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Clinical Utility of Umbilical Coiling Index in Perinatal Risk Stratification

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ABSTRACT

Background: The umbilical cord plays an essential role in feto-maternal exchange. Its vascular coiling contributes to its structural strength and function. The umbilical Coiling Index (UCI) is a simple measure used to assess this coiling. Abnormal coiling, either reduced or excessive, has been linked to adverse perinatal outcomes, but data from Indian populations remain limited.

Objective: To study the association between the Umbilical Coiling Index (UCI) and perinatal outcomes in term pregnancies.

Methods: This cross-sectional observational study was carried out over 24 months in the Department of Obstetrics and Gynaecology, ELMCH, Lucknow. A total of 196 term singleton deliveries (37–41 weeks) were included. The umbilical cord was examined postnatally for length, number of complete vascular coils, and other morphological features. UCI was calculated as the number of complete coils per centimetre of cord length and was categorised, based on the distribution in the study population, as hypo-coiled (UCI<0.12), normo-coiled (UCI-0.12–0.36), and hyper-coiled (UCI>0.36). Maternal, foetal, and neonatal outcomes were analysed statistically using SPSS version 25.0, with p<0.05 considered significant.

Results: The mean UCI was 0.161 ± 0.034 spirals/cm. Of 196 cases, 63.3% were normo-coiled, 14.8% hypo-coiled, and 21.9% hyper-coiled. Abnormal coiling was associated with adverse outcomes, including low Apgar scores, increased NICU admissions, foetal growth restriction and abnormal foetal heart rate patterns. Caesarean section rates were higher among hypo-coiled cords due to non-reassuring foetal status. Maternal comorbidities—particularly hypertensive disorders and GDM—showed frequent overlap with abnormal UCI.

Conclusion: Both hypo- and hyper-coiled umbilical cords were linked with adverse perinatal outcomes. UCI measurement, especially when integrated with foetal growth and Doppler studies, can serve as a simple, non-invasive marker for antenatal risk stratification. Larger multicentric studies are warranted to establish its routine use in obstetric practice.

KEYWORDS: *Foetal growth restriction, Hypo-coiling, Hyper-coiling, NICU admission, Perinatal outcome, Umbilical Coiling Index.*

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INTRODUCTION

The umbilical cord is essential for maintaining foetal circulation, enabling the transfer of oxygen and nutrients from mother to the foetus while removing waste products. Structurally, the cord contains two arteries and one vein enclosed within Wharton's jelly, a mucopolysaccharide-rich matrix which protects the vessels from torsion, compression, and traction. Strong et al. introduced the concept of UCI (umbilical coiling index) in 1994, highlighting the importance of vascular coiling in maintaining cord function.[1] Normal coiling is believed to provide flexibility and strength to the cord, safeguarding foetal circulation. However, abnormal coiling either hypo-coiling [too few spirals] or hyper-coiling [too many spirals], has been associated with unfavourable perinatal outcomes including foetal growth restriction [FGR], abnormal foetal heart rate, preterm birth, and stillbirth.[2]

Although UCI has been studied in different populations, there is limited data from Indian settings. Given the ongoing burden of maternal and perinatal morbidity, it is important to evaluate simple and reliable markers that may help in early risk identification.

This study seeks to bridge that gap by evaluating the association between UCI and perinatal outcomes in term pregnancies. By combining careful measurement of cord

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coiling at birth with detailed maternal and neonatal data, it aims not only to clarify the clinical significance of UCI but also to contribute toward more proactive strategies in antenatal risk assessment and obstetric care.

METHODOLOGY

This cross-sectional observational study was carried out over 24-months [2022–2025] in the Department of Obstetrics and Gynaecology, ELMCH, Lucknow. The study population comprised women delivering singleton, live-born infants between 37–41 weeks of gestation. Deliveries were included regardless of mode [vaginal or cesarean], provided the umbilical cord was available for immediate postnatal examination. A total of 196 cases were enrolled. Inclusion criteria were: cephalic presentation and complete perinatal records. Multiple gestation, non-cephalic presentation, preterm birth, intrauterine foetal demise [IUFD], and major congenital anomalies, were excluded from the study.

