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Umbilical Cord Coiling Index as A Marker of Perinatal Outcome

Sadiq Jan[1], Ayesha Qamar[2*], Muhammad Asif Javed[3], Seharish Zulfiqar[4], Sara Jamil[5] and Moizza Aziz[6]

[1]Department of Gynecology, Islamic International Medical College, Islamabad, Pakistan
[2]Department of Gynecology, Pakistan Aeronautical Complex Hospital Kamra, Pakistan
[3]Department of Radiology, Imran Idrees Teaching Hospital, Sialkot, Pakistan
[4]Department of Anatomy, Rai Medical College, Sargodha, Pakistan
[5]Department of Gynecology, Frontier Medical College, Abbottabad, Pakistan
[6]Department of Gynecology, Pakistan Air Force Hospital, Islamabad, Pakistan

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Corresponding Author:
Ayesha Qamar
Department of Gynecology, Pakistan Aeronautical Complex Hospital Kamra, Pakistan
ashley.virk90@gmail.com

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ABSTRACT

Umbilical cord coiling patterns have a considerable effect on both pregnancy outcomes and fetal health. **Objectives:** To assess the postnatal umbilical coiling index and investigate its association with normal coiling, hypo-coiling, and hyper-coiling patterns about maternal and perinatal outcomes. **Methods:** This cross-sectional study was conducted at the Obstetrics and Gynecology Department of Pakistan Aeronautical Complex Hospital Kamra from January 2024 to June 2024. The patterns of umbilical cord coiling were analyzed in 200 Livebirths. This study utilized convenience sampling to select a sample of live births for assessing the relationship between the umbilical cord coiling index and perinatal outcomes. Data were collected on maternal factors and neonatal outcomes, including Apgar scores. Statistical analysis was conducted using SPSS version 26.0, with descriptive statistics to summarize the data and inferential tests (e.g., chi-square test, t-test, regression analysis) to evaluate associations between umbilical cord coiling patterns and perinatal outcomes. **Results:** The study revealed that hypo-coiled cords were linked to older maternal age (≥35 years) and higher gestational diabetes rates. Hypo-coiled infants had a low birth weight incidence of 28.6%, significantly lower coiling index (0.07 ± 0.02), and lower Apgar scores at one minute (6.8 ± 1.2) and five minutes (8.2 ± 0.9). These results suggest umbilical cord coiling patterns are crucial indicators of maternal health and neonatal outcomes, highlighting the need for careful monitoring in at-risk pregnancies. **Conclusions:** It was concluded that there is a correlation between neonatal outcomes and factors such as maternal age, gestational diabetes, and abnormal umbilical cord coiling patterns.

INTRODUCTION

The umbilical cord, commonly known as the "funis," plays a crucial role in fetal development, health, and survival. It acts as the main pathway for delivering nutrients and oxygen from the placenta to the fetus while also facilitating the removal of waste products [1]. The structure and coiling patterns of the umbilical cord can greatly affect fetal health and the outcomes of pregnancy. An effectively functioning umbilical cord is vital for maintaining proper blood flow, which is essential for promoting healthy growth and development of the fetus [2]. Blood from the fetus can enter and exit the placenta through this tri-vascular channel. All 360-degree spiral loops of umbilical veins encircling the Wharton's jelly are referred to as coils. Unknown coiling origins exist in around 95% of umbilical cords. They calculated "The Index of Twist," a measurement of umbilical coiling, by dividing the total number of coils by the length of the umbilical cord [3]. Among the various features of the human umbilical cord, one of the most enigmatic and fascinating aspects is the blood vessels' twisted or spiral path. Though the names are used interchangeably to prevent confusion, the vessels of the cord are mathematically wrapped as cylindrical helices rather than spirals [4]. Restricted blood flow is one of the many issues linked to this illness. This might have negative

