Umbilical Cord Thickness, Cross Sectional Area and Coiling Index by Second TrimesterUltrasonography as Predictors of Perinatal Outcome

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Abstract

Background: Present study was carried out to determine the fetomaternal outcome in relation to cord indices (Umbilical Cord Thickness, Cross Sectional Area and Coiling Index) measuredduring the second trimester (18-24 weeks) ultrasonography.

Material & Methods: It was a prospective observational study conducted between JULY 1ST, 2021 TO JUNE 30th, 2022 at Department of Obstetrics and Gynecology, Gauhati Medical College and Hospital, Guwahati. During the study period, we included 500 consecutive women eligible to participate in the study.

Results: The mean age was found to be 25.57 with a SD of 3.174, the minimum age being 19 years and maximum age was 34 years. In the study, 6(1.2%) participants, 464(92.8%) participants and 30(6%) participants were <10th percentile (hypocoiled), 10th to 90th percentile (normocoiled) and >90th percentile (hypercoiled) of coiling index. In the study, 35(7%) participants, 429(85.8%) participants and 36(7.2%) participants were <10th percentile,10th to 90th percentile and >90th percentile of cross sectional area. In the study, 30(6%), 447(89.4%) and 23(4.6%) were <10th percentile,10th to 90th percentile and >90th percentile of cord thickness. Abnormal cord indices are significantly associated with meconium stained liquor, LBW/IUGR, Low APGAR scores, increased NICU admissions, neonatal death, congenitalanomalies and even intra-uterine fetal demise.

Conclusion: It has been concluded that abnormal cord indices are very strongly associated with adverse perinatal outcome and maternal complications. Hence, USG in the second trimester has a very potential value in screening theseadversities
Keywords: Umbilical Cord Thickness, Cross Sectional Area, Coiling Index , Second TrimesterUltrasonography , Perinatal Outcome

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Introduction

The umbilical cord is the connecting link between the new life yet to come and the mother, thus sustaining the new life by providing the necessary support required. As gestational age advances, the umbilical cord develops more coils. Coiling is a protective mechanism to prevent the vessels in the cord from being compressed.[1]

A considerable array of structural umbilical cord abnormalities exists which includes: excessively long or short cords, hyper or hypocoiling, cysts, single umbilical artery, supernumerary vessels, stricture(s), furcate and velamentous insertions (including vasa previa), umbilical vein and arterial thromboses, umbilical artery aneurysm, hematomas and tumors (including hemangioma angiomyxoma and teratoma) and rarely an absent umbilical cord.[2] During the last two decades, which has elapsed since we last assessed the challenges encountered in ultrasonographic assessment of the umbilical cord, advanced technologies including color and Power Doppler imaging and three- dimensional sonography have become popular and enabled enhanced imaging of this somewhat evasive and vital anatomical structure.[3]

Despite immense technical advances in imaging and other methods of fetal assessment, the available screening protocol and diagnostic tools have major limitations leading to adverse outcomes as a result of failure to detect fetal compromise at the same time as a high rate of obstetric intervention for suspected compromise that turns out to have been unnecessary or over diagnosed. Similarly, the available strategies for identifying women at risk of preterm birth have their limitations. Thus, we tested the utility of umbilical cord‘s morphological measurements using antenatal ultrasonography among a prospectively recruited cohort of antenatal women in predicting adverse perinatal outcomes.

Aims and Objectives

Aim

To evaluate the association between sonographic measurements of umbilical cord thickness, cross-sectional area and coiling index in second trimester ultrasonography with perinatal outcomes.

Objectives

1. To evaluate the association between sonographic measurements of umbilical cord thickness, cross-sectional area and coiling index in secondtrimester ultrasonography with perinatal outcomes.
2. To determine if it can be a predictor for congenital anomalies, preterm labour, meconium stained liquor, low birth weight (LBW),low APGAR scores, NICU admission, neonatal death and intrauterine fetal death(IUFD).

Materials and Methods

Study Design: It was a prospective observational study

Study Duration: It was 12 months (July 1st, 2021 To June 30th , 2022)

Place of Study: Department of Obstetrics and Gynecology, Gauhati Medical College and Hospital, Guwahati.

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Inclusion Criteria

1. Singleton pregnancy irrespective of parity.
2. Reliable gestational age between 18 to 24 weeks at the time ofsonography.
3. Normal amniotic fluid.
4. Presence of three vesseled umbilical cord.
5. Booked pregnant females who plan to deliver in our department.