Umbilical cord assessment: Immediately after birth, the cord was clamped and cut approximately 5 cm from the neonatal umbilical insertion. It was then laid on a sterile flat surface without stretching. The cord length was measured from the foetal end to placental insertion using a standardised non-elastic tape, with 5 cm added to account for the initial clamping site. Coiling was assessed by counting complete vascular coils, defined as a 360° spiral of the vessels around Wharton's jelly. To reduce error, the first and last 5 cm of the cord were excluded. The UCI was calculated as: UCI=Number of complete coils/ Cord length [cm].Other cord features such as coiling direction, nuchal cord, and false knots were noted. Based on the distribution in the study population, UCI was categorised as: [a] Hypo-coiled: UCI < 0.12, [b] Normo-coiled: UCI 0.12–0.36, [c] Hyper-coiled: UCI > 0.36.

Neonatal Outcomes: Data was collected from records and direct assessment, including birth weight, Apgar scores at 1 and 5 minutes, and neonatal intensive care unit [NICU] admission. Cases with anomalies requiring exclusion were reclassified.

Statistical Analysis: Data analysis was carried out using SPSS software [version 25.0]. Chi-square test or Fisher's exact test was used for categorical variables while the t-test or ANOVA was used for continuous variables. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 196 women with term singleton pregnancies were included in the study. The mean maternal age was 27.7 ± 4.9 years, with nearly half [49.5%] falling in the 26–30 year age group. Multiparous women comprised a slightly larger proportion [52.6%] compared to primigravidas [47.4%]. (Table –1)

Umbilical Coiling Index Distribution: The mean UCI was 0.161 ± 0.034 spirals/cm. Based on percentile cut-offs derived from the study population, cords were classified as: [a] Normo-coiled: 124 cases [63.3%]; [b] Hypo-coiled: 29 cases [14.8%]; [c] Hyper-coiled: 43 cases [21.9%]. [Table -2]

Perinatal Outcomes: Adverse perinatal events were more common in pregnancies with abnormal coiling. Foetal heart rate abnormalities were present in just over half of all cases [51.0%], with a higher prevalence among both hypo-coiled and hyper-coiled groups. Nearly half of the newborns [46.4%] required NICU admission, and low birth weight [<2.5 kg] was observed in 23.5% of babies. (Table 3,4)

Meconium-stained amniotic fluid, an indicator of foetal distress, occurred in 43.4% of cases. A nuchal cord was present in 53.6% of deliveries, though not all were clinically significant. FGR was identified in 44.9% of newborns, and this was more frequently associated with abnormal coiling indices. (Table 3,4)

Maternal Outcomes: Hypertensive disorders and gestational diabetes mellitus [GDM] were each present in 52.0% of cases, while anaemia and premature rupture of membranes were noted in 46.9%. These co-morbidities are often overlapped with abnormal UCI, amplifying the risk of adverse outcomes. (Table –5)

Table 1: Association of age and parity with umbilical coiling index.

Variable		No.	**Normocoiled**		Hypocoiled		***p-value* (Hypo vs Normo)**	**Hyper coiled**		***p-value* (Hyper vs Normo)**
			No.	%	No.	%		No.	%	
Age	< 20 yr	18	6	4.8%	4	13.8%	chi sq. =15.49, p=0.004	8	18.6%	chi sq. =16.75, p=0.002
	20 – 25 yr	28	12	9.7%	7	24.1%		9	20.9%	
	26 – 30 yr	97	73	58.9%	11	37.9%		13	30.2%	
	31 – 35 yr	46	31	25.0%	4	13.8%		11	25.6%	
	> 35 yr	7	2	1.6%	3	10.3%		2	4.7%	
Parity	Primi	93	60	48.4%	11	37.9%	chi sq.=1.03, p=0.309	22	51.2%	chi sq.=0.10, p=0.754
	Multi	103	64	51.6%	18	62.1%		21	48.8%	

Mode of Delivery: Cesarean section was the predominant mode of delivery, accounting for 66.8% of cases [42.3% elective and 24.5% emergency]. Vaginal deliveries were less frequent, with 19.4% spontaneous and 13.8% induced. Pregnancies with abnormal UCI, particularly hypo-coiling, demonstrated a higher likelihood of operative intervention due to non-reassuring foetal status. (Table 6)

Table 2: Distribution of cases according to Umbilical Coiling Index.

Parameter	**UCI**
Mean	0.161+0.34
10th percentile	0.112
median	0.161
90th percentile	0.208
Category	N [%]
Normocoiled	124 [63.3%]
Hypo coiled	29[14.8%]
Hyper coiled	43[21.9%]

Table 3: Perinatal Outcomes among study participants.

