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ORIGINAL ARTICLE

Umbilical Coiling Index Assessment During Routine Fetal Anatomic Survey: A Screening Tool for Fetuses at Risk

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Abstract

Background The umbilical cord is the lifeline of the foetus as it supplies water, nutrients, and oxygen. Protection of these blood vessels is needed and provided by Wharton's Jelly, amniotic fluid and the helical pattern, or coiling, of the umbilical cord vessels.

Aim To establish the relationship between antenatal umbilical cord coiling index (aUCI) measured at 18–20 weeks along with level II USG and adverse perinatal outcomes.

Methods A cross-sectional study was conducted on 408 antenatal women, enrolled at the time of fetal anatomic survey, and their cord coiling index (aUCI) was measured, and its association with perinatal outcomes was observed. Umbilical coiling index was classified as Hypocoiled if UCI <10th percentile, hypercoiled >90th percentile, normocoiled between 10th and 90th percentile.

Results 408 antenatal women were enrolled for the study. Mean aUCI was 0.43 ± 0.30 (normocoiled group), 0.18 ± 0.4 (hypocoiled), and 0.53 ± 0.05 (hypercoiled group). The average gestational age at delivery in hypocoiled group was 36.8 ± 2.34 weeks, and it was shorter than 38.3 ± 1.82 weeks of the normocoiled group and 38.9 ± 1.72 weeks of the hypercoiled group. Mean birth weight observed was 2055 ± 744 (hypocoiled group), 3049 ± 564 (hypercoiled), and 3102 ± 564 (normocoiled) $p < 0.001$. Preterm births 52 (59%) and low birth weight 76 (69%) were significantly associated with hypocoiling.

Conclusion Abnormal umbilical cord coiling index, detected at the fetal ultrasound anatomic survey in the second trimester (18–20 weeks), can be used potentially as a screening or as a predictive tool for adverse antenatal or perinatal events.

Keywords Hypocoiled · Hypercoiled · Normocoiled · Perinatal outcome

Introduction

Umbilical cord is the most vital channel for the fetus as it supplies water, nutrients, and oxygen [1]. It extends from the fetal umbilicus to the fetal surface of placenta. The umbilical cord forms between 5th and 12th post-menstrual week of gestation with contributions from body stalk, omphalomesenteric or vitelline duct, yolk sac, and allantois. The umbilical cord grows until the end of second trimester. It attains an average diameter of 1.7 cm and length of 50–60 cm. The spiraling of the umbilical cord is observed from 28 days after fertilization. The cord develops up to 0–40 spiral turns as it elongates during gestation. Umbilical cord twists and turns more toward the left than the right which can be revealed by ultrasound [2].

The mechanism by which physiological coiling occurs is still speculated. It may be related to early fetal activity, hemodynamic factors or other anatomical tissues such as the presence of Roach muscle. Therefore, there must be adequate fluid space and fetal activity to ensure normal length and coiling of the umbilical cord [3].

Whether genetically determined or an acquired phenomenon, umbilical coiling provides turgor and compression resistant properties thereby protecting the fragile vascular system. It also serves as an active pump mechanism in the process of venous return to the fetus (cardiac assist pump) supported by the finding of the different genetic growth potential in twins or hemodynamic changes secondary to placental disease [4].

Studies have shown the possibility of reduced umbilical cord supportive tissue (thinner cords) involvement in the etiology of umbilical cord coiling. Marked segmental thinning may be associated with increased congenital anomalies and perinatal outcome [5]. Therefore, altered umbilical cord thickness and diameter may predispose the fetus to the umbilical coiling pattern and possibly may compromise full fetal intrauterine growth potential [6]. Knowledge of normal umbilical cord development anatomy and awareness of the common abnormalities of the cord are therefore important for accurate prenatal diagnosis and assessment for the outcome of pregnancy.

Various studies have been done on umbilical coiling index postnatally, and the association was established between hypocoiled and hypercoiled cord defined as UCI <10th percentile and >90th percentile, respectively, with adverse perinatal outcomes [7]. Hypocoiled cord was associated with increased incidence of fetal demise, intrapartum fetal heart rate deceleration, operative delivery for fetal distress, low Apgar score, structural and chromosomal abnormalities, chorioamnionitis, and preterm delivery [8]. This marks underlying intrinsic abnormal development and increased risk of acute reduction in blood flow due to kinking. Hypercoiling of the cord was associated with fetal growth retardation, intrapartum fetal acidosis and asphyxia, vascular thrombosis, and cord stenosis by predisposing to compression mediated flow reduction and possible predisposition to the development of fetoplacental vascular thrombosis [9]. Thus, it appears that abnormal coiling is a chronic state established in early gestation that may have chronic and acute effect on the fetus.