Exclusion Criteria

1. Multiple pregnancy.
2. Lethal fetal congenital anomaly.
3. Inadequate longitudinal image of the cord to allow accurate coiling index measurement / antenatal or labour data and inappropriate cross-sectional image of the fetal abdomen.
4. If the patient could not be followed till delivery for any reason.

Sampling

The sample size was calculated using following formulae:N = $(Z_{\alpha/2})^2 * (PQ) / E^2$

N = Sample size, $Z_{\alpha/2}$ = Z value at 5% error (1.96)

P = Taken as 73.3% (Sharma et al reported that 73.3% of the meconium stainedliquor cases had hypercoiled cord), Q = 1-P, E = Allowable error (taken as 5%)N = $(1.96)^2 * (0.733*0.267)/(0.05)^2$

N = 300.73 (minimum sample size)

During the study period, we included 500 consecutive women eligible toparticipate in the study.

Sonographic Assessments

All sonographic examinations were performed by a single sonographer using a standard USG machine with color Doppler (Model-MINDRAY DC-80) and single crystal transducer of 5.0–6.0 mHz. The patients were asked to lie in a supine position, and scanning was conducted in a variety of imaging planes. Fetal anomaly scan between 18 and 20 weeks was also carried out. The cord indices were calculated in the free-floating mid-segment 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.

Measurements were performed by marking the outer edges of the umbilical cord for thickness and by encircling the outer edge of the cord in transverse section for cross sectional area.

Coiling index: 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 (UCI = 1/distancebetween the inner edge of an arterial or venous wall to the outer edge of the next coil).

All three measurements were 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.

Data Collection

Data were collected using a pre-designed semi-structured study proforma. Gestational age was based on reliable last menstrual period or first trimester ultrasound examination or both. Detailed menstrual, obstetric and medical histories of each patient were taken and general, physical, systemic and obstetricexamination was done. Relevant investigations were done according to clinical findings.

Statistical Analysis

The analysis included profiling of patients on different demographic, laboratory and clinical parameters. Descriptive analysis of quantitative parameters was expressed as means and standard deviation. Ordinal data were expressed as absolute number and percentage. Cross tables were generated and chi square test was used for testing of associations and student t test was usedfor comparison of quantitative parameters. P-value < 0.05 is considered statistically significant. All analysis were done using SPSS software, version 24.0.

Ethical Statement

The study protocol conforms to the Declaration of Helsinki and was approvedby the Institutional Ethics Committee before commencement. Written informed consent was taken from all patients. No harm is intended for the subjects. The same was explained to the participants before consenting in their own understandable language. The participants were not subjected to any extra cost for the study.

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Results and Observations

Obstetric history	**Frequency**	**Percent**
Gravida		
1	205	41
2	218	43.6
3	68	13.6
4	9	1.8
Parity		
0	284	56.8
1	204	40.8
2	12	2.4
Living issue		
0	287	57.4
1	206	41.2
2	7	1.4
No Abortion	359	71.8
Induced abortion	76	15.2
Spontaneous abortion	65	13
Comorbidity		
Gestational DM	64	12.8
Hypothyroidism	45	9
Pregnancy induced hypertension	21	4.2
None	370	74
Mode of delivery		
Spontaneous	327	65.4
Instrumental	31	6.2
Lower section cesarean section	142	28.4
Gestational age		
Early preterm (32 to 33 completed weeks)	1	0.2
Late preterm (34 to 36 completed weeks)	69	13.8
Term	430	86
Placental anomaly		
No	496	99.2
Yes	4	0.8
Total	500	100

Table- 1. Distribution of mothers according to obstetric history, Comorbidity**,** mode of delivery, gestational age and placental anomaly

In this Study, We observed that 205(41%)women were primigravida, and rest were multigravida, and 204(40.8%)women were para 1 and 12(2.4%)women were para 2. In our sample, 76(15.2%) women had a history of induced abortions and 65(13%)women had a history of spontaneous abortion. In our sample, 370(74%) participants had no past medical history. We observed that 64(12.8%) women had history of gestational diabetes mellitus, 45(9%)women had hypothyroidism and 21(4.2%)women had pregnancy induced hypertension. We observed that spontaneous normal vaginal delivery occurred in 327(65.4%) participants. Lower segment cesarean section was done in 142(28.4%) participants and instrumental delivery was done in 31(6.2%) participants. Based on gestational age, 430(86%) were term deliveries, 69(13.8%) were late preterm and only one was early preterm. Placental anomaly was diagnosed in only 4(0.8%) cases and the anomaly was reported to be an accessory lobe in all 4 cases.

