 0.06 ($p = 0.039$*). Abnormal umbilical artery Doppler findings were observed in 16.36% of cases, showing a significant link with UCD values and fetal compromise ($p = 0.022$*).

Perinatal Outcomes (Table 3)

The average birth weight was 2,862.14 ± 417.55 g, with a highly significant association with UCD ($p < 0.001$*). The mean gestational age at delivery was 38.07 ± 1.92 weeks, also statistically significant ($p = 0.044$*). Preterm births occurred in 17.27% of cases, significantly associated with reduced UCD ($p = 0.012$*). Cesarean deliveries accounted for 34.55% of births ($p = 0.076$), while vaginal births made up 65.45%. APGAR scores <7 at 1 minute were seen in 9.09% of newborns ($p = 0.051$), and 7.27% had scores <7 at 5 minutes, with the latter reaching statistical significance ($p = 0.038$*). NICU admissions (13.64%) were significantly linked to smaller UCDs ($p = 0.019$*). Perinatal morbidity occurred in 10.91% of cases ($p = 0.014$*), whereas perinatal mortality was low at 1.82% and did not show statistical significance ($p = 0.171$).

Comparison of Umbilical Cord Diameter with Fetal Growth Status (Table 4)

When comparing fetal growth categories, 81.82% of fetuses had normal growth (≥10th percentile) with a mean UCD of 9.01 ± 0.87 mm, whereas 18.18% had fetal growth restriction (FGR) (<10th percentile) with a significantly lower mean UCD of 6.79 ± 0.74 mm. The difference was statistically significant ($p < 0.001$*), emphasizing that a thinner umbilical cord is strongly associated with FGR.

Multiple Regression Analysis (Table 5)

Regression analysis revealed that umbilical cord diameter was a significant independent predictor of several perinatal outcomes. For each millimeter increase in UCD, birth weight increased by 186.73 grams ($p < 0.001$*), and gestational age at delivery increased by 0.23 weeks ($p = 0.012$*). UCD was also a positive predictor of better APGAR scores at 5 minutes ($\beta = 0.18$, $p = 0.011$*). Conversely, UCD was inversely associated with NICU admission ($\beta = -0.37$, $p = 0.009$*) and perinatal morbidity ($\beta = -0.29$, $p = 0.017$*), suggesting that a narrower UCD significantly increases the risk of neonatal complications.

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Table 1: Baseline Demographic and Clinical Characteristics (n = 110)

Parameter	Mean ± SD / n (%)	p-value
Maternal Age (years)	27.45 ± 4.82	0.324
Gestational Age at Scan (weeks)	29.17 ± 5.64	0.041*
Gravidity		
– Primigravida	54 (49.09%)	0.118
– Multigravida	56 (50.91%)	–
Body Mass Index (kg/m²)	24.84 ± 3.21	0.093
Hemoglobin Level (g/dL)	11.19 ± 1.28	0.215
– Anemia (Hb < 11 g/dL)	42 (38.18%)	0.089
History of Previous Miscarriage	15 (13.64%)	0.337
Smoking or Tobacco Exposure	9 (8.18%)	0.029*

Table 2: Sonographic Parameters

Parameter	Mean ± SD	Range	p-value
Umbilical Cord Diameter (mm)	8.61 ± 1.24	5.5 – 11.4	<0.001*
Estimated Fetal Weight (g)	1,424.35 ± 483.29	610 – 2,910	<0.001*
Amniotic Fluid Index (AFI, cm)	13.07 ± 2.69	7.0 – 20.2	0.027*
Umbilical Artery S/D Ratio	2.64 ± 0.39	1.7 – 3.8	0.041*
Pulsatility Index (PI)	1.12 ± 0.18	0.78 – 1.65	0.033*
Resistance Index (RI)	0.62 ± 0.06	0.50 – 0.77	0.039*
Abnormal Doppler Indices	18 (16.36%)	–	0.022*

Table 3: Perinatal Outcomes

Outcome	Mean ± SD / n (%)	p-value
Birth Weight (g)	2,862.14 ± 417.55	<0.001*
Gestational Age at Delivery (wks)	38.07 ± 1.92	0.044*
Preterm Delivery (<37 weeks)	19 (17.27%)	0.012*
Term Delivery (≥37 weeks)	91 (82.73%)	–
Mode of Delivery		
– Cesarean Section	38 (34.55%)	0.076
– Vaginal Delivery	72 (65.45%)	–
APGAR Score <7 at 1 min	10 (9.09%)	0.051
APGAR Score <7 at 5 min	8 (7.27%)	0.038*
NICU Admissions	15 (13.64%)	0.019*
Perinatal Morbidity	12 (10.91%)	0.014*
Perinatal Mortality	2 (1.82%)	0.171

Table 4: Comparison of Umbilical Cord Diameter with Fetal Growth Status

Fetal Growth Status	n (%)	Mean UCD (mm) ± SD	p-value
Normal growth (≥10th percentile)	90 (81.82%)	9.01 ± 0.87	<0.001*
FGR (<10th percentile)	20 (18.18%)	6.79 ± 0.74	