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effects like low birth weight, fetal growth limitation, and an increase in caesarean delivery rates [5]. Conversely, hyper-coiled cords, due to their excessively high number of coils, have an Umbilical Cord Index (UCI) that is more than the 90th percentile. Hyper-coiling can lead to complications including cord entanglement, compression, as well as torsion, which lead to potential fetal harm and adversely impact Apgar scores, however, it may look advantageous because of its extended length and apparent toughness [6]. Healthcare practitioners need to understand the importance of these coiling variations since improper coiling during pregnancy may suggest that stricter surveillance and intervention are necessary [7]. A recent study suggests that maternal characteristics such as age, and parity, along with underlying medical concerns may affect patterns of umbilical cord coiling. Thus, to enhance prenatal care and the overall health of women and fetuses, it is imperative to examine the relationships among cord coiling patterns, mother-related factors, and newborn outcomes [8]. The umbilical cord coiling index is a critical parameter that can influence neonatal outcomes. Variations in cord coiling have been associated with various maternal factors, such as age and gestational diabetes, which may impact fetal development and health. However, there remains a significant gap in the literature regarding the specific effects of these maternal factors on umbilical cord coiling patterns and their subsequent influence on neonatal outcomes. Previous studies have indicated that abnormal coiling patterns can lead to adverse perinatal outcomes; however, few have comprehensively examined how maternal characteristics contribute to these variations. By addressing this gap, we hope to provide valuable insights into the implications of cord coiling variations and inform clinical practices for monitoring pregnancies at risk.

This study aims to assess the postnatal umbilical coiling index (UCI) and investigate its association with normal coiling, hypo-coiling, and hyper-coiling patterns in maternal and perinatal outcomes

METHODS

This cross-sectional study was conducted in the Obstetrics and Gynecology Department at Pakistan Aeronautical Complex (PAC) Hospital Kamra from January 2024 to June 2024. Inclusion Criteria included singleton pregnancy, gestational age of 37 weeks or more and cephalic presentation. Exclusion Criteria included multiple pregnancies, intrauterine fetal death abnormal presentations and congenital malformations. The sample size was calculated using the formula for comparing proportions across three or more groups, we can use the following formula: $n=(Z\alpha/2+Z\beta)2\cdot(p1(1-p1)+p2(1-p2))+p3(p1-p3)2/(p1-p2)2$, where p1=0.30, p2=0.50, p3=0.70, $Z\alpha/2=1.96$ (90% confidence), and $Z\beta=0.84$ (80% power) and effect size (p2-p1=0.20). A total of 200 participants were enrolled in the study. For each participant, a detailed obstetric history and clinical examination were performed. After delivery, the umbilical cord was examined and clamped. The Umbilical Cord Coiling Index (UCI) was calculated as the number of coils per centimeter of cord length using the formula: UCI=Number of coils/Length of the umbilical cord in cm. The UCI was classified into three categories [9]. Normal Coiled Cord: UCI=0.1 to 0.3 coils/cm, hypo-coiled Cord: UCI < 0.1 coils/cm and hyper-coiled Cord: UCI >0.3 coils/cm. Various maternal factors, including Appearance, Pulse, Grimace, Activity and Respiration (APGAR) scores at one and five minutes, low birth weight (defined as less than 2,500 grams), meconium-stained amniotic fluid, delivery method (vaginal, assisted, or cesarean), "neonatal intensive care unit (NICU) admissions, and newborn morbidity and mortality were also recorded. Data were analyzed using SPSS version 26.0. Continuous variables were presented as means with standard deviations, while categorical variables were shown as frequencies and percentages. The chi-square test or Fisher's exact test was used to compare categorical outcomes among the UCI groups, and the t-test was used for continuous variables. Statistical significance was set at a p-value of less than 0.05. This study was conducted by the ethical standards of the Declaration of Helsinki and was approved by the Institutional Review Board (IRB) of Hospital Kamra (IRB approval number: PACH/1/Trg/4). Informed consent was obtained from all participants before their inclusion in the study.