Cord indices	**Mean**	**Std. Deviation**	**Minimum**	**Maximum**	**10th percentile**	**90th percentile**
Coiling index	0.7	0.10	0.47	1.11	0.56	0.83
Cross sectional area (cm2)	1.5	0.37	0.62	3.46	1.13	2.02
Cord thickness (cm)	1.4	0.17	0.9	2.1	1.2	1.6

Table 2. Showing the umbilical cord anthropometric parameters.

Table 3 shows that the mean coiling index was 0.71 with 0.10 SD with a minimum and maximum coiling index of 0.47 and 1.11 respectively. The 10th percentile was found to be 0.56 and 90th percentile was found to be 0.83. The mean cross sectional area was found to be 1.58 cm2 with 0.37 SD. The minimum and maximum values being 0.62 cm2 and 3.46 cm2 respectively. The 10th percentile was found to be 1.13 cm2 and 90th percentile was found to be 2.02cm2. The mean cord thickness was found to be 1.40 cm with 0.17 SD. The minimum and maximum values were found to be 0.9 cm and 2.1 cm. The 10th percentile and 90th percentile values were found to be 1.2 cm and 1.6 cm.

Coiling index	**Frequency**	**Percent**
< 10th percentile	6	1.2
10 to 90 percentile	464	92.8
> 90th percentile	30	6
Cross-sectional area		
< 10th percentile	35	7
10 to 90 percentile	429	85.8
> 90th percentile	36	7.2
Cord thickness		
< 10th percentile	30	6
10 to 90 percentile	447	89.4
> 90th percentile	23	4.6
Total	500	100

Table-3 . Distribution of mothers according to cord indices

Based on coiling index, 6 (1.2%) cords were < 10th percentile (hypocoiled) and 30(6%) cords were >90th percentile (hypercoiled). Based on cross-sectional area, 35(7%) cords were < 10th percentile and 36(7.2%) cords were > 90th percentile. Based on cord thickness, 30(6%) cords were < 10th percentile and 23(4.6%) cords were > 90th percentile.

Cord indices		**Gestational Diabetes Mellitus**		**Total**	
Coiling index		**No**	**Yes**		**p value**
< 10th percentile	N	3	3	6	< 0.05
	%	50.00%	50.00%	100.00%	
10 to 90 percentile	N	407	57	464	
	%	87.70%	12.30%	100.00%	
> 90th percentile	N	26	4	30	
	%	86.70%	13.30%	100.00%	
Cross-sectional area		No	Yes		
< 10th percentile	N	32	3	35	0.36
	%	91.40%	8.60%	100.00%	
10 to 90 percentile	N	375	54	429	
	%	87.40%	12.60%	100.00%	
> 90th percentile	N	29	7	36	
	%	80.60%	19.40%	100.00%	
Cord thickness		No	Yes		
< 10th percentile	N	26	4	30	0.79
	%	86.70%	13.30%	100.00%	
10 to 90 percentile	N	391	56	447	
	%	87.50%	12.50%	100.00%	
> 90th percentile	N	19	4	23	
	%	82.60%	17.40%	100.00%	
Total	N	436	64	500	
	%	87.20%	12.80%	100.00%	

Table 4. Association of cord indices with gestational diabetes mellitus

In our sample, we observed that the incidence of gestational diabetes mellitus was significantly higher among those cases who had coiling index <10th percentile (hypocoiled had 50% GDM), as compared to 10th to 90th and >90th percentile. This table shows that out of 6 participants who had coiling index <10th percentile,3 (50%)participants had GDM. Out of 464 participants, who had coiling index between 10th and 90th percentile,57 (12.30%)participants had GDM. Out of 30 participants who had coiling index >90th percentile,4 (13.30%)participants had GDM. The association was found to be statistically significant (p value <0.05) Distribution of cases according to cross-sectional area and cord thickness were not significantly associated with GDM.(p value -0.36 and 0.79 respectively).

