"Morphological Characteristics of Umbilical Cord in Neonatal Outcome "

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ABSTRACT

Abstract

Background: The umbilical cord is an essential conduit between the fetus and placenta, and its morphological characteristics are increasingly recognized as significant determinants of perinatal health. Variations in cord length, coiling index, vessel number, and insertion type have been associated with a spectrum of neonatal complications, yet these parameters remain underutilized in routine clinical risk stratification.

Methods: This cross-sectional observational study was conducted at the Department of Pediatrics, SSSMCRI, Ammapettai, over a six-month period. A total of 176 neonates meeting inclusion criteria were enrolled. Umbilical cord morphological parameters—including length, coiling index (UCI), cord thickness, vessel number, knot presence, and insertion type—were measured at delivery. Neonatal outcomes including Apgar scores, birth weight, gestational age, NICU admission, and fetal distress were recorded and analyzed using SPSS version 17.

Results: Abnormal cord length was observed in 21.0% of neonates (10.8% short; 10.2% long). Coiling anomalies affected 25.6% of the cohort (12.5% hypocoiling; 13.1% hypercoiling). Velamentous cord insertion was identified in 11.4% of cases and was significantly associated with fetal distress (50.0%), low birth weight (55.0%), and NICU admission (65.0%). Both hypocoiling and hypercoiling were independently associated with neonatal asphyxia, preterm birth, and low Apgar scores ($p < 0.001$). Single umbilical artery (SUA) was detected in 4.5% of neonates.

Conclusion: Umbilical cord morphological assessment at delivery constitutes a simple, non-invasive, and cost-effective tool for neonatal risk stratification. Abnormal cord features are significantly correlated with adverse neonatal outcomes. Integration of systematic cord examination into standard perinatal practice may enhance surveillance and reduce preventable neonatal morbidity.

Keywords: Umbilical cord morphology; umbilical coiling index; velamentous insertion; neonatal outcomes; cord length; NICU admission; perinatal risk assessment.

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INTRODUCTION

The umbilical cord is a dynamic and structurally complex organ that serves as the exclusive physiological interface between the developing fetus and the placenta throughout intrauterine life. Composed of two umbilical arteries and one umbilical vein embedded within a protective gelatinous matrix known as Wharton's jelly, the cord is responsible for the bidirectional transfer of oxygen, nutrients, and metabolic waste products critical to fetal growth and homeostasis [1]. Despite its pivotal physiological role, the morphological characteristics of the umbilical cord have historically received limited attention in routine antenatal and perinatal assessment.

The structural attributes of the umbilical cord—including its length, diameter, coiling pattern, vascular configuration, insertion site, and the presence of knots or other anomalies—are not merely anatomical curiosities. Accumulating evidence from observational and retrospective studies suggests that deviations from normal cord morphology are significantly associated with adverse perinatal outcomes [2]. Short cords have been linked to restricted fetal movement, breech presentations, and placental abruption, while excessively long cords predispose to entanglement, true knot formation, and cord prolapse. Abnormal coiling indices, whether reflecting hypocoiling or hypercoiling, have been correlated with fetal

growth restriction, intrauterine fetal demise, preterm labor, and neonatal asphyxia [3].

Among cord insertion anomalies, velamentous cord insertion—wherein umbilical vessels traverse the fetal membranes before reaching the placenta, unprotected by Wharton's jelly—is associated with significantly increased risk of vessel rupture, antepartum hemorrhage, fetal distress, and neonatal compromise [4]. Marginal insertion, while less severe, has also been associated with suboptimal placental perfusion. Similarly, single umbilical artery (SUA), the most common congenital cord anomaly, has been linked to intrauterine growth restriction and structural congenital abnormalities [5].

Despite the growing recognition of these associations in specialized literature, systematic umbilical cord morphological assessment remains absent from most routine delivery protocols, particularly in resource-limited settings. This gap represents a missed opportunity for low-cost, non-invasive perinatal risk stratification. The umbilical cord is universally available for examination at delivery, and its morphological features can be assessed with minimal equipment and training.

