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Original Research Article

Association of Umbilical Cord Diameter with Antenatal Risk Factors and Neonatal Outcome in Low Birth Weight Infants: A Prospective Observational Study

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Abstract

Background: Umbilical cord thickness reflects the amount of Wharton's jelly and cord vascularity, and has been proposed as a simple, non-invasive antenatal marker of fetal well-being. Reduced cord thickness has been linked with intrauterine growth restriction and low birth weight (LBW), but its relationship with specific maternal risk factors and neonatal morbidity in LBW infants remains incompletely characterized in Indian settings.

Objectives: To determine the correlation of umbilical cord diameter (UCD) with antenatal maternal risk factors, and to assess its association with clinical course and neonatal outcome in low birth weight infants.

Methods: This prospective observational study was conducted in the neonatal intensive care unit (NICU) of the Department of Paediatrics, Geetanjali Medical College and Hospital, Udaipur, over 20 months (April 2024–December 2025). Low birth weight neonates (1250–2500 g, gestational age >32 weeks) were enrolled consecutively; neonates who died within 6 hours of life, had congenital malformations, were discharged against medical advice, or whose parents declined consent were excluded. Umbilical cord diameter was measured 2.5 cm from the neonatal end using a digital Vernier caliper in the horizontal, non-stretched position. Maternal antenatal risk factors and neonatal outcomes were recorded and correlated with UCD. Categorical variables were compared using the chi-square/Fisher's exact test and continuous variables using the t-test; $p<0.05$ was considered significant. Receiver operating characteristic (ROC) curve analysis was used to derive an optimal UCD cut-off.

Results: Of 140 neonates screened, 114 were included (mean birth weight 2329 ± 202 g; 55.3% term). ROC analysis identified a UCD cut-off of ≤11 mm as providing the best combination of sensitivity (90.9%) and specificity (73.9%) for predicting adverse outcome. Neonates with UCD ≤11 mm had significantly lower mean birth weight (2138.7 ± 271.8 g vs. 2386.3 ± 143.4 g, $p<0.001$) and lower gestational age (35.6 ± 1.5 vs. 37.3 ± 1.3 weeks, $p<0.001$) than those with UCD >11 mm. A thin cord (≤11 mm) was significantly associated with maternal pregnancy-induced hypertension (PIH) (p=0.021) and maternal hypothyroidism (p=0.042), but not with gestational diabetes mellitus or premature rupture of membranes. NICU admission was required in 45.5% of neonates with UCD ≤11 mm versus 2.9% with UCD >11 mm ($p<0.001$). Oxygen therapy (47.7% vs. 8.6%, $p<0.001$) and CPAP support (25.0% vs. 1.4%, $p<0.001$) were also significantly more frequent among neonates with a thin umbilical cord.

Conclusion: A reduced umbilical cord diameter (≤11 mm) is significantly associated with maternal PIH and hypothyroidism, and with adverse neonatal outcomes including lower birth weight, lower gestational age, and greater need for NICU admission, oxygen, and CPAP support. Antenatal or immediate postnatal measurement of umbilical cord diameter is a simple, inexpensive, and reproducible tool that may help identify high-risk low birth weight infants who need closer surveillance and neonatal preparedness.

Keywords: Umbilical cord diameter; Wharton's jelly; low birth weight; NICU admission; pregnancy-induced hypertension; neonatal outcome.

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Introduction

The umbilical cord is the vital conduit between the fetus and the placenta, transporting oxygen and nutrients to the fetus and removing metabolic waste [1]. It typically contains two arteries and one vein embedded in a mucoid connective tissue, Wharton's jelly, which cushions the cord vessels against compression during fetal movement and uterine contraction [2]. Umbilical cord thickness (or diameter) is largely determined by the volume of Wharton's jelly and the caliber of the cord vessels, and has emerged as a simple ultrasonographic and postnatal anthropometric parameter reflecting fetal growth and well-being [3].

A thin cord, with reduced Wharton's jelly and compromised vascular development, has been associated with intrauterine growth restriction, low birth weight, and adverse perinatal outcome, whereas an abnormally thick cord has been reported in maternal diabetes, fetal hydrops, and macrosomia [4–6]. Low birth weight (LBW), defined by the World Health Organization as birth weight <2500 g irrespective of gestational age, remains a major contributor to neonatal morbidity and mortality worldwide, accounting for an estimated 15–20% of births globally, with a disproportionate burden in South Asia, including India [7–9]. The aetiology of LBW is multifactorial and includes maternal malnutrition, anaemia, hypertensive disorders of pregnancy, infections, gestational diabetes and inadequate antenatal care, all of which can compromise uteroplacental circulation and, in turn, umbilical cord development [10,11]. Because cord diameter can be measured simply, cheaply and reproducibly — either antenatally by ultrasonography or immediately after delivery — it has been proposed as a non-invasive marker that may allow early identification of high-risk pregnancies even before overt clinical manifestations appear [12–15].

