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Original Research Article

ANTENATAL UMBILICAL CORD COILING INDEX AS A PREDICTOR OF ADVERSE PERINATAL OUTCOMES: A PROSPECTIVE ANALYTICAL STUDY

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ABSTRACT

Background: The umbilical cord coiling index (UCI) reflects the structural integrity of the umbilical cord and may serve as an antenatal marker for predicting adverse perinatal outcomes. The objective is to evaluate the association between antenatal UCI patterns and adverse maternal and fetal outcomes, including intrauterine growth restriction (IUGR), preterm delivery, low birth weight (LBW), low APGAR scores, and other perinatal parameters. **Materials and Methods:** A prospective analytical study was conducted on 207 antenatal women between 18- and 24-week gestation at a tertiary care center. UCI was measured by ultrasound Doppler, categorizing cords as normocoiled, hypercoiled, or hypocoiled. Participants were followed until delivery, with outcomes including IUGR, preterm birth, LBW, APGAR scores, cardiotocography (CTG) abnormalities, meconium-stained liquor (MSL), and NICU admissions recorded. Statistical analysis involved chi-square tests and sensitivity-specificity assessments. **Result:** Normocoiled cords were observed in 79.2% of cases, hypercoiled in 11.6%, and hypocoiled in 9.2%. Abnormal coiling (hyper- and hypocoiling) was significantly associated with higher rates of IUGR (66.7% and 68.4%, p=0.001), preterm delivery (62.5% and 68.4%, p=0.001), LBW (62.5% and 63.2%, p=0.001), and APGAR scores <7 (62.5% and 63.2%, p=0.001). No significant correlations were found between UCI and CTG abnormalities, MSL, or NICU admissions. UCI showed high specificity (>88%) but low to moderate sensitivity for most adverse outcomes. **Conclusion:** Antenatal UCI is a valuable marker for identifying pregnancies at risk of adverse outcomes such as IUGR, preterm birth, LBW, and low APGAR scores. Its high specificity supports its role in ruling out risk, but limited sensitivity necessitates its use alongside other clinical assessments for comprehensive risk stratification.

INTRODUCTION

The umbilical cord is the fetus's lifeline, supplying essential nutrients, oxygen, and fluids for growth and survival. It is vulnerable to damage from kinking, compression, traction, and torsion. Rich in hematopoietic stem cells, it is protected by Wharton's jelly, amniotic fluid, and the coiled, helical structure of its vessels.[1,2] The umbilical cord safeguards the fetal blood supply during term pregnancy. The amnion's outer layer regulates fluid pressure, while Wharton's jelly—a porous, fluid-filled tissue—prevents vessel compression.[2] The origin of umbilical cord coiling is uncertain. Proposed theories include fetal movements, active or passive embryonic torsion, uneven vascular development, fetal hemodynamic forces, and the structure of muscle fibers in the umbilical artery wall.[1] A distinctive feature of the human umbilical cord is the twisted or coiled arrangement of its blood vessels. Though often called spirals, they are technically cylindrical helices from a mathematical perspective.[3]

Umbilical vessel coiling begins as early as 28 days after conception, with about 95% of fetuses showing coiling by 9 weeks. These helices can be detected via ultrasonography as early as the first trimester.[4] Berengarius first described the spiral path of umbilical vessels in 1521, later confirmed by Columbus in 1559 and Arantius in 1564. In 1600, Fabricius identified both left (sinistral) and right (dextral) helices. Edmonds et al. (1954) introduced the "index of twist," calculated by dividing the number of coils by cord length, and suggested embryonic rotational movement as the cause of coiling.[5] If umbilical cord twists occurred randomly, left and right twists would appear equally. However, studies consistently show a predominance of left-sided twists.[1] The number of umbilical cord twists, ranging from 0 to 40, is similar in the first trimester and at term. Coiling provides turgor, making the cord both strong and flexible, and may serve as a long-term indicator of fetal health.[5]

A coil is defined as the umbilical vessel 360-degree spiral path. The total number of coils divided by the total cord length in centimeters provide the umbilical cord coiling index (UCI). Rana et al. conducted a study on the frequency distribution of UCI (1995).[6] The umbilical cord coils to increase its strength and flexibility as well as to give protection against outside forces that can jeopardize the fetus blood supply.[7] Numerous sonographic and anatomical research have examined the UCI and blood flow pattern. These studies examined the use of sonography as a marker of fetal impairment in order to identify abnormal coiling and associated blood flow pattern in pregnancy.[8]