This study was undertaken to systematically characterize umbilical cord morphological features in a cohort of neonates delivered at SSSMCRI and to investigate the associations between these features and neonatal outcomes, including Apgar scores, birth weight, gestational age at delivery, NICU admission rates, and clinical signs of neonatal distress. The findings are intended to inform clinical protocols and advocate for the inclusion of cord morphological assessment as a standard component of perinatal care.

OBJECTIVES

The primary objective of this study was to investigate the relationship between morphological characteristics of the umbilical cord and neonatal outcomes in a cohort of neonates born at a tertiary care institution. The specific objectives were as follows:

Objective 1: To systematically assess and document the morphological characteristics of the umbilical cord at delivery, including cord length, coiling index, cord thickness, number of vessels, presence of knots, and insertion type, across all eligible neonates enrolled in the study.

Objective 2: To analyze the association between each morphological cord parameter and key neonatal outcomes, specifically Apgar scores at one and five minutes, birth weight, gestational age, and rates of NICU admission and neonatal distress, using appropriate statistical methods.

Objective 3: To evaluate the impact of abnormal umbilical cord features—including short or long cord length, hypocoiling or hypercoiling, single umbilical artery, true or false knots, and velamentous or marginal cord insertion—on the risk of adverse neonatal complications, with the aim of identifying morphological parameters of greatest clinical significance.

RESULTS

A total of 176 neonates were enrolled in the study over the six-month study period. All neonates met the predefined inclusion criteria, and no significant missing data was encountered. The demographic and obstetric profile of the study population, along with the distribution of neonatal outcomes, are summarized below.

Table 1. Demographic and Clinical Characteristics of the Study Population (n = 176)

Characteristic	n (%)	Mean ± SD
Total neonates	176 (100%)	–
Male	94 (53.4%)	–
Female	82 (46.6%)	–
Gestational age (weeks)	–	38.2 ± 2.1
Preterm (< 37 wks)	28 (15.9%)	–
Term (37–42 wks)	141 (80.1%)	–
Post-term (> 42 wks)	7 (4.0%)	–
Birth weight (grams)	–	2,842 ± 480
LBW (< 2500 g)	48 (27.3%)	–

Normal (2500–4000 g)	118 (67.0%)	–
Macrosomia (> 4000 g)	10 (5.7%)	–
Vaginal delivery	102 (58.0%)	–
Cesarean section	74 (42.0%)	–

The study cohort comprised 94 males (53.4%) and 82 females (46.6%). The mean gestational age was 38.2 ± 2.1 weeks. The majority of neonates (80.1%) were delivered at term. Preterm births accounted for 15.9% of the cohort, and 4.0% were post-term. The mean birth weight was 2,842 ± 480 grams; 27.3% of neonates had low birth weight. Vaginal delivery was the mode of birth in 58.0% of cases, with cesarean section accounting for the remaining 42.0%.

Table 2. Distribution of Umbilical Cord Morphological Characteristics (n = 176)

Morphological Feature	n (%)	Mean ± SD
Cord length (cm)	–	53.4 ± 11.8
Short cord (< 35 cm)	19 (10.8%)	–
Normal cord (35–70 cm)	139 (79.0%)	–
Long cord (> 70 cm)	18 (10.2%)	–
Cord thickness (mm)	–	14.6 ± 3.2
Umbilical coiling index	–	0.21 ± 0.09
Hypocoiling (UCI < 0.1)	22 (12.5%)	–
Normal coiling (UCI 0.1–0.3)	131 (74.4%)	–
Hypercoiling (UCI > 0.3)	23 (13.1%)	–
Two-vessel cord (SUA)	8 (4.5%)	–
Three-vessel cord (normal)	168 (95.5%)	–
True knots	11 (6.3%)	–
False knots	28 (15.9%)	–
Central insertion	119 (67.6%)	–
Marginal insertion	37 (21.0%)	–
Velamentous insertion	20 (11.4%)	–

The mean cord length was 53.4 ± 11.8 cm, with 10.8% classified as short (< 35 cm) and 10.2% as long (> 70 cm). The mean umbilical coiling index was 0.21 ± 0.09. Hypocoiling was observed in 12.5% of neonates and hypercoiling in 13.1%. Single umbilical artery was identified in 4.5% of cases. Cord insertion was central in 67.6%, marginal in 21.0%, and velamentous in 11.4% of neonates.