The umbilical cord can be visualized throughout most of the gestation and is detectable soon after visualization of fetal pole. Many umbilical cord abnormalities can be detected sonographically and have important prognostic implication for perinatal morbidity and mortality.

Current guidelines for second-trimester sonographic examination recommend evaluation of the fetal anatomy and growth, placental location, amniotic fluid volume, and examination of umbilical cord by trained sonographer [10]. Umbilical cord assessment is routinely limited to cord vessel number because single umbilical artery is well established to be linked with poor pregnancy outcome.

Sonographic measurement of umbilical cord in the first trimester is difficult, and thus, errors in the measurement may be big. In the third trimester of pregnancy, the volume of amniotic fluid is reduced, and thus, the difference between umbilical cord coiling and torsion is difficult to assess and errors in measurement may be more [11]. Hence, in our study, the time of measurement of umbilical coiling index was between 18 and 20 weeks at the time of anomaly scan.

We conducted a study to establish a relationship between umbilical coiling index and perinatal outcome, which can be adopted as a second-trimester screening of fetuses at risk so that appropriate preventive measures could be taken for the birth of a healthy baby.

Aims and Objectives

To evaluate the relationship of sonographic measurements of umbilical coiling index in second trimester (18–20 weeks) with the perinatal outcome.

Materials and methods

A cross-sectional study was conducted from May 2014 to Jan 2015. This study was performed on all booked pregnant women attending the Obstetric outpatient Department for regular antenatal checkup between 18 and 20 weeks and planned to deliver at our Hospital.

Inclusion Criteria

1. Singleton pregnancy of any parity.
2. Gestational age between 18 and 20 weeks.
3. Normal amniotic fluid.
4. Presence of three vesseled umbilical cord.
5. Consenting to participate in the study.

Exclusion Criteria

1. Multiple pregnancy.
2. Fetal congenital anomaly.
3. Maternal medical disorders like diabetes mellitus and hypertension that could interfere with fetal growth.
4. If the patient could not be followed till delivery for any reason.
5. Any umbilical cord or placental anomaly.
6. Inadequate longitudinal image of the cord to allow accurate coiling index measurement/antenatal or labor data and inappropriate cross-sectional image of the fetal abdomen.

Sample Size

The previous studies showed that that proportion of preterm birth in hypocoiled or hypercoiled was around 35%, and in normocoiled, this proportion was around 8%. Considering these proportions with 80% power and 5% level of significance with a ratio 1:1 (hypocolied/hypercoiled vs control), a sample size of 43 each of hypocoiled, hypercolied, and normocoiled subjects was required. So, 430 subjects were needed to get at least 43 in each group. Since it was 1-year study, 60–65 eligible subjects per months were expected and were recruited in first 7 months, and next 5 months were follow-up period. We ended our study with 408 women because the desired number of women in each group (hypocoiled, normocoiled, and hypercoiled) was achieved.

Gestational age was based on reliable last menstrual period or first trimester ultrasound examination or both. Patient's demographic characteristics, antenatal check up, and any past medical or antenatal complications were documented. All sonographic examination was performed by a single sonographer using a standard USG machine with color Doppler and transducer of 3.5–5.0 mHz.

Fetal anomaly scan between 18 and 20 weeks was carried out along with the umbilical coiling index measurement in the free-floating midsegment of the cord as the fixed ends are not representative of coiling pattern of most of the cord, and free-floating loop is the part which is most vulnerable to kinking and compression.

The distance between a pair of coils will be measured in 'cm' from the inner edge of an arterial or venous wall to the outer edge of the next coil along the ipsilateral side of the umbilical cord, the direction being from the placental end to the fetal end. The coiling index is calculated as the reciprocal value of this distance (Fig. 1) (UCI = 1/distance between the inner edge of an arterial or venous wall to the outer edge of the next coil).

These women were then followed till term to note the various parameters like

(a) Gestational age at delivery.
(b) Presence of meconium stained amniotic fluid.
(c) Mode of delivery.
(d) Apgar score at 5 min.
(e) Neonatal birth weight.
(f) Small for gestational age/FGR/other complications.
(g) NICU admissions.

Umbilical coiling index was considered low if below the 10th percentile and high if above 90th percentile, and [10th and 90th] percentile was calculated for each parameter using the data collected in the study.