Ultrasonography enables prenatal detection of umbilical cord anomalies. Since coiling is typically complete by the end of the first trimester and remains stable thereafter, the umbilical coiling index (UCI) can be accurately assessed in the second trimester. As the cord lengthens between existing coils, no new coils form. In the third trimester, imaging becomes limited due to reduced amniotic fluid relative to fetal size, so measurements are usually taken near the placenta or mid-cord. In contrast, the second trimester offers better visibility due to relatively higher amniotic fluid levels.[9]

It has been discovered that abnormal UCI and atypical umbilical cord blood flow pattern are linked to unfavorable perinatal outcomes, such as higher hospitalizations for critical care, fetal pain, and intrauterine mortality. Therefore, prenatal measurement of the coiling index would serve as a predictor of a poor perinatal outcome.[10] The purpose of this study was to investigate the potential correlation between unfavorable perinatal outcomes and abnormal umbilical cord coiling patterns as detected sonographically between 18 and 24 weeks of gestation.

MATERIALS AND METHODS

Study Design: This was a prospective analytical study conducted over 1.5 years in the Department of Radiodiagnosis in collaboration with the Department of Obstetrics and Gynaecology at Maharishi Markandeshwar Institute of Medical Science and Research Hospital, Mullana, Ambala. The study included approximately 207 antenatal women attending the antenatal OPD during the study period who met the eligibility criteria.

Inclusion and exclusion criteria:

Only antenatal women with booked cases and singleton pregnancies who were willing to participate, follow up, and deliver at the study institute were included. Women with high-risk pregnancies such as gestational hypertension, gestational diabetes mellitus, or Rh incompatibility were excluded. Other exclusion factors included preexisting medical or surgical conditions, malpresentations, single umbilical artery or placental anomalies, fetal congenital anomalies, and inadequate visualization of the umbilical cord.

Study Procedure: Ultrasound was performed using Philips EPIQ-7 GI with a C5-1 curvilinear transducer. Detailed personal, obstetric, and medical histories were recorded. Informed consent was obtained after explaining the procedure in the patient's vernacular language. All procedures complied with PCPNDT (1994) Act, including documentation and "FORM-F" submission. Transabdominal ultrasound was performed with the patient in a supine position. Fetal cardiac activity and gestational age were documented. Color Doppler aided visualization of the umbilical cord. Umbilical Coiling Index (UCI) was calculated as the reciprocal of the distance between adjacent coils, measured at three different free-floating cord segments; the average was recorded. The direction of coiling (from placental to fetal end) was also noted.

Follow-up and perinatal outcomes: Patients were monitored until delivery to assess perinatal outcomes. Gestational age was determined using Naegele's rule. Birth weight was recorded immediately after birth, with weights below 2.5 kg classified as low birth weight. The color of the amniotic fluid was noted, with special attention to meconium-stained liquor. The mode of delivery—whether vaginal, forceps-assisted, or vacuum-assisted—was documented. NICU admissions were recorded, and APGAR scores at 1 minute were noted, with scores below 7 considered abnormal.

Data Analysis: The collected data were entered in MS Excel and analyzed using SPSS software. Qualitative variables were presented as percentages and analyzed using the Chi-square test. Quantitative data were expressed as mean ± standard deviation and evaluated using the independent t-test. A p-value of ≤ 0.05 was considered statistically significant.

RESULTS

The study included women with a mean age of 29.25 ± 4.27 years, with the majority aged 26–30 years (35.3%). Most participants were second gravidas (G2: 50.2%). The mean Umbilical Coiling Index (UCI) was 0.22 ± 0.11, with 79.2% normocoiled, 11.6% hypercoiled, and 9.2% hypocoiled cords. Intrauterine growth restriction (IUGR) was observed in 30.4%, and abnormal CTG in 27.1% of cases. Meconium-stained liquor (MSL) occurred in 57.5%. Most deliveries were at term (72.5%). Of the newborns, 59.9% were male. The mean birth weight was 2.78 ± 0.38 kg, with 28.0% having low birth weight. APGAR scores below 7 were seen in 31.4%, and NICU admissions were required for 56.5% of newborns [Table 1].

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Table 1: Demographic, clinical, and perinatal characteristics of the study population (n=207).