Despite this, data correlating umbilical cord diameter with specific antenatal maternal risk factors and detailed neonatal clinical course in low birth weight infants, particularly from Indian tertiary-care settings, remain limited. This study was therefore undertaken to evaluate the association of umbilical cord diameter with antenatal maternal risk factors and to assess its relationship with the clinical course and neonatal outcome of low birth weight infants.

Aim and Objectives

Aim: To evaluate umbilical cord diameter in newborns and its relationship with antenatal risk factors and neonatal outcome in low birth weight infants.

Primary Objective: To determine the correlation of umbilical cord diameter with antenatal maternal risk factors.

Secondary Objective: To assess the clinical course and neonatal outcome in low birth weight infants in relation to umbilical cord diameter.

Materials and Methods

Study Design and Setting: This was a hospital-based, prospective observational study conducted in the neonatal intensive care unit (NICU) and postnatal wards of the Department of Paediatrics, Geetanjali Medical College and Hospital (GMCH), Udaipur, Rajasthan, India, over a period of 20 months (April 2024 to December 2025).

Study Population: Inclusion criteria: All low birth weight neonates weighing >1250 g and up to 2500 g, with a gestational age >32 weeks, born during the study period.

Exclusion criteria: Neonatal death within 6 hours of life; major congenital malformation; discharge against medical advice (LAMA); and parental refusal to participate.

Sample Size: The minimum sample size was calculated using the formula $N = [(Z1-\alpha/2 + Z1-\beta)^2 \times P(1-P)] / E^2$, with $Z1-\alpha/2 = 1.96$ (95% confidence level), $Z1-\beta = 0.8413$ (80% power), an assumed prevalence of low birth weight (P) of 17.5%, and an acceptable absolute error (E) of 10%, yielding a minimum requirement of 113 neonates. A total of 140 neonates were screened, of whom 114 met the inclusion criteria and were enrolled after exclusion of 26 neonates (Figure 1).

Data collection and measurement of umbilical cord diameter: A detailed general and anthropometric examination (weight, length, head and chest circumference), vital signs, Apgar scores at 1 and 5 minutes, need for resuscitation, and NICU admission were recorded for each enrolled neonate. Umbilical cord diameter was measured after delivery, in the horizontal, non-stretched position, at a point 2.5 cm from the base of the cord at the neonatal end, using a digital Vernier caliper.

Relevant antenatal maternal risk factors — including pregnancy-induced hypertension (PIH), gestational diabetes mellitus (GDM), maternal hypothyroidism, premature rupture of membranes (PROM), amniotic fluid abnormalities, and pre-pregnancy medical illness — were extracted from antenatal records and maternal history.

Statistical Analysis: Data were analysed using descriptive statistics (frequencies, percentages, mean ± standard deviation). Categorical variables were compared using the chi-square test or Fisher's exact test as appropriate, and continuous variables were compared using the independent-samples t-test. Receiver operating characteristic (ROC) curve analysis was performed to determine the optimal UCD cut-off for predicting adverse neonatal outcome; a cut-off of ≤11 mm provided the best combination of sensitivity (90.9%) and specificity (73.9%) and was used to dichotomise the cohort for subsequent analyses. A two-tailed p-value <0.05

was considered statistically significant. Ethical clearance was obtained from the Institutional Ethics Committee, and written informed consent was obtained from parents/guardians of all enrolled neonates prior to inclusion.

Results

Of 140 neonates screened during the study period, 26 were excluded (failure to meet inclusion criteria, declined consent, or incomplete data), leaving 114 neonates for final analysis.

Baseline maternal and neonatal characteristics: The majority of mothers were aged 26–30 years (36.0%), followed by 21–25 years (28.9%); primigravida mothers constituted 58.8% of the cohort. Lower-segment caesarean section was the predominant mode of delivery (63.2%). The study population had a female preponderance (59.6% female vs. 40.4% male). The mean birth weight was 2329 ± 202 g, and 55.3% of neonates were born at term (≥37 weeks) (Table 1).