Statistical Analysis

The data was analysed using *t* test and Chi square test and multivariate regression tests.

Results

416 antenatal women were enrolled for the study but 8 women were lost to follow up, so remaining 408 women were considered for the study. 158 (38.7%) women were primigravidas and 250 (62.5%) women were multigravidas $p = 0.054$ (NS). Women were grouped into Hypocoiled 84 (20.5%), normocoiled 188 (46%), and hypercoiled group 136 (33.3%). Mean maternal age was 22.9 ± 4.41. Mean

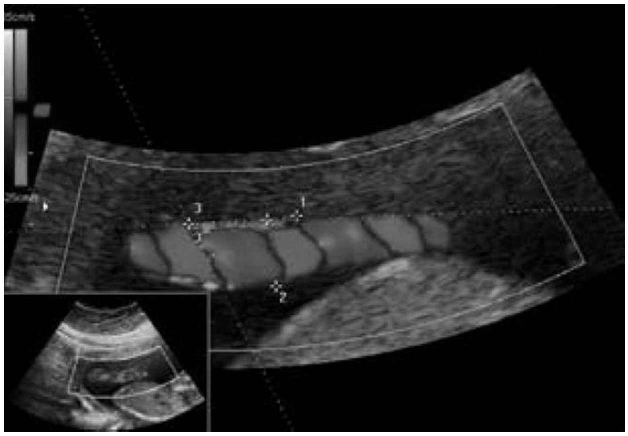

Fig. 1 Measurement of UCI

umbilical coiling index (aUCI) was 0.43 ± 0.30 in (normocoiled group), 0.18 ± 0.4 (hypocoiled), and 0.53 ± 0.05 (hypercoiled group). The average gestational age at delivery in hypocoiled group was 36.8 ± 2.34 weeks, and it was shorter than 38.3 ± 1.82 weeks of the normocoiled group and 38.9 ± 1.72 weeks of the hypercoiled group, $p < 0.001$ (Table 1).

Meconium-stained liquor was observed in 30 (7.3%) women; out of 30 women, meconium staining associated with hypocoiling and normocoiling was 4 (13.3%) in each group but a significant correlation was found with hypercoiling 22 (73.33%), $p < 0.001$.

Abruption was documented in 16 (3.9%) women. Abruption in 12 (75%) women was significantly associated with hypocoiling $p < 0.001$. Normocoiling 2 (12.5%) and hypercoiling 2 (12.5%) had no significant correlation with abruption.

Fetal distress was observed in 10 (2.4%) women, and however, no significant correlation was found between intrapartum fetal heart rate abnormalities and abnormal cord coiling. 2 (20%) hypocoiled, 6 (60%) normocoiled, and 2 (20%) hypercoiled group, $p = 0.648$ (Table 2).

352 (86%) women had normal vaginal delivery, and 36 (8.8%) had instrumental deliveries. A significant correlation was found between hypocoiling 24 (66.6%) and instrumental delivery. $\chi^2 = 53.74$; $p < 0.001$. No association was seen in normocoiled 8 (22.2%) or hypercoiled groups 4 (11.1%). LSCS was done in 20 (4.9%) women and not associated with abnormal umbilical coiling index (Table 3).

Table 1 Demographic characteristics

	Total	Hypocoiling	Normocoiling	Hypercoiling	p value
N (%)	408 (100%)	84 (20.5%)	188 (46%)	136 (33.3%)	
Maternal age	22.9 ± 4.41	24.6 ± 4.54	22.7 ± 4.35	23.1 ± 4.31	0.0042
Mean (years)					NS
Parity					0.054
Primi	208 (50.9%)	38 (18.2%)	108 (52%)	62 (30%)	(NS)
Multi	200 (49%)	46 (23%)	88 (44%)	74 (37%)	
aUCI mean	–	0.18 ± 0.4	0.40 ± 0.30	0.53 ± 0.05	
Gestational age at delivery (weeks)	38.21 ± 1.92	36.8 ± 2.34	38.3 ± 1.82	38.9 ± 1.72	

Table 2 Intrapartum characteristics

	Total	Hypocoiling	Normocoiling	Hypercoiling	p value
Meconium- liquor	30 (7.3%)	4 (13.3%)	4 (13.3%)	22 (73.3%)	$p < 0.001$
Abruptio	16 (3.9%)	12 (75%)	2 (12.5%)	2 (12.5%)	$p < 0.001$
Fetal distress	10 (2.4%)	2 (20%)	6 (60%)	2 (20%)	$p = 0.648$