Table 5: Multiple Regression Analysis for Prediction of Perinatal Outcomes Using Umbilical Cord Diameter (UCD)

Dependent Variable	β Coefficient	Standard Error	t-value	p-value	95% CI (Lower–Upper)
Birth weight (g)	186.73	34.15	5.47	<0.001*	119.20 – 254.26
Gestational age at delivery (weeks)	0.23	0.09	2.56	0.012*	0.05 – 0.41
APGAR score at 5 min	0.18	0.07	2.57	0.011*	0.04 – 0.32
NICU admission (Yes = 1, No = 0)	-0.37	0.14	-2.64	0.009*	-0.64 – -0.10
Perinatal morbidity	-0.29	0.12	-2.42	0.017*	-0.53 – -0.05

Adjusted for: Maternal age, gestational age at scan, umbilical artery PI, and AFI.
*Statistically significant ($p < 0.05$)

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DISCUSSION

This study evaluated the clinical significance of umbilical cord diameter (UCD) measured via sonography and its association with fetal growth and perinatal outcomes in a cohort of 110 pregnant women. Our findings suggest that UCD is a valuable and non-invasive predictor of fetal well-being.

The mean UCD in our study population was 8.61 ± 1.24 mm, with significantly smaller diameters observed among fetuses diagnosed with fetal growth restriction (FGR) (mean 6.79 ± 0.74 mm, $p < 0.001$). This aligns closely with findings from Gbande et al. (2023), who reported that UCD was significantly lower in growth-restricted fetuses and advocated its use as a reliable sonographic indicator of fetal growth.[8] Similarly, Mohamed et al. (2022) demonstrated that a reduced UCD measured in the second and third trimesters was significantly associated with adverse perinatal outcomes, particularly FGR, supporting our results.[9]

Our data further showed that UCD was a strong predictor of birth weight, with each 1 mm increase in UCD associated with a 186.73 g increase in birth weight ($p < 0.001$). This association was echoed in the work of Vasques et al. (2003), who found that umbilical cord cross-sectional area strongly correlated with fetal anthropometric parameters such as estimated fetal weight and gestational age.[10] In addition, a thinner UCD in our study significantly predicted earlier gestational age at delivery ($\beta = 0.23$ weeks, $p = 0.012$), increased likelihood of NICU admission ($\beta = -0.37$, $p = 0.009$), and higher rates of perinatal morbidity ($\beta = -0.29$, $p = 0.017$), emphasizing its relevance in prenatal risk stratification.

The significant association between reduced UCD and abnormal Doppler indices in our study ($p = 0.022$) is of particular importance. It indicates impaired placental blood flow, which can compromise fetal oxygenation. This finding resonates with Bhutia et al. (2014), who showed that vascular anomalies such as disrupted Hyrtl's anastomosis are linked to pregnancy complications like hypertension and poor fetal circulation.[11] Likewise, Gordon et al. (2007) provided a hemodynamic explanation, showing that the configuration of placental vasculature, including the umbilical cord, plays a key role in maintaining optimal fetal perfusion.[12]

Furthermore, the umbilical cord's structural integrity may influence neonatal outcomes. In our cohort, thinner UCDs were significantly associated with lower APGAR scores at 5 minutes ($p = 0.038$) and higher NICU admission rates. These outcomes are consistent with the histopathological findings of Qureshi and Jacques (1994), who reported that segmental thinning of umbilical vessels can impair fetal blood flow, potentially leading to hypoxia and lower neonatal vitality scores.[13] The concept that cord morphology reflects fetal well-being was also emphasized by Weissman and Drugan (2001), who highlighted the importance of sonographic assessment of cord thickness in identifying fetuses at risk for chromosomal and developmental abnormalities.[14]

Moreover, the presence of maternal risk factors such as tobacco exposure in 8.18% of cases, which was significantly associated with adverse outcomes ($p = 0.029$), supports earlier studies linking environmental and maternal factors with compromised cord structure. This was similarly discussed by Strong et al. (1993), who found that non-coiled or abnormally thin cords were associated with fetal distress and poor perinatal outcomes.[15]

Although our findings are robust, they also open the path for further investigation. For instance, while Weissman and Jakobi (1997) found increased UCD in gestational diabetes associated with macrosomia, our study focused more on the lower end of the growth spectrum, thus providing a complementary perspective on the diagnostic utility of UCD across varying fetal growth conditions.[16]

CONCLUSION

This study demonstrates that umbilical cord diameter, as measured by sonography, is a valuable and non-invasive marker for assessing fetal growth and predicting perinatal outcomes. A thinner UCD was significantly associated with fetal growth restriction, lower birth weight, earlier gestational age at delivery, and increased NICU admissions. These findings support the integration of UCD measurement into routine prenatal ultrasound evaluations. Incorporating this simple parameter may enhance early detection of at-risk fetuses and improve perinatal management.

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