Table 1: Baseline maternal and neonatal characteristics of the study population (n = 114)

Characteristic	Category	n	%
Maternal age (years)	≤20	5	4.4
	21–25	33	28.9
	26–30	41	36.0
	31–35	23	20.2
	≥36	12	10.5
Gravida	Primigravida	67	58.8
	Multigravida	47	41.2
Mode of delivery	LSCS	72	63.2
	Vaginal delivery	42	36.8
Gender	Male	46	40.4
	Female	68	59.6
Birth weight (g)	<1500	2	1.8
	1500–1999	14	12.3
	2000–2499	73	64.0
	≥2500	25	21.9
Gestational age	Term (≥37 wk)	63	55.3
	Late preterm (34–36 wk)	43	37.7
	Moderate preterm (32–33 wk)	6	5.3
	Very preterm (28–31 wk)	2	1.7

Mean birth weight = 2329 ± 202 g. LSCS: lower-segment caesarean section.

Umbilical cord diameter, birth weight and gestational age: On ROC analysis, a UCD cut-off of ≤11 mm gave the highest combined sensitivity (90.9%) and specificity (73.9%) for adverse outcome and was used to classify neonates into thin-cord (≤11 mm, n=44) and normal-cord (>11 mm, n=70) groups. Neonates with UCD ≤11 mm had a significantly lower mean birth weight and lower mean gestational age than those with UCD >11 mm (Table 2).

Table 2: Correlation of umbilical cord diameter (UCD) with birth weight and gestational age

Parameter	UCD ≤11 mm (n=44)	UCD >11 mm (n=70)	p-value
Mean birth weight (g)	2138.68 ± 271.8	2386.29 ± 143.4	<0.001
Mean gestational age (weeks)	35.6 ± 1.5	37.3 ± 1.3	<0.001

Umbilical cord diameter and antenatal maternal risk factors: Among the study population, PIH was present in 10.5%, maternal hypothyroidism in 7.9%, GDM in 7.0%, PROM in 2.6%, and oligohydramnios in 5.3% of pregnancies. UCD ≤11 mm was significantly associated with PIH (p=0.021) and maternal hypothyroidism (p=0.042).

No significant association was found between UCD and GDM, PROM, or oligohydramnios (Table 3).

Table 3: Association of umbilical cord diameter with maternal antenatal risk factors

Maternal risk factor	Present, UCD ≤11 mm n=44(%)	Present, UCD >11 mm n=70(%)	p-value
Pregnancy-induced hypertension	8 (18.2)	4 (5.7)	0.021
Maternal hypothyroidism	5 (11.4)	4 (5.7)	0.042
Gestational diabetes mellitus	4 (9.1)	4 (5.7)	0.704
PROM / significant leaking	2 (4.5)	1 (1.4)	0.558

PROM: premature rupture of membranes.

Umbilical cord diameter and neonatal outcome: NICU admission was required in 19.3% of neonates overall, but was markedly more frequent among those with UCD ≤11 mm (45.5%) compared with those with UCD >11 mm (2.9%; p<0.001). Similarly, the requirement for oxygen supplementation and CPAP support was significantly higher in the thin-cord group. No significant association was found between UCD and neonatal hypoglycaemia, requirement for inotropic support, mechanical ventilation, or sepsis, although these adverse events were numerically more frequent in neonates with a thin cord (Table 4).

Table 4: Association of umbilical cord diameter with neonatal clinical course and outcome

Neonatal outcome	UCD ≤11 mm n=44(%)	UCD >11 mm n=70(%)	p-value
NICU admission	20 (45.5)	2 (2.9)	<0.001
Oxygen requirement	21 (47.7)	6 (8.6)	<0.001
CPAP requirement	11 (25.0)	1 (1.4)	<0.001
Phototherapy required	4 (9.1)	1 (1.4)	0.704
Birth asphyxia / respiratory distress	3 (6.8)	0 (0.0)	0.056
Neonatal sepsis	2 (4.5)	0 (0.0)	0.148
Mechanical ventilation	1 (2.3)	0 (0.0)	0.386
Inotrope requirement	1 (2.3)	0 (0.0)	0.386
Neonatal hypoglycaemia	1 (2.3)	1 (1.4)	0.386

CPAP: continuous positive airway pressure; NICU: neonatal intensive care unit.

Discussion

In this prospective observational study of 114 low birth weight infants, umbilical cord diameter showed a strong and consistent association with both antenatal maternal risk factors and neonatal outcome, supporting its role as a simple, non-invasive marker of fetoplacental well-being.