Table-5. Association of cord indices with pregnancy induced hypertension

Cord indices		PIH		Total	p value
Coiling index		**No**	**Yes**		
< 10th percentile	N	5	1	6	< 0.01
	%	83.30%	16.70%	100.00%	
10 to 90 percentile	N	450	14	464	
	%	97.00%	3.00%	100.00%	
> 90th percentile	N	24	6	30	
	%	80.00%	20.00%	100.00%	
Cross-sectional area		No	Yes		
< 10th percentile	N	29	6	35	< 0.01
	%	82.90%	17.10%	100.00%	
10 to 90 percentile	N	416	13	429	
	%	97.00%	3.00%	100.00%	
> 90th percentile	N	34	2	36	
	%	94.40%	5.60%	100.00%	
Cord thickness		No	Yes		
< 10th percentile	N	24	6	30	< 0.01
	%	80.00%	20.00%	100.00%	
10 to 90 percentile	N	434	13	447	
	%	97.10%	2.90%	100.00%	
> 90th percentile	N	21	2	23	
	%	91.30%	8.70%	100.00%	
Total	N	479	21	500	
	%	95.80%	4.20%	100.00%	

We observed that pregnancy induced hypertension was significantly associated with coiling index <10th percentile and >90th percentile (p value < 0.01), as well as <10th percentile cross-sectional area (17.1%, p value < 0.01) and < 10th percentile cord thickness (20%, p value < 0.01).

Table 6 shows that, out of 6 participants who had coiling index <10th percentile, 1 participant (16.70%) had PIH. Out of 464 participants who had coiling index between 10th and 90th percentile, 14 participants (3.00%) had PIH. Out of 30 participants who had coiling index >90th percentile, 6 participants (20.00%) had PIH. The association was found to be statistically significant (p value <0.05)

Out of 35 participants who had cross sectional area of<10th percentile, 6(17.10%) participants had PIH.429 participants who had cross sectional area between 10th and 90th percentile, 13participants (3%) had PIH. Out of 36 participants who had cross sectional area of>90th percentile, 2 participants (5.60%) had PIH. The association was found to be statistically significant (p value <0.01).

Out of 30 participants who had cord thickness of <10th percentile, 6(20.00%) had PIH.447 participants who had cord thickness between 10th and 90th percentile , 13 participants(2.90%) had PIH. Out of 23 participants who hadcord thickness of >90th percentile, 2 participants (8.70%) had PIH. The association here was statistically significant (p value <0.01).

Cord indices		Congenital anomaly		Total	p value*
Coiling index		**No**	**Yes**		
< 10th percentile	N	6	0	6	0.52
	%	100.00%	0.00%	100.00%	
10 to 90 percentile	N	459	5	464	
	%	98.92%	1.08%	100.00%	
> 90th percentile	N	29	1	30	
	%	96.67%	3.33%	100.00%	
Cross-sectional area					
< 10th percentile	N	34	1	35	0.53
	%	97.14%	2.86%	100.00%	
10 to 90 percentile	N	424	5	429	
	%	98.83%	1.17%	100.00%	
> 90th percentile	N	36	0	36	
	%	100.00%	0.00%	100.00%	
Cord thickness					
< 10th percentile	N	29	1	30	0.48
	%	96.67%	3.33%	100.00%	
10 to 90 percentile	N	442	5	447	
	%	98.88%	1.12%	100.00%	
> 90th percentile	N	23	0	23	
	%	100.00%	0.00%	100.00%	
Total	N	494	6	500	
	%	98.80%	1.20%	100.00%	

Table-6. Association of cord indices with congenital anomaly

There were 6 cases of non-lethal congenital anomalies. None of the cord indices were significantly associated with the occurrence of congenital anomaly. The anomalies which were found are as follows- 4 babies were born with CTEV(bilateral), 1 with cleft lip and 1 with syndactyly with hydrocoele.

Cord indices		Preterm (< 37 completed weeks)		Total	p value*
Coiling index		**No**	**Yes**		
< 10th percentile	N %	5	1	6	0.61
	N %	83.33%	16.67%	100.00%	
10 to 90 percentile	N %	401	63	464	

> 90th percentile		86.42%	13.58%	100.00%	
		24	6	30	
		80.00%	20.00%	100.00%	
Cross-sectional area					
< 10th percentile	N	26	9	35	0.11
	%	74.29%	25.71%	100.00%	
10 to 90 percentile	N	372	57	429	
	%	86.71%	13.29%	100.00%	
> 90th percentile	N	32	4	36	
	%	88.89%	11.11%	100.00%	
Cord thickness					
< 10th percentile	N	24	6	30	0.48
	%	80.00%	20.00%	100.00%	
10 to 90 percentile	N	385	62	447	
	%	86.13%	13.87%	100.00%	
> 90th percentile	N	21	2	23	
	%	91.30%	8.70%	100.00%	
Total	N	430	70	500	
	%	86.00%	14.00%	100.00%	