Variable	Domain	Number	Percentage
Age group	Mean age	29.25 ± 4.27 years	
	20-25 years	50	24.2
	26-30 years	73	35.3
	31-35 years	69	33.3
	36-40 years	15	7.2
Gravidity	Primi	35	16.9
	G2	104	50.2
	G3	68	32.9
Umblical cord index	Mean UCI	0.22 ± 0.11	
	Hypercoiled	24	11.6
	Hypocoiled	19	9.2
	Normocoiled	164	79.2
IUGR		63	30.4
Abnormal CTG		56	27.1
MSL		119	57.5
Gestation age	Preterm	57	27.5
	Term	150	72.5
Gender of baby	Female	83	40.1
	Male	124	59.9
Birth weight	Mean birth weight	2.78 ± 0.38 kg	
	Low birth weight	58	28.0
	Normal birth weight	149	72.0
APGAR score	APGAR<7	65	31.4
	APGAR>=7	142	68.6
NICU admission		117	56.5

The distribution of umbilical cord coiling patterns varied significantly with maternal age (p=0.040), with hypercoiling more common in the 20-25 age group and hypocoiling in 31-35 years. Gravidity showed no significant association with coiling patterns (p=0.915). Both hypercoiled and hypocoiled cords were strongly associated with adverse outcomes, including higher rates of IUGR (66.7% and 68.4% vs. 20.7%, p=0.001), preterm birth (62.5% and 68.4% vs. 17.7%, p=0.001), low birth weight (62.5% and 63.2% vs. 18.9%, p=0.001), and low APGAR scores (<7) (62.5% and 63.2% vs. 23.2%, p=0.001). No significant differences were found for abnormal CTG, meconium-stained liquor, gender of baby, or NICU admissions across coiling types. These results suggest that abnormal umbilical cord coiling is significantly associated with poorer fetal growth and perinatal outcomes [Table 2].

Table 2: Association of umbilical cord coiling patterns (hypercoiled, hypocoiled, normocoiled) with maternal age, gravidity, fetal outcomes, and perinatal parameters.

Variable	Domain	Hypercoiled		Hypocoiled		Normocoiled		P value
		N	%	N	%	N	%	
Age group	20-25 years	11	45.8	4	21.1	35	21.3	0.040*
	26-30 years	5	20.8	3	15.8	65	39.6	
	31-35 years	7	29.2	9	47.4	53	32.3	
	36-40 years	1	4.2	3	15.8	11	6.7	
Gravidity	Primi	4	16.7	3	15.8	28	17.1	0.915
	G2	14	58.3	10	52.6	80	48.8	
	G3	6	25	6	31.6	56	34.1	
IUGR		16	66.7	13	68.4	34	20.7	0.001*
Ab. CTG		7	29.2	6	31.6	43	26.2	0.857
MSL		13	54.2	11	57.9	95	57.9	0.941
Gestation age	Preterm	15	62.5	13	68.4	29	17.7	0.001*
	Term	9	37.5	6	31.6	135	82.3	
Gender of baby	Female	7	29.2	12	63.2	64	39	0.065
	Male	17	70.8	7	36.8	100	61	
Birth weight	NBW	9	37.5	7	36.8	133	81.1	0.001*
	LBW	15	62.5	12	63.2	31	18.9	
APGAR Score	APGAR<7	15	62.5	12	63.2	38	23.2	0.001*
	APGAR>=7	9	37.5	7	36.8	126	76.8	
NICU Admission		11	45.8	11	57.9	95	57.9	0.532

Table 3: Sensitivity and specificity analysis of UCI for adverse outcomes.

Adverse Outcome	Sensitivity (%)	Specificity (%)
Low Birth Weight (LBW)	46.6	89.3
Intrauterine Growth Restriction (IUGR)	46.0	90.3
Preterm Delivery	49.1	90.0
APGAR Score < 7	41.5	88.7
NICU Admission	18.6	76.7
Meconium-Stained Liquor (MSL)	20.2	78.4
Abnormal CTG	23.2	80.1

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UCI shows high specificity across most outcomes (>88%), indicating a strong ability to correctly identify pregnancies without complications. However, its sensitivity is relatively low, particularly for NICU admission (18.6%), meconium-stained liquor (20.2%), and abnormal CTG (23.2%), suggesting limited effectiveness in detecting actual cases. The highest sensitivity is seen for preterm delivery (49.1%), followed by low birth weight (46.6%) and IUGR (46.0%) [Table 3].