The mean birth weight in our cohort (2329 ± 202 g) and the predominance of term/late-preterm deliveries are comparable to other Indian cohorts of low birth weight infants. We found no significant gender difference in mean UCD (male 11.42 ± 2.51 mm vs. female 11.31 ± 2.68 mm), consistent with the observations of Scott and Wilkinson [16]; however, Elghazaly et al., studying 1020 Sudanese neonates, reported significantly larger cord diameters in males, a finding echoed by Barbieri et al. and Sepulveda et al. [17-19]. Such discrepancies may reflect differences in population genetics, nutritional status, or measurement technique.

A key finding of our study was the significant positive correlation between UCD and both birth weight and gestational age: neonates with UCD >11 mm had significantly higher birth weight (2386.3 ± 143.4 g vs. 2138.7 ± 271.8 g, p<0.001) and gestational age (37.3 ± 1.3 vs. 35.6 ± 1.5 weeks, p<0.001) than those with UCD ≤11 mm. Similar inverse relationships between reduced cord thickness and adverse fetal growth have been reported by Narayan et al. and Singh et al., who observed significantly smaller UCD among neonates with antenatal risk factors compared with controls [20,21]. Barbieri et al. similarly demonstrated progressive enlargement of Wharton's jelly area with advancing gestation, up to approximately 32 weeks [18].

Among maternal risk factors, PIH and hypothyroidism were significantly associated with a thin umbilical cord (≤11 mm) in our cohort, consistent with the hypothesis that placental vascular insufficiency in hypertensive disorders and impaired placental development in thyroid dysfunction adversely affect Wharton's jelly deposition and cord growth. Singh et al. reported a similar, and numerically stronger, association between PIH and reduced UCD [21].

In contrast, we found no significant association between UCD and GDM, consistent with Singh et al., Udoh et al., Sepulveda et al., Balkawade and Shinde, and Tahmasebi and Alighanbari, who likewise found no relationship between GDM and cord thickness [21-25]. Similarly, oligohydramnios and PROM were not significantly associated with UCD in our study, which is consistent with Singh et al. but at variance with Narayan et al., who reported significantly reduced cord diameter in severe oligohydramnios [20,21].

The relationship between reduced UCD and adverse neonatal outcome was particularly striking: nearly half (45.5%) of neonates with UCD ≤11 mm required NICU admission compared with only 2.9% of those with UCD >11 mm (p<0.001), and thin-cord infants also had significantly higher requirements for supplemental oxygen and CPAP support. Comparable findings were reported by Singh et al., who found substantially higher NICU admission rates among neonates with antenatal risk factors, and by Narayan et al., who observed significantly lower cord diameter among NICU-admitted neonates [20,21]. Together, these observations reinforce the biological plausibility that a thin umbilical cord — reflecting diminished Wharton's jelly and possible chronic placental insufficiency — predisposes to compromised fetal growth and heightened neonatal respiratory and metabolic vulnerability.

Although associations with neonatal hypoglycaemia, need for inotropic support, mechanical ventilation, and sepsis did not reach statistical significance, the consistent trend toward higher rates of these complications in the thin-cord group suggests that a larger sample may reveal significant associations for these less common outcomes.

Strengths and limitations: Strengths of this study include its prospective design, standardized measurement technique using digital callipers, and comprehensive assessment of both antenatal maternal factors and detailed neonatal outcomes. Limitations include the single-centre design, the relatively modest sample size for detecting associations with less frequent outcomes (e.g., sepsis, hypoglycaemia), the postnatal (rather than purely antenatal ultrasonographic) measurement of cord diameter, and the absence of long-term neurodevelopmental follow-up. Multicentric studies with larger sample sizes and antenatal ultrasonographic cord measurement are needed to validate the proposed UCD cut-off and to strengthen the generalisability of these findings.

Conclusion

A reduced umbilical cord diameter (≤11 mm) is significantly associated with maternal pregnancy-induced hypertension and hypothyroidism, and with adverse neonatal outcomes including lower birth weight, lower gestational age, and increased requirement for NICU admission, oxygen therapy, and CPAP support. Umbilical cord diameter is therefore a simple, inexpensive, and reproducible marker of placental insufficiency and impaired fetal growth that may aid clinicians in identifying high-risk low birth weight infants who require closer antenatal surveillance and enhanced neonatal preparedness at birth.

Ethical Approval: This study was approved by the Institutional Ethics Committee of Geetanjali Medical College and Hospital, Udaipur. Written informed consent was obtained from the parents/guardians of all participating neonates.

Author Contributions: DP: data collection, analysis, manuscript drafting. HJ: study concept, supervision, and critical revision. SG: co-supervision, methodology, critical revision. SM: departmental supervision and final approval.

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