Table 7. Association of cord indices with preterm delivery

In our sample, 70(14%) newborns were preterm. It was observed that 1(16.6%) of those with coiling index <10th percentile had preterm delivery and 6(20%) of those with coiling index > 90th percentile were preterm. However, no significant association was found (p value = 0.61). Similarly, 9(25.7%) and 4(11.1%) of those with cross-sectional area <10th percentile and > 90th percentile were preterm respectively. However, no significant association was found (p value = 0.11). Similarly, 6(20%) and 2(8.7%) of those with cord thickness <10th percentile and > 90th percentile were preterm respectively. However, no significant association was found (p value = 0.48).

Cord indices		**Meconium stained liqour**		**Total**	**p value***
Coiling index		**No**	**Yes**		
< 10th percentile	N	5	1	6	< 0.01
%		83.33%	16.67%	100.00%	
10 to 90 percentile	N	353	111	464	
%		76.08%	23.92%	100.00%	
> 90th percentile	N	8	22	30	
%		26.67%	73.33%	100.00%	
Cross-sectional area					
< 10th percentile	N	11	24	35	< 0.01
%		31.43%	68.57%	100.00%	
10 to 90 percentile	N	325	104	429	
%		75.76%	24.24%	100.00%	
> 90th percentile	N	30	6	36	
%		83.33%	16.67%	100.00%	
Cord thickness					
< 10th percentile	N	8	22	30	< 0.01
%		26.67%	73.33%	100.00%	
10 to 90 percentile	N	338	109	447	
%		75.62%	24.38%	100.00%	
> 90th percentile	N	20	3	23	
%		86.96%	13.04%	100.00%	
Total	N	366	134	500	
%		73.20%	26.80%	100.00%	

Table 8. Association of cord indices with meconium stained liquor

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In the present study, overall incidence of MSL was 26.8%. We observed that MSL was significantly more common in cases with coiling index > 90thpercentile (73.3%, p value < 0.01), cross-sectional area < 10th percentile (68.5%,p value < 0.01) and cord thickness < 10th percentile (73.3%, p value < 0.01).

Table 9 shows that out of the 6 participants who had coiling index <10th percentile , 1(16.67%)participant had meconium stained liquor. Out of 464 participants who had coiling index between 10th and 90th percentile, 111(23.92%) participants had meconium stained liquor. Out of 30 participants who had coiling index >90th percentile (hypercoiled cords), 22(73.33%)participants had meconium stained liquor. The association here was found to be statistically significant(p value<0.01).

Out of 35 participants who had cross sectional area <10thpercentile,24(68.57%) had mecomium stained liquor.429 participants who had cross sectional area between 10th and 90th percentile , 104(24.24%)participants had meconium stained liquor. Out of 36 participants who had cross sectional area of >90th percentile,6 (16.67%)participants had meconium stained liquor. The association here is statistically significant (p value < 0.01).

Out of 30 participants who had cord thickness of <10th percentile,22 (73.33%)participants had meconium stained liquor. out of 447 participants who had cord thickness between 10th and 90th percentile , 109(24.38%)participants had meconium stained liquor. Out of 23 participants who had cord thickness of >90th percentile, only 3 (13.04%) participants had meconium stained liquor. The association here was statistically significant (p value <0.01).

Cord indices		Low birth weight (<2.5 kg)		Total	p value*
Coiling index		**No**	**Yes**		
< 10th percentile	N	5	1	6	< 0.01
%		83.33%	16.67%	100.00%	
10 to 90 percentile	N	362	102	464	
%		78.02%	21.98%	100.00%	
> 90th percentile	N	12	18	30	
%		40.00%	60.00%	100.00%	
Cross-sectional area					
< 10th percentile	N	14	21	35	< 0.01
%		40.00%	60.00%	100.00%	
10 to 90 percentile	N	336	93	429	
%		78.32%	21.68%	100.00%	
> 90th percentile	N	29	7	36	

%		80.56%	19.44%	100.00%	
Cord thickness					
< 10th percentile	N	12	18	30	< 0.01
%		40.00%	60.00%	100.00%	
10 to 90 percentile	N	348	99	447	
%		77.85%	22.15%	100.00%	
> 90th percentile	N	19	4	23	
%		82.61%	17.39%	100.00%	
Total	N	379	121	500	
%		75.80%	24.20%	100.00%	

Table 9. Association of cord indices with low birth weight

In the present study, incidence of low birth weight was 24.2%. We observed that LBW was significantly more common in cases with coiling index >90th percentile (60%, p value < 0.01), cross-sectional area < 10th percentile (60%, p value < 0.01) and cord thickness < 10th percentile (60%, p value < 0.01).