RESULTS

In the hypo-coiled group, the mean maternal age is 30.1 years, compared to 28.6 years in the normal group and 29.4 years in the hyper-coiled group. However, a higher proportion of mothers aged 35 years or older is found in the hypo-coiled group (25.7%) compared to the normal (13.4%) and hyper-coiled (8.7%) groups. The hypo-coiled group also has the highest average parity (2.8). The prevalence of gestational diabetes is greater in the hypo-coiled group (22.9%) than in the normal (10.6%) and hyper-coiled (8.7%) groups. Hypertensive disorders are also more common in the hypo-coiled group (17.1%) compared to the normal (9.2%) and hyper-coiled (4.3%) groups. There is a significant difference in obesity prevalence, with 22.9% of the hypo-coiled group being obese compared to 12.7% in the normal and 8.7% in the hyper-coiled groups (p=0.04). Additionally, smoking rates are significantly higher in the hypo-coiled group (20.0%) than in the normal (9.2%) and hyper-coiled (4.3%) groups (p=0.02). Finally, the hypo-coiled group had an average of 5.3 antenatal care visits, slightly fewer than the normal (6.1) and hyper-coiled (5.9)

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groups, but this difference is not significant (p=0.09). The hypo-coiled group has a lower average birth weight (2590 ± 400 grams) than the normal (2900 ± 350 grams) and hyper-coiled (2780 ± 320 grams) groups, (Table 1).

Table 1: Maternal Factors and Their Association with Umbilical Cord Coiling Pattern

Maternal Factors	Hypo-coiled (n=35)	Normal Coiled (n=142)	Hyper-coiled (n=23)	p-value
Maternal Age (Years)	30.1 ± 4.5	28.6 ± 4.0	29.4 ± 3.8	0.15
Age ≥35 Years (%)	9 (25.7%)	19 (13.4%)	2 (8.7%)	0.04*
Parity (Mean ± SD)	2.8 ± 1.2	2.4 ± 1.1	2.5 ± 1.0	0.18
Primiparity (%)	14 (40.0%)	72 (50.7%)	9 (39.1%)	0.24
Gestational Diabetes (%)	8 (22.9%)	15 (10.6%)	2 (8.7%)	0.03*
Hypertensive Disorders (%)	6 (17.1%)	13 (9.2%)	1 (4.3%)	0.05*
Pre-pregnancy BMI (kg/m^2)	27.1 ± 4.2	25.8 ± 3.9	26.0 ± 4.0	0.12
Hypertensive Disorders (%)	6 (17.1%)	13 (9.2%)	1 (4.3%)	0.05*
Pre-pregnancy BMI (kg/m^2)	27.1 ± 4.2	25.8 ± 3.9	26.0 ± 4.0	0.12
Obesity (BMI ≥ 30) (%)	8 (22.9%)	18 (12.7%)	2 (8.7%)	0.04*
Smoking (%)	7 (20.0%)	13 (9.2%)	1 (4.3%)	0.02*
Antenatal Care Visits (Mean)	5.3 ± 2.1	6.1 ± 1.9	5.9 ± 2.0	0.09
Birth Weight (Grams)	2590 ± 400	2900 ± 350	2780 ± 320	0.02*
Meconium-Stained Amniotic Fluid (%)	2590 ± 400	2900 ± 350	2780 ± 320	0.02*
Low Birth Weight (<2500g) (%)	10 (28.6%)	20 (14.1%)	2 (8.7%)	0.01*
Cesarean Delivery (%)	15 (42.9%)	39 (27.5%)	5 (21.7%)	0.04*