DISCUSSION

The umbilical cord is essential for fetal growth and survival but is vulnerable to damage from compression, torsion, and traction. Its structural integrity depends on Wharton's jelly and the characteristic helical coiling of two arteries and one vein, which protects these vessels from external stress.[6,11] First described by Berengarius in 1521,[5] the helical coiling provides the cord with both durability and flexibility.[7] The origin of coiling remains uncertain, with hypotheses including fetal movements, torsion, vascular growth differences, and muscle fiber orientation.[1,5] Coiling begins by day 28 of gestation and is present in 95% of fetuses by week nine, observable by first-trimester ultrasound.[4] The number of coils tends to remain stable throughout gestation, with more coils near the fetal end, reflecting cumulative fetal influences.[7,12] While UCI has traditionally been studied postnatally, this study focuses on antenatal ultrasonographic UCI assessment and its relation to pregnancy outcomes.

In this study, normocoiled cords were most frequent (79.2%), with hypercoiled and hypocoiled cords in 11.6% and 9.2%, respectively, consistent with typical obstetric populations. Similar distributions were noted by Reddy et al,[13] Somani et al,[14] Singireddy et al,[15] Mittal et al,[16] and Aanandini et al,[17] supporting the clinical relevance of antenatal UCI evaluation.

Maternal age was significantly associated with UCI patterns (p = 0.040); hypercoiling was more common in younger women (20–25 years), hypocoiling in the 31–35 age group, and normocoiling in those aged 26–30. This suggests age-related influences on abnormal coiling, though mechanisms remain unclear. Chitra et al,[1] and Somani et al,[14] similarly reported increased abnormal coiling with advanced maternal age, while Kalluru et al,[8] and Subashini et al,[2] found no significant associations.

No significant correlation was found between gravidity and UCI (p = 0.915), with gravida 2 dominating all coiling groups, indicating parity does not affect coiling patterns. This aligns with findings by Makde et al,[18] Monga et al,[19] Subashini et al,[2] and Singh et al.[20]

Abnormal coiling was strongly associated with IUGR (p = 0.001), with 66.7% of hypercoiled and 68.4% of hypocoiled cords linked to IUGR, while 79.3% of normocoiled cords correlated with normal growth. These findings suggest both extremes of coiling may indicate impaired fetal growth, warranting enhanced monitoring. Similar associations were reported by Chholak et al.[21] Singireddy et al,[15] observed higher abnormal coiling in antepartum complications, but without statistical significance.

Preterm birth was significantly higher in abnormal UCI patterns (p = 0.001), occurring in 62.5% of hypercoiled and 68.4% of hypocoiled cords versus 17.7% normocoiled. This confirms the link between abnormal coiling and preterm delivery risk. Comparable results were reported by Reddy et al,[13] de Laat et al,[22] and Sharma et al.[23]

Low birth weight was also significantly more frequent in abnormal UCI cases—62.5% in hypercoiled and 63.2% in hypocoiled cords compared to 18.9% normocoiled (p = 0.001). Similar findings were reported by Somani et al,[14] Makde et al,[18] Mittal et al., Khan and Thakur, and Agarwal et al.[16,24,25] Excessive coiling may impair uteroplacental blood flow, contributing to LBW.

Neonates with abnormal UCI had significantly lower APGAR scores (<7) at birth—62.5% hypercoiled, 63.2% hypocoiled, versus 23.2% normocoiled (p = 0.001). This indicates both hyper- and hypocoiling associate with immediate postnatal compromise. Supporting data come from Somani et al. (14), Singireddy et al,[15] Devi et al,[26] Sharma et al,[23] and Makde et al.[18] Hypocoiling can cause cord kinking/compression, while hypercoiling may cause torsion or looping, reducing fetoplacental flow and neonatal vitality. Aanandini et al,[17] reported no significant association.

Despite 27.1% abnormal CTG patterns, no significant correlation with UCI was found (p = 0.857), with similar rates across coiling groups, indicating limited predictive value for fetal heart rate abnormalities. Singh et al,[20] concurred, though Somani et al,[14] found significant associations, suggesting coiling deviations may affect fetal monitoring. Sharma et al,+[23] linked hypocoiling to multiple adverse outcomes including CTG changes.