Table 10 shows that out of the 6 participants who had coiling index <10th percentile , 1 (16.67%) had LBW baby. Out of 464 participants who had coiling index between 10th and 90th percentile, 102 (21.98%) had LBW baby. Out of 30 participants who had coiling index >90th percentile (hypercoiled cords), 18 (60%) had LBW baby. The association here was found to be statistically significant(p value<0.01).

In this study, out of 35 participants who had cross sectional area <10th percentile,21(60%) had LBW baby.429 participants who had cross sectional area between 10th and 90th percentile ,93(21.68%) had LBW baby.36 participants who had cross sectional area of >90th percentile,7 (19.44%)had LBW baby. The association here is statistically significant (p value < 0.01).

Out of 30 participants who had cord thickness of <10th percentile, 18(60%)had LBW baby.447 participants who had cord thickness between 10th and 90th percentile ,99 (22.15%) had LBW baby.23 participants who had cord thickness of >90th percentile, only 4(17.39%) had LBW baby. The association here was statistically significant (p value <0.01).

Cord indices		**APGAR less than 7 at 5 mins**		**Total**	**p value***
Coiling index		**No**	**Yes**		
< 10th percentile	N	6	0	6	< 0.01
%		100.00%	0.00%	100.00%	
10 to 90 percentile	N	463	1	464	

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%		99.78%	0.22%	100.00%	
> 90th percentile	N	27	3	30	
%		90.00%	10.00%	100.00%	
Cross-sectional area					
< 10th percentile	N	32	3	35	< 0.01
%		91.43%	8.57%	100.00%	
10 to 90 percentile	N	428	1	429	
%		99.77%	0.23%	100.00%	
> 90th percentile	N	36	0	36	
%		100.00%	0.00%	100.00%	
Cord thickness					
< 10th percentile	N	27	3	30	< 0.01
%		90.00%	10.00%	100.00%	
10 to 90 percentile	N	446	1	447	
%		99.78%	0.22%	100.00%	
> 90th percentile	N	23	0	23	
%		100.00%	0.00%	100.00%	
Total	N	496	4	500	
%		99.20%	0.80%	100.00%	

Table 10. Association of cord indices with APGAR < 7 at 5 mins

In the present study, incidence of low APGAR (less than 7) at 5 mins was 24.2%, while there was no case with low APGAR (less than 4) at 1 min. We observed that low APGAR was significantly more common in cases with coiling index > 90th percentile (10%, p value < 0.01), cross-sectional area < 10th percentile (8.57%, p value < 0.01) and cord thickness < 10th percentile (10%, p value < 0.01).

Table 11 shows that out of the 6 participants who had coiling index <10th percentile ,none of the babies had low APGAR Score. Out of 464 participants who had coiling index between 10th and 90th percentile,1 (0.22%) baby had low APGAR Score. Out of 30 participants who had coiling index >90th percentile(hypercoiled cords),3 (10%) babies had low APGAR Score. The association here was found to be statistically significant(p value<0.01).

Out of 35 participants who had cross sectional area <10th percentile,3 (8.57%)babies had low APGAR Score.429 participants who had cross sectional area between 10th and 90th percentile ,1(0.23%) baby had low APGAR Score.36 participants who had cross sectional area of >90th percentile ,no baby had low APGAR Score. The association here is statistically significant(p value <0.01).

Out of 30 participants who had cord thickness of <10th percentile,3(10%) babies had low APGAR Score.447 participants who had cord thickness between 10th and 90th percentile ,1(0.22%) baby had low APGAR Score.23 participants who had cord thickness of >90th percentile, no baby had low APGAR Score. The association here was statistically significant(p value <0.01).