A p-value of less than 0.001 indicates a significant difference in the mean coiling index between the hypo-coiled (0.07 ± 0.02) and hyper-coiled (0.35 ± 0.06) groups. The coiling patterns of the groupings differ statistically from one another. Furthermore, the umbilical cord length of the hypo-coiled group is 46.2 ± 5.1 cm, p-value<0.001, shorter than that of the hyper-coiled (60.1 ± 5.9 cm) and normal groups (53.8 ± 6.7 cm). It would appear from this that the length of the rope rises with the degree of coiling. At a p-value less than 0.001, the hypo-coiled group had an average of 6.2 ± 1.1 coils, which is substantially less than the normal (12.7 ± 2.3) and hyper-coiled (18.3 ± 2.9) groups. This suggests a lower number of coils when hypo-coiling occurs. The hypo-coiled group's mean chord diameter (1.2 ± 0.3 cm) is less than that of the normal (1.4 ± 0.4 cm) and hyper-coiled (1.6 ± 0.5 cm) groups, with a p-value of 0.02. This implies that there may be more coiling and thickness in the umbilical cords. Additionally, the hypo-coiled group had a larger percentage of single umbilical arteries (14.3%) with a p-value of 0.05 than the normal (5.6%) and hyper-coiled (4.3%) groups. All groups combined include a majority of people with two umbilical arteries; however, the hypo-coiled group has the lowest proportion (85.7%) in contrast to the hyper-coiled (95.7%) and normal (94.4%) groups. The difference in the number of arteries between the groups appear to be marginally significant, as indicated by the p-value of 0.05 (Table 2).

Table 2: Coiling Patterns and Structural Attributes of the Umbilical Cord

Characteristic	Hypo-coiled (n=35)	Normal Coiled (n=142)	Hyper-coiled (n=23)	Total (n=200)	p-value
Coiling Index (Mean ± SD)	0.07 ± 0.02	0.22 ± 0.05	0.35 ± 0.06	0.21 ± 0.10	<0.001*
Length of Cord (cm)	46.2 ± 5.1	53.8 ± 6.7	60.1 ± 5.9	52.1 ± 8.2	<0.001*
Number of Coils	6.2 ± 1.1	12.7 ± 2.3	18.3 ± 2.9	11.6 ± 5.2	<0.001*
Cord Diameter (cm)	1.2 ± 0.3	1.2 ± 0.3	1.6 ± 0.5	1.4 ± 0.4	<0.02*
Umbilical Arteries (%)					
Single Artery	5 (14.3%)	1.2 ± 0.3	1.6 ± 0.5	1.4 ± 0.4	0.05*
Two Arteries	30 (85.7%)	134 (94.4%)	22 (95.7%)	186 (93.0%)	0.05*

The analysis shows a weak but statistically significant negative correlation between the Umbilical Cord Coiling Index (UCI) and Apgar scores at 1 minute (r=-0.253, p=0.0003) and 5 minutes (r=-0.250, p=0.0003). This indicates that lower UCI values are associated with lower Apgar scores, reflecting poorer immediate neonatal outcomes. While UCI influences Apgar scores, other factors may also contribute to these outcomes (Table 3).

Table 3: Analysis of Correlation Between UCI and Apgar Scores

Variable Pair	Correlation Coefficient (r)	p-value	Interpretation
UCI vs.Apgar Score at1 Minute	-0.253	0.0003	Negative correlation; lower UCI linked to lower Apgar score at 1 minute.
UCI vs. Apgar Score at 5 Minutes	-0.250	0.0003	Negative correlation; lower UCI linked to lower Apgar score at 5 minutes.

The scatter plots illustrate the correlation between the Umbilical Cord Coiling Index (UCI) and Apgar scores at 1 minute. In the first plot, a negative trend is observed, indicating that lower UCI values are associated with lower Apgar scores at 1 minute. A reference line marks the critical threshold of Apgar <7 to highlight the clinical significance. These visual representations reinforce the finding that reduced UCI is linked to lower Apgar scores, aligning with the statistical analysis (Figure 1).