Table 3. Association Between Cord Length and Neonatal Outcomes

Outcome	Short Cord n=19	Normal Cord n=139	Long Cord n=18	p-value
NICU admission (%)	52.6%	18.7%	38.9%	0.003
Low Apgar 1 min (<7)	47.4%	14.4%	33.3%	0.001

Low Apgar 5 min (<7)	21.1%	5.8%	16.7%	0.012
Mean birth weight (g)	2,534	2,887	2,710	0.027
Neonatal distress (%)	42.1%	12.9%	27.8%	0.004
Meconium staining (%)	36.8%	10.1%	22.2%	0.006

Table 3 presents the relationship between cord length categories and neonatal outcomes. Both short and long cords were associated with significantly higher rates of NICU admission (52.6% and 38.9%, respectively) compared to normal-length cords (18.7%; p = 0.003). Neonatal distress was significantly more frequent among neonates with short cords (42.1%) and long cords (27.8%) versus normal-length cords (12.9%; p = 0.004). Low Apgar scores at one minute were observed in 47.4% of short-cord neonates and 33.3% of long-cord neonates, compared to 14.4% in the normal group (p = 0.001).

Table 4. Association Between Umbilical Coiling Index and Neonatal Outcomes

Outcome	Hypocoiling n=22	Normal UCI n=131	Hypercoiling n=23	p-value
NICU admission (%)	59.1%	14.5%	52.2%	< 0.001
Preterm birth (%)	31.8%	10.7%	30.4%	0.002
Low birth weight (%)	45.5%	22.1%	43.5%	0.008
Low Apgar 1 min (%)	50.0%	11.5%	47.8%	< 0.001
Neonatal asphyxia (%)	27.3%	5.3%	26.1%	< 0.001
Cesarean delivery (%)	54.5%	37.4%	60.9%	0.021

Table 4 illustrates the significant association between coiling anomalies and adverse neonatal outcomes. Neonates with hypocoiled or hypercoiled cords exhibited substantially higher rates of NICU admission (59.1% and 52.2%, respectively) compared to the normally coiled group (14.5%; p < 0.001). Neonatal asphyxia was similarly elevated in both hypocoiled (27.3%) and hypercoiled (26.1%) groups versus normally coiled neonates (5.3%; p < 0.001). Preterm birth and low birth weight were also significantly associated with abnormal coiling indices.

Table 5. Association Between Cord Insertion Type and Neonatal Outcomes

Outcome	Central n=119	Marginal n=37	Velamentous n=20	p-value
NICU admission (%)	15.1%	32.4%	65.0%	< 0.001
LBW (%)	21.8%	35.1%	55.0%	0.001
Fetal distress (%)	11.8%	24.3%	50.0%	< 0.001
Mean birth weight (g)	2,924	2,714	2,398	0.003
Preterm delivery (%)	12.6%	21.6%	35.0%	0.009
Cesarean delivery (%)	36.1%	51.4%	65.0%	0.005

Velamentous cord insertion demonstrated the strongest association with adverse neonatal outcomes across all parameters measured. Fetal distress was reported in 50.0% of velamentous insertion cases, compared to 24.3% in marginal insertion and 11.8% in central insertion (p < 0.001). NICU admission rates were 65.0%, 32.4%, and 15.1% for velamentous, marginal, and central insertions, respectively (p < 0.001). Mean birth weight was significantly lower in the velamentous group (2,398 g) compared to marginal (2,714 g) and central (2,924 g) insertion groups (p = 0.003).