Table 3 Mode of delivery

	Total	Hypocoiled	Normocoiled	Hypercoiled
NVD	352 (86.2%)	56 (15.9%)	168 (47.7%)	128 (36.3%)
Instrumental delivery	36 (8.8%)	24 (66.6%)	8 (22.2%)	4 (11.1%)
LSCS	20 (4.9%)	4 (20%)	12 (60%)	4 (20%)

Table 4 Neonatal outcome

	Total	Hypocoiled	Normocoiled	Hypercoiled	*p* value
Apgar at 5 min					
<7	190 (46.5%)	72 (38%)	42 (22.1%)	114 (60%)	<0.001
>7	218 (53.4%)	12 (6.4%)	146 (85.3%)	22 (8.2%)	
Preterm birth	88 (21.5%)	52 (59%)	22 (25%)	14 (15.9%)	<0.001
L.Bwt	110 (26.9%)	76 (69.0%)	24 (21.8%)	10 (9%)	<0.001
Mean B.wt		2055 ± 744	3102 ± 583	3049 ± 564	<0.001
NICU stay >24 h	124 (30.3%)	38 (30.6%)	44 (35.4%)	42 (33.8%)	<0.001

Table 5 Sensitivity, specificity, positive, and negative predictive values of significant variables

Parameters	Sensitivity (95% CI)	Specificity (95% CI)	PPV (95% CI)	NPV (95% CI)
Preterm birth				
Hypocoiled	0.70 (0.61–0.78)	0.88 (0.85–0.91)	0.70 (0.61–0.78)	0.88 (0.85–0.91)
Hypercoiled	0.30 (0.19–0.45)	0.58 (0.56)	0.10 (0.06–0.152)	0.84 (0.81–0.87)
Low B.wt				
Hypocoiled	0.76 (0.7–0.80)	0.96 (0.93–0.98)	0.90 (0.83–0.95)	0.88 (0.86–0.91)
Hypercoiled	0.46 (0.37–0.55)	0.76 (0.72–0.80)	0.45–0.54 (0.36–0.54)	0.77 (0.73–0.81)
NICU stay >24 h				
Hypocoiled	0.46 (0.37–0.55)	0.76 (0.72–0.80)	0.45 (0.36–0.54)	0.77 (0.73–0.81)
Hypercoiled	0.49 (0.39–0.58)	0.61 (0.57–0.64)	0.31 (0.25–0.37)	0.77 (0.73–0.81)

88 (21.5%) women had preterm births: hypocoiled 52 (59%), normocoiled 22 (25%), and hypercoiled 14 (15.9%). Hypocoiling was significantly linked to preterm births $p < 0.001$.

Mean birth weight observed was 2055 ± 744 (hypocoiled group), 3049 ± 564 (hypercoiled), and 3102 ± 583 (normocoiled) $p < 0.001$.

Low birth weight occurred in 110 (26.9%) babies. A strong association was found between hypocoiling and low birth weight. 76 (69%) low birth weight babies belonged to hypocoiled, 24 (21.8%) normocoiled, and 10 (9%) hypercoiled groups, $p < 0.001$ (Table 4).

Sensitivity, specificity, positive, and negative predictive values of hypocoiling are 0.70 (95% CI 0.61–0.78), 0.88 (95% CI 0.85–0.91), 0.70 (95% CI 0.61–0.78), 0.88 (95% CI 0.85–0.91), and 0.76 (95% CI 0.71–0.80), 0.96 (95% CI 0.93–0.98), 0.90 (95% CI 0.83–0.95), 0.88 (95% CI 0.86–0.91) for preterm birth and low birth weight, respectively.

Apgar less than 7 at 5 min was documented in 190 (46.5%) babies. 72 (38%) in hypocoiled and 42 (22.1%) in normocoiled groups. There was a significant correlation between hypercoiling 114 (60%) and low Apgar, $p < 0.001$.

NICU stay beyond 24 h was observed in 124 (30.3%) babies: hypocoiled 38 (30.6%), 44 (35.4%) normocoiled and 42 (33.8%) hypercoiled.

Hypocoiling had specificity 0.76 (95% CI 0.72–0.80) and NPV 0.77 (95% CI 0.73–0.81). Hypercoiling had NPV 0.77 (95% CI 0.72–0.81) (Table 5).

Discussion

The umbilical coiling index has been found to be an effective indicator of perinatal outcome. Several studies have been done to find the relationship between UCI and various perinatal factors. Table 6 depicts the comparison of association of abnormal cord coiling with perinatal outcome in present study versus previous studies.