Perinatal Outcome		**No.**	**%**
Fetal Heart Rate	110 to 160 bpm	96	49.0%
	<110 or >160 bpm	100	51.0%
Meconium stained Liquor	Liquor -Clear	111	56.6%
	Liquor- MSL	85	43.4%
NICU Admission	Not Required	105	53.6%
	Required	91	46.4%
Nuchal Cord	Absent	91	46.4%
	Present	105	53.6%
Oligohydramnios	Liqour- Adequate	85	43.4%
	Liquor-Reduced	111	56.6%
Hypertensive Disorders	Absent	94	48.0%
	Present	102	52.0%
Anaemia	Hb>11 g/dl	104	53.1%
	Hb<11g/dl	92	46.9%
PROM	Membrane Intact	104	53.1%
	Membrane Ruptured before labour	92	46.9%
GDM	OGTT- Negative	94	48.0%
	OGTT- Positive	102	52.0%
FGR	Absent	108	55.1%
	Present	88	44.9%
Birth weight	< 2.5 kg	46	23.5%
	>= 2.5 kg	150	76.5%

Table 4: Association of Perinatal Outcome with Umbilical Coiling Index.

Fetal outcome	Normocoiled (N=124)	Hypocoiled (N=29)	Odd ratio (95% CI), *p value* (hypocoiled vs normocoiled)	Hypercoiled (N=43)	Odd ratio (95% CI), *p value* (hypercoiled vs normocoiled)
Fetal distress present	59 (47.6%	11 (37.9%)	0.67 (0.29–1.54), p=0.348	18 (41.9%)	0.79 (0.39–1.60), p=0.517
Meconium in liquor	45 (36.3%)	14 (48.3%)	1.64 (0.73–3.70), p=0.234	26 (60.5%)	2.68 (1.32–5.48), p=0.006
Nuchal cord present	64 (51.6%)	15 (51.7%)	1.00 (0.45–2.26), p=0.991	26 (60.5%)	1.43 (0.71–2.90), p=0.316
Apgar at 5 min, <7	11 (8.9%)	4 (13.8%)	1.64 (0.48–5.59), p=0.422	5 (11.6%)	1.35 (0.44–4.14), p=0.597
Birth weight <2.5 kg	26 (21.0%)	13 (44.8%)	3.06 (1.31–7.17), p=0.008	7 (16.3%)	0.73 (0.29–1.84), p=0.505
Birth weight >2.5 kg	98 (79.03%)	16 (55.17%)	0.33 (0.14–0.76), p=0.016	36 (83.72%)	1.36 (0.54–3.42), p=0.658

Table 5: Association of Maternal Outcome with Umbilical Coiling Index.

Maternal outcome (n)	Normocoiled (N=124)	Hypocoiled (N=29)	Odd ratio (95% CI), *p value* (hypocoiled vs normocoiled)	Hypercoiled (N=43)	Odd ratio (95% CI), *p value* (hypercoiled vs normocoiled)
Oligohydramnios	72 (58.1%)	16 (55.2%)	0.89 (0.39–2.01), p=0.965	22 (51.2%)	0.47 (0.23–0.96) p=0.477
Hypertensive disorders	65 (52.4%)	15(51.7)%	0.97 (0.43–2.18), p=0.998	23 (53.5%)	1.04 (0.52–2.09) p=1
Anaemia	57 (46.0%)	18(62.1%)	1.92 (0.84–4.41), p=0.092	18 (41.9%)	0.85 (0.42–1.71) p=0.723
PROM	59 (47.6%)	19 (65.5%)	2.09 (0.90–4.86), p=0.050	16 (37.2%)	0.65 (0.32–1.33), p=0.239
GDM	65 (52.4%)	16 (55.2%)	1.12 (0.50–2.52), p=0.961	20 (46.5%)	0.79 (0.39–1.58), p=0.504
Polyhyrodramnios	61 (49.2%)	18 (62.1%)	1.69 (0.74–3.87) p=0.264	20 (46.5%)	0.90 (0.45–1.80), p=0.762

Table 6: Mode of Delivery among study participants.

Mode of Delivery	Normocoiled (N=124)	Hypocoiled (N=29)	Odd ratio (95% CI), *p value* (hypocoiled vs normocoiled)	Hypercoiled (N=43)	Odd ratio (95% CI), *p value* (hypercoiled vs normocoiled)
Spontaneous vaginal	23 (18.5%)	10 (34.5%)	2.31 (0.95–5.63), p=0.060	5 (11.6%)	0.58 (0.21–1.63), p=0.295
Induced vaginal	14 (11.3%)	4 (13.8%)	1.26 (0.38–4.15), p=0.707	9 (20.9%)	2.08 (0.83–5.23), p=0.114
Emergency cesarean	34 (27.4%)	6 (20.7%)	0.69 (0.26–1.84), p=0.458	8 (18.6%)	0.61 (0.26–1.44), p=0.251
Elective cesarean	53 (42.7%)	9 (31.0%)	0.60 (0.25–1.43), p=0.248	21 (48.8%)	1.28 (0.64–2.56), p=0.488