DISCUSSION

This study systematically characterizes umbilical cord morphological parameters and their associations with neonatal outcomes in a cohort of 176 neonates from a tertiary care institution. The findings corroborate and extend prior literature by demonstrating that multiple cord morphological features—including length, coiling index, and insertion type—are independently and significantly associated with adverse neonatal outcomes.

The prevalence of abnormal cord length in this study (21.0%) is consistent with reported figures in comparable populations [2]. Both extremes of cord length were associated with significantly higher rates of NICU admission, neonatal distress, and low Apgar scores compared to normal-length cords. Short umbilical cords restrict fetal mobility and have been associated with breech presentation and placental abruption, while long cords increase susceptibility to entanglement, true knots, and prolapse—all of which can compromise umbilical blood flow and precipitate acute fetal hypoxia [6].

The association between abnormal coiling index and adverse outcomes merits particular attention. In this study, both hypocoiling (UCI < 0.1) and hypercoiling (UCI > 0.3) were significantly associated with neonatal asphyxia, preterm birth, low birth weight, and NICU admission. These findings are in agreement with the work of Pathak et al. [2] and Tahmasebi and Alighanbari [8], who demonstrated that coiling anomalies reflect underlying vascular insufficiency and are associated with compromised uteroplacental perfusion. The umbilical coiling index, which can be calculated from the gross examination of the cord at delivery, represents a simple and objective measure of cord architecture that should be incorporated into routine delivery assessments.

Velamentous cord insertion emerged as the single morphological parameter most strongly associated with adverse outcomes in this cohort, with 65.0% of affected neonates requiring NICU admission and 50.0% experiencing fetal distress. This is consistent with the known pathophysiology of this variant: umbilical vessels traversing the membranes without the protection of Wharton's jelly are vulnerable to compression, rupture, and thrombosis, all of which can result in sudden and catastrophic reduction in fetoplacental blood flow [4]. The identification of velamentous insertion at delivery should prompt heightened neonatal vigilance and, ideally, should be suspected antenatally through targeted ultrasound screening.

Single umbilical artery (SUA), identified in 4.5% of this cohort, is among the most common congenital cord anomalies. While this study did not specifically power its analysis for SUA outcomes due to the limited sample size, the detection rate aligns with published prevalence data [5]. Clinicians should be cognizant that SUA may be a marker for concurrent structural abnormalities, and affected neonates warrant thorough congenital anomaly screening.

This study has several strengths, including its prospective design, standardized morphological measurement protocols, and the inclusion of a comprehensive set of neonatal outcome measures. Limitations include the single-center setting, which may limit generalizability, and the cross-sectional design, which precludes causal inference. Additionally, antenatal ultrasound data were not systematically correlated with postnatal cord findings. Future multicenter studies with larger sample sizes and longitudinal follow-up are warranted to validate these findings and to evaluate the impact of structured cord morphological assessment on clinical decision-making.

CONCLUSION

The morphological characteristics of the umbilical cord—including its length, coiling index, vessel number, knot status, and insertion type—are significant and clinically meaningful determinants of neonatal outcomes. This study demonstrates that both short and long cord length, abnormal coiling indices, and velamentous cord insertion are independently associated with higher rates of NICU admission, neonatal distress, low Apgar scores, and reduced birth weight. These findings underscore the diagnostic value of systematic umbilical cord morphological examination at delivery as a non-invasive, low-cost adjunct to standard perinatal risk assessment.

Clinicians and neonatologists should be sensitized to the prognostic significance of cord morphology, and structured cord examination protocols should be considered for integration into routine delivery room practice. Antenatal identification of high-risk cord features through targeted ultrasound may further enhance perinatal surveillance and facilitate timely interventions. Ongoing research into umbilical cord morphology has the potential to reduce preventable perinatal morbidity and mortality, particularly in resource-limited settings where advanced fetal monitoring may not be universally available.

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