Meconium-stained liquor (MSL) was present in 57.5% but showed no significant association with UCI (p = 0.941). Incidence was similar across coiling categories, suggesting UCI does not predict MSL reliably. However, Reddy et al,[13] Gupta et al,[11] Devi et al,[26] Somani et al,[14] Strong et al,[27] Ezimokhai et al,[28] and Khan and Thakur,[24] reported significant links between abnormal coiling and MSL, possibly due to hypocoiled cords' susceptibility to kinking and blood flow interruption.[13]

NICU admission occurred in 56.5% of neonates, with no significant association with UCI (p = 0.532). While UCI relates to fetal growth and birth outcomes, it may not independently predict neonatal intensive care needs. Contrasting findings exist: Reddy et al,[13] de Laat et al,[22] Devi et al,[26] Somani et al,[14] Pergialiotis et al,[29] Sharma et al,[23] Makde et al,[18] Kumar et al,[30] and Khan and Thakur,[24] reported significant links between abnormal coiling and NICU admission or respiratory distress.

UCI demonstrated high specificity (>88%) for most adverse outcomes, effectively ruling out complications with normal coiling. Sensitivity was moderate to low, highest for preterm delivery (49.1%), LBW (46.6%), and IUGR (46.0%), but low for NICU admission (18.6%), MSL (20.2%), and abnormal CTG (23.2%). This suggests UCI is a useful screening tool to exclude risk but should be combined with other diagnostics for better detection. Ndolo et al. reported UCI sensitivity of 47.6% and specificity of 76.9% for preterm birth prediction, highlighting its adjunctive role.[31] El-Sayed et al. found umbilical artery resistance index (URI) more reliable than UCI in predicting adverse outcomes linked to hypercoiling.[32]

The study's strengths are its large sample size and thorough assessment of maternal and fetal outcomes, with UCI categorization enabling clear links to adverse events and high specificity supporting its antenatal utility. Limitations include modest sensitivity for NICU admission, MSL, and abnormal CTG, a cross-sectional design limiting causal conclusions, no multivariate analysis, single-center scope, and lack of long-term follow-up affecting generalizability. Future research should combine UCI with other tools, pursue longitudinal and multicenter studies, standardize and automate UCI measurement, and further investigate the mechanisms behind abnormal coiling to improve risk stratification.

CONCLUSION

This study highlights UCI as a useful antenatal marker for predicting adverse outcomes like IUGR, preterm delivery, low birth weight, and low APGAR scores. While UCI has high specificity, its low sensitivity limits its use as a standalone tool. No significant links were found with CTG abnormalities, MSL, or NICU admission. Thus, UCI should be included in routine ultrasounds but interpreted alongside other clinical and imaging assessments for effective risk management.