DISCUSSION

In this study, we observed that both hypo- and hyper-coiling of the umbilical cord were associated with clinically significant perinatal outcomes—notably low Apgar scores, higher NICU admissions, foetal distress, and FGR. These findings are broadly in agreement with previous studies including the meta-analyses by Pergialiotis V et al. which reported that deviation at either end of the coiling spectrum predisposes babies to greater risk.3 We observed that hyper-coiling was more commonly asssociated with foetal growth restriction, and hypo-coiling with intrapartum compromise. Similar patterns have been reported in earlier Indian and international studies.[2,4]

The relevance of these findings becomes more important when UCI measurements are done during antenatal sonographic studies. For example, Mittal et al. demonstrated at 20–24 weeks that hypo-coiling predicted oligohydramnios and abnormal foetal heart rate, while hyper-coiling signalled a risk of growth restriction. Similarly, Sharma et al. contended for incorporating UCI measurement into routine anomaly scans, as it reliably flagged foetuses at risk for preterm birth and low birthweight. Earlier physiologic studies also support this biological plausibility—showing that antenatal UCI correlates well with postnatal UCI, and even with venous flow dynamics.

Recent studies suggest that abnormal cord coiling is not just an isolated finding at birth but may reflect a process that begins earlier in pregnancy. Subashini et al.[5] reported a strong correlation between antenatal and postnatal UCI and found higher rates of emergency cesarean delivery and low birthweight in cases with abnormal coiling. Similarly, Boyama and Yılmaz[6] observed that both hypo- and hyper-coiled cords were associated with increased risk of adverse outcomes at term. These findings support the view that UCI may have both predictive and clinical importance.

However, not all studies have shown a clear correlation between abnormal cord coiling and unfavourable outcomes. Kumar et al.,[7] did not find a statistically significant link between abnormal coiling and perinatal outcomes in term pregnancies. Similarly, a large cohort study in 2024[8] reported that although abnormal coiling was associated with maternal diabetes, its relationship with neonatal outcomes became weaker after adjusting for other factors. This suggests that the impact of UCI may be less obvious in low risk, term pregnancies, or when outcomes are analysed together.

From a pathophysiological perspective, abnormal coiling may affect fetoplacental circulation, predisposing to venous or chorionic plate thrombosis, cord stenosis, and impaired feto-placental perfusion that can explain both the chronic course of growth restriction and the acute intrapartum intolerance we observed.[9]

Interestingly, improving how we measure coiling may help make predictions more accurate. For example, modified indices that focus specifically on venous coiling have shown stronger associations with decelerations, operative delivery, and nuchal cord entanglement. This suggests that looking at individual vessel patterns may provide additional insights beyond the overall UCI.[8] Methodological differences across studies, including timing of assessment (antenatal vs postnatal), variation in cut off values and differences in study populations, may account for variability in findings. For Indian practice, however, the overlap between our findings and those of mid-trimester UCI studies is particularly compelling. While UCI should not be viewed in isolation, our findings suggest that it can serve as a valuable complement to routine surveillance, particularly when interpreted alongside foetal growth trends and Doppler studies.[10] Incorporating UCI into mid-trimester anomaly scans may offer a simple, non-invasive means of refining risk assessment without adding significant burden to clinical workflows.

As with any single-centre study, our results call for validation in larger, multi-centre Indian cohorts. Yet the message is clear: the pattern of cord coiling carries meaning, and attention to it may help us identify vulnerable pregnancies a little earlier, intervene a little sooner, and ultimately give more babies the best possible start in life.

Incorporating machine-learning tools that analyse both coiling index and vessel texture features on Doppler images offers exciting possibilities for clinical translation. Until then, UCI should be seen as a useful complement—rather than a replacement—for established foetal surveillance tools. Its true strength may lie in combination, particularly when interpreted alongside growth trends and uterine/umbilical Doppler velocimetry.

CONCLUSION

Abnormal umbilical coiling, whether hypo- or hyper-coiled, was associated with low Apgar scores, NICU admissions, foetal growth restriction, and intrapartum distress. UCI assessment, especially when combined with foetal growth, and Doppler studies, may enhance risk stratification. Larger multi-centre studies are needed to confirm its role in routine Indian obstetric practice.

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