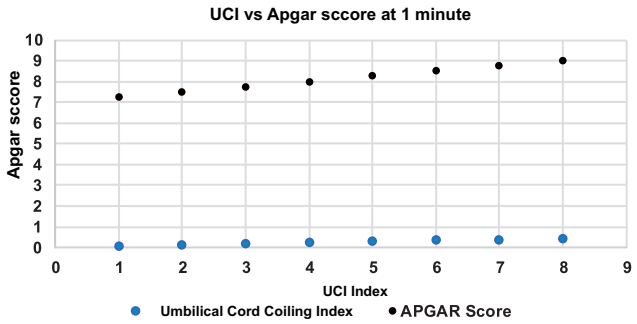

Figure 1: Scatter Plots Showing the Correlation Between the Umbilical Cord Coiling Index (UCI) and Apgar Scores at 1 Minute

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The scatter plots illustrate the correlation between the Umbilical Cord Coiling Index (UCI) and Apgar scores at and 5 minutes. the second plot demonstrates a negative relationship between UCI and Apgar scores at 5 minutes, with the critical threshold also emphasized. These visual representations reinforce the finding that reduced UCI is linked to lower Apgar scores, aligning with the statistical analysis (Figure 2).

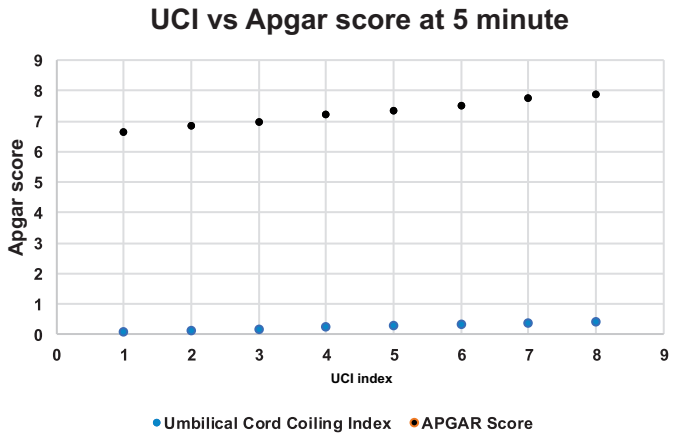

Figure 2: Scatter Plots Showing the Correlation Between the Umbilical Cord Coiling Index (UCI) and Apgar Scores at 5 Minutes

The analysis revealed that the hypo-coiled group had a significantly lower mean birth weight (2590 ± 400 grams) compared to the normal coiled (2900 ± 350 grams) and hyper-coiled groups (2780 ± 320 grams), with a p-value of 0.02. Additionally, a higher proportion of low-birth-weight infants (<2500 g) was observed in the hypo-coiled group (28.6%) compared to the normal coiled (14.1%) and hyper-coiled groups (8.7%), with a p-value of 0.01. These findings suggest that hypo-coiling is strongly associated with lower birth weight and a greater risk of low birth weight outcomes (Table 4).

Table 4: Analysis of Birth Weight Across the Three UCI Groups

Intrapartum Factor	Hypo-coiled (n=35)	Normal Coiled (n=142)	Hyper-coiled (n=23)	p-value
Birth Weight (Grams)	2590 ± 400	2900 ± 350	2780 ± 320	0.02
Low Birth Weight (%)	28.6% (n=10)	14.1% (n=20)	8.7% (n=2)	0.01