Mittal et al. [12] observed that hypocoiling was significantly associated with preterm labor (*P* value 0.0344) and instrumental vaginal delivery (*P* value 0.0275).

Hypercoiling was found to be significantly associated with fetal growth restriction (*P* value 0.0323) and intrapartum fetal heart rate abnormalities (0.0399).

Our study did not find any correlation between abnormal coiling index and intrapartum fetal heart rate abnormalities.

Table 6 Comparison of association of abnormal cord coiling with perinatal outcome in present study versus previous studies

	Oligo-hydramnios	Fetal growth restriction	Instrumental delivery	Preterm birth	Intrapartum fetal heart rate abnormalities	Meconium staining	NICU	Low birth weight
Jo et al. [11]								
$n = 226$								
Hypocoiling (20)	–	–	–	SS ($p < 0.04$)	–	–	SS ($p < 0.041$)	SS ($p < 0.044$)
Normocoiling (182)	–	–	–	–	–	–	–	–
Hypercoiling (24)	–	–	–	–	–	–	–	–
Sharma et al. [1]								
Hypocoiling (94)	–	SS ($p < 0.001$)	–	SS ($p < 0.001$)	–	–	–	SS ($p < 0.001$)
Normocoiling (454)	–	–	–	–	–	–	–	–
Hypercoiling (52)	–	–	–	–	–	SS ($p < 0.001$)	–	–
Mittal et al. [12]								
Hypocoiling (18)	SS ($p = 0.0021$)	–	SS ($p = 0.0275$)	SS ($p = 0.0344$)	SS ($p = 0.0399$)	–	–	SS ($p = 0.0344$)
Normocoiling (162)	–	–	–	–	–	–	–	
Hypercoiling (20)	–	SS ($p = 0.003$)	–	–	SS ($p = 0.0399$)	–	–	SS ($p = 0.0095$)
Present study								
Hypocoiling (84)			SS ($p < 0.001$)	SS ($p < 0.001$)				SS ($p < 0.001$)
Normocoiling (188)								
Hypercoiling (136)						SS ($p < 0.001$)		

SS statistically significant

Sharma et al. [1] studied the association between antenatal umbilical coiling index (a UCI) and perinatal outcome. The study showed under coiling was associated with spontaneous preterm delivery (47.87%), low Apgar score (52.13%), LBW (52.59%), FGR (21.28%), and NICU admission (76.34%). Over coiling was associated with preterm deliveries (65.38%), increased cesarean Sects. (61554%), meconium staining of liquor (67.31%), low Apgar score (63.46%), and NICU admission (72.55%). There was a positive strong correlation between antenatal UCI and birth weight ($r = +0.426$). Thus, the study concluded that abnormal coiling is strongly correlated with low birth weight.

Tahmasebi and Alighanbari [13] Department of radiology, Jundishapur medical university, Ahvaz, Iran conducted a study of evaluation of umbilical cord thickness, cross-sectional area and coiling index as predictors of pregnancy outcome. A statistically significant correlation was observed between small umbilical cord thickness, cross-sectional area and low birth weight. However, no statistically significant correlation was found between umbilical cord coiling index and low birth weight, 5 min Apgar score, and meconium staining.

Jo et al. [11] also observed, preterm delivery was significantly increased in pregnant women who showed the hypocoiling (OR 9.6, 95% CI 2.0944.07), and low birth weight and admission to NICU were not statistically significant.

Goynumer et al. [14] found significant differences in mean gestational age, mode of delivery, birth weight, and adverse perinatal outcome between fetuses with umbilical cord thickness below 5th centile (lean umbilical cord) vs those with umbilical cord thickness above the 95th percentile (non-lean cord) in the first and early second trimester of gestation. He concluded that the umbilical cord thickness correlated with birth weight, and therefore, a lean umbilical cord thickness at first and early second trimester should prompt the physician a strict monitoring of pregnancy.

Conclusion

Abnormal umbilical cord coiling index, detected at the fetal ultrasound anatomic survey in the second trimester (18–20 weeks), is associated with a higher prevalence of fetuses at risks. This observation can be used potentially as a screening or a predictive tool for adverse antenatal or perinatal events so that appropriate preventive measures could be employed for the birth of a healthy baby.

Compliance with ethical Standards

Conflicts of interest All the authors declare that they have no conflict of interest.

Ethical Statements Prior ethical clearance was obtained from Institutional Ethical Committee—Human Research of our institution.

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