REFERENCES

1. Chitra T, Sushanth Y, Raghavan S. Umbilical coiling index as a marker of perinatal outcome: an analytical study. Obstet Gynecol Int. 2012;2012:213689.
2. Subashini G, Anitha C, Gopinath G, Ramyathangam K. A longitudinal analytical study on umbilical cord coiling index as a predictor of pregnancy outcome. Cureus. 2023;15(3).
3. Chaurasia B, Agarwal B. Helical structure of the human umbilical cord. Cells Tissues Organs. 1979;103(2):226-30.
4. Lacro RV, Jones KL, Benirschke K. The umbilical cord twist: origin direction, and relevance. Am J Obstet Gynecol. 1987;157(4):833-8.
5. Edmonds HW. The spiral twist of the normal umbilical cord in twins and in singletons. Am J Obstet Gynecol. 1954;67(1):102-20.
6. Rana J, Ebert GA, Kappy KA. Adverse perinatal outcome in patients with an abnormal umbilical coiling index. Obstet Gynecol. 1995;85(4):573-7.
7. Strong TH Jr, Jarles DL, Vega JS, Feldman DB. The umbilical coiling index. Am J Obstet Gynecol. 1994;170(1):29-32.
8. Kalluru PKR, Kalluru HR, Allagadda TR, Talur M, Gonepogu MC, Gupta S. Abnormal umbilical cord coiling and association with pregnancy factors. J Turk Ger Gynecol Assoc. 2024;25(1):44.
9. Sahoo K, Mahajan A, Shaha P, Kshirsagar NS. Evaluation of umbilical coiling index as a predictor of pregnancy outcome. Int J Health Sci Res. 2015;5(3):92-100.
10. Aafreen A, Pankaj A, Pankaj A. A prospective study to evaluate umbilical coiling index as a marker of maternal outcome. J South Asian Fed Obstet Gynaecol. 2023;15(6):654-7.
11. Gupta S, Faridi MMA, Krishnan J. Umbilical coiling index. J Obstet Gynaecol India. 2006;56(4):315-9.
12. Ercal T, Lacin S, Altunyurt S, Saygili U, Cinar O, Mumcu A. Umbilical coiling index: is it a marker for the foetus at risk? Int J Clin Pract. 1996;50(5):254-6.
13. Reddy N, Anuradha C, Kandasamy V. Association between umbilical cord coiling index and perinatal outcome. J South Asian Fed Obstet Gynaecol. 2024;16(1).
14. Somani S, Kishan TV, Sudhir S, Madhavi N. Significance of umbilical coiling index in antenatal period and its association with perinatal outcome. New Indian J OBGYN. 2024;10(2):357-60.
15. Singireddy N, Chugh A, Bal H, Jadhav S. Re-evaluation of umbilical cord coiling index in adverse pregnancy outcome – does it have role in obstetric management? Eur J Obstet Gynecol Reprod Biol X. 2024;21:100265.
16. Mittal A, Nanda S, Sen J. Antenatal umbilical coiling index as a predictor of perinatal outcome. Arch Gynecol Obstet. 2015;291(4):763-8.
17. Aanandini T, John LB, Rathod S. Antenatal umbilical cord coiling index as a predictor of pregnancy outcome. Int J Obstet Gynecol Res. 2021:383-7.
18. Makde SO, More V, Sharma M, Sakarkar S, Nayak AH. Study of postnatal umbilical coiling index and its correlation with maternal and perinatal outcome. J South Asian Fed Obstet Gynaecol. 2023;15(1):76-80.
19. Monga R, Goel JK, Bagchi S, Sah S, Goel R. Correlation of antenatal umbilical cord coiling index with perinatal outcome. J South Asian Fed Obstet Gynaecol. 2018;10(2):127-30.
20. Singh S, Pai S, Sahu B. Study of umbilical coiling index and perinatal outcome. Int J Reprod Contracept Obstet Gynecol. 2020;9(10):3977-82.
21. Chholak D, Gupta P, Khajotia S. Study to evaluate association of umbilical coiling index and perinatal outcome. Int J Reprod Contracept Obstet Gynecol. 2017;6(2):408-12.
22. De Laat M, Franx A, Nikkels P, Visser G. Prenatal ultrasonographic prediction of the umbilical coiling index at birth and adverse pregnancy outcome. Ultrasound Obstet Gynecol. 2006;28(5):704-9.
23. Sharma B, Bhardwaj N, Gupta S, Gupta PK, Verma A, Malviya K. Association of umbilical coiling index by colour Doppler ultrasonography at 18–22 weeks of gestation and perinatal outcome. J Obstet Gynaecol India. 2012;62(6):650-4.
24. Khan T, Thakur R. Association of postnatal umbilical coiling index with maternal and perinatal outcome. Int J Clin Obstet Gynaecol. 2019;3(1):144-9.
25. Agarwal S, Purohit R, Jain G. Umbilical cord coiling index and perinatal outcome in normal and abnormal pregnancies. Sch J App Med Sci. 2014;2(1D):447-50.
26. Devi A, Ramesh S, Naik H, Huchegowda S. Umbilical coiling index and its relation to perinatal outcome. J Clin Obstet Gynecol. 2021;31(1):6-13.
27. Strong TH Jr, Finberg HJ, Mattox JH. Antepartum diagnosis of noncoiled umbilical cords. Am J Obstet Gynecol. 1994;170(5):1729-33.
28. Ezimokhai M, Rizk DE, Thomas L. Maternal risk factors for abnormal vascular coiling of the umbilical cord. Am J Perinatol. 2000;17(8):441-6.
29. Pergialiotis V, Kotrogianni P, Koutaki D, Christopoulos-Timogiannakis E, Papantoniou N, Daskalakis G. Umbilical cord coiling index for the prediction of adverse pregnancy outcomes: a meta-analysis and sequential analysis. J Matern Fetal Neonatal Med. 2020;33(23):4022-9.

30. Kumar S, Chetty S. Umbilical coiling index as a marker of perinatal outcome: An analytical study at Navodaya Medical College, Raichur. Indian J Child Health. 2017;4(1):18-21.
31. Ndolo JM, Vinayak S, Silaba MO, Stones W. Antenatal umbilical coiling index and newborn outcomes: cohort study. J Clin Imaging Sci. 2017;7:16.
32. El-Sayed TH, Khairy HT, Mansour GM, Khater AMG. Antenatal umbilical coiling index as a predictor of NICU admission as fetal adverse outcome using color Doppler in the third trimester – a nested case control study. Egypt J Hosp Med. 2023;92:6877-84.

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