DISCUSSION

The umbilical coiling index (UCI) is the estimation of cord twists over a given length It is quantified by pregnancy ultrasound, and the possibility of using it as a marker of perinatal outcome has also been raised [10]. A typical UCI indicates the embryo in progress is satisfying necessities for oxygen and blood, which makes it beneficial for the strength of the embryo. Association with issues study has connected both hypo-coiling and hyper-coiling to poor prenatal outcomes. Fetal distress, an elevated risk of abnormal fetal heart rate, as well as stillbirth due to decreased blood flow or cord accidents are some of these possible effects [11]. Hypo-coiling is associated with preterm birth, intrauterine development limitation, and an increased risk of cesarean delivery due to fetal discomfort. Research that suggests the UCI might be used as a means of forecasting poor perinatal outcomes shows that an increased UCI can be associated with greater fetal cardiac variability, indicating enhanced fetal health, along with a low UCI is linked to higher levels of IUGR as well as low Apgar ratings at birth [12]. In the current study, emphasis on the Apgar scores, this study assesses the relationship between different maternal variables, patterns of umbilical cord coiling, and the outcomes of newborns. Different patterns of umbilical cord coiling are connected with maternal age, parity, pre-pregnancy BMI, and gestational diseases such as diabetes and hypertensive disorders [13]. The hypo-coiled group had notably higher rates of gestational diabetes and older mothers (≥35 years). These results imply the possibility of pregnancy and delivery problems due to the fetus being predisposed to aberrant cord coiling by specific maternal circumstances [14]. In all three groups, hypo-coiled babies weighed less at delivery than babies with normal or hyper-coiled cords, according to the study, which also showed significant variations in birth weight. One reason to be concerned about the hazards of inadequate cord coiling is the significant increase in the incidence of low birth weight (<2500g) in the hypo-coiled group [15]. Further evidence for the possible need for closer monitoring of pregnancies with atypical umbilical cord coiling patterns comes from the higher incidence of cesarean births and NICU admissions in the hypo-coiled group [16]. In the current study, the structural properties of the umbilical cord about its coiling patterns between the groups, there were notable differences in the coiling index, cord diameter, number of coils, and length of the rope. There may be a connection between the shape and function of cords because hypo-coiled cords had the lowest coiling index and several coils. The shorter hypo coiled cords and long umbilical cords may result in decreased oxygenation status of the fetus, affecting the transabdominal ultrasound fluid volume estimation which is a surrogate marker of fetal weight thereby explaining variation between birth weights [17]. Of note, cords that were hypo-coiled were more likely to exhibit a single umbilical artery, suggesting a potential relationship between abnormal coiling and congenital cord anomalies. A diminutive stream of blood flowing to even one artery can have implications for the growth and development of a fetus in general [18]. Association of umbilical cord coiling variations with Apgar scores at one and five minutes in the newborns' Hypo-coiled cords were also associated with lower scores on the Apgar scale compared to newborns with normal as well as hyper-coiled cords. Such a discrepancy suggests that poor nutritional support to the fetus in labour might be associated with inadequate umbilical cord coiling, possibly secondary by reduction in

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oxygen and nutrient supply. This is also particularly important for the larger group of babies scoring <7 (n=19 boys and 5 girls) both early and late concerning hypo-coiling as that could be a normal endpoint [19]. The findings of this study underscore the potential need for enhanced prenatal monitoring of umbilical cord coiling patterns, particularly in high-risk populations such as older mothers and those with gestational diabetes. Abnormal coiling has been associated with adverse neonatal outcomes, including low birth weight and lower Apgar scores, as demonstrated in our results. These outcomes align with previous studies, such as those by Kalluru et al., which also reported similar associations between hypo-coiling and poor perinatal outcomes [20]. The present findings underscore the significance of determining maternal attributes that might have links with overall attributes of the umbilical cord. More prenatal surveillance and perhaps earlier delivery may be indicated for pregnancies with abnormal umbilical cord coiling patterns to improve obstetric outcomes. Furthermore, the observational design of the study limits the ability to establish causation between maternal factors and umbilical cord coiling patterns. Future research with larger, more diverse populations and a longitudinal design could help clarify these relationships and improve the understanding of the implications of cord coiling variations in various maternal health contexts.

CONCLUSIONS

It was concluded that abnormal coiling patterns of the umbilical cord, gestational diabetes and maternal age showed a negative relation with newborn outcomes. Conclusion Because hypo-coiled umbilical cords are associated with lower birth weights and Apgar scores, enhanced surveillance with intervention methods is needed to improve the quality of maternal-fetal well-being.

Authors Contribution

Conceptualization: SJ
Methodology: SJ, AQ, MAJ, SZ, SJK
Formal analysis: AQ, MA
Writing review and editing: MA

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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