Cord indices		NICU admission		Total	p value*
Coiling index		**No**	**Yes**		
< 10th percentile	N	3	3	6	< 0.01
	%	50.00%	50.00%	100.00%	
10 to 90 percentile	N	407	57	464	
	%	87.72%	12.28%	100.00%	
> 90th percentile	N	19	11	30	
	%	63.33%	36.67%	100.00%	
Cross-sectional area					
< 10th percentile	N	24	11	35	< 0.05
	%	68.57%	31.43%	100.00%	
10 to 90 percentile	N	374	55	429	
	%	87.18%	12.82%	100.00%	
> 90th percentile	N	31	5	36	
	%	86.11%	13.89%	100.00%	
Cord thickness					
< 10th percentile	N	19	11	30	< 0.01
	%	63.33%	36.67%	100.00%	
10 to 90 percentile	N	391	56	447	
	%	87.47%	12.53%	100.00%	
		19	4	23	

> 90th percentile	N %	82.61%	17.39%	100.00%	
Total	N	429	71	500	
%		85.80%	14.20%	100.00%	

Table 11. Association of cord indices with NICU admission

In the present study, incidence of NICU admission was 14.2%. We observed that NICU admission was significantly more common in cases with coiling index <10th percentile (50%, p value < 0.01), cross-sectional area < 10th percentile (31.4%, p value < 0.01) and cord thickness < 10th percentile (36.6%,p value < 0.01).

Table 12 shows that out of the 6 participants who had coiling index <10th percentile ,3(50%) babies had NICU Admission. Out of 464 participants who had coiling index between 10th and 90th percentile,57(12.28%) babies had NICUadmission. Out of 30 participants who had coiling index >90th percentile(hypercoiled cords),11 (36.67%)babies had NICU admission. The association here was found to be statistically significant(p value<0.01).

Out of 35 participants who had cross sectional area <10th percentile,11(31.43%)babies had NICU admission.429 participants who had cross sectional area between 10th and 90th percentile ,55(12.82%) babies had NICU admission.36 participants who had cross sectional area of >90th percentile,5 (13.89%)babies had NICU admission. The association here is statistically significant(p value <0.05)

Out of 30 participants who had cord thickness of <10th percentile,11(36.67%) babies had NICU Admission.447 participants who had cord thickness between 10th and 90th percentile ,56 (12.53%)babies had NICU admission.23 participants who had cord thickness of >90th percentile,4 (17.39%)

Cord indices		**Neonatal death**		**Total**	**p value***
Coiling index		**No**	**Yes**		
< 10th percentile	N	6	0	6	< 0.01
%		100.00%	0.00%	100.00%	
10 to 90 percentile	N	464	0	464	
%		100.00%	0.00%	100.00%	
> 90th percentile	N	27	3	30	
%		90.00%	10.00%	100.00%	

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Cross-sectional area					
< 10th percentile	N	32	3	35	< 0.01
	%	91.43%	8.57%	100.00%	
10 to 90 percentile	N	429	0	429	
	%	100.00%	0.00%	100.00%	
> 90th percentile	N	36	0	36	
	%	100.00%	0.00%	100.00%	
Cord thickness					
< 10th percentile	N	27	3	30	< 0.01
	%	90.00%	10.00%	100.00%	
10 to 90 percentile	N	447	0	447	
	%	100.00%	0.00%	100.00%	
> 90th percentile	N	23	0	23	
	%	100.00%	0.00%	100.00%	
Total	N	497	3	500	
%		99.40%	0.60%	100.00%	

Table 12. Association of cord indices with neonatal deaths

In the present study, incidence of neonatal deaths was 0.6%. We observed that neonatal death was significantly more common in cases with coiling index > 90^{th} percentile (10%, p value < 0.01), cross-sectional area < 10th percentile (8.57%, p value < 0.01) and cord thickness < 10th percentile (10%, p value < 0.01).(2 neonates died due to birth asphyxia and 1 due to neonatal sepsis)

Table 13 shows that out of the 6 participants who had coiling index <10^{th} percentile ,no neonatal death was reported. Out of 464 participants who had coiling index between 10^{th} and 90^{th} percentile, no neonatal death was reported. Out of 30 participants who had coiling index >90^{th} percentile(hypercoiled cords),3(10%) babies had neonatal death. The association here was found to be statistically significant(p value<0.01).

Out of 35 participants who had cross sectional area <10^{th} percentile,3(8.57%) babies had neonatal death.429 participants who had cross sectional area between 10^{th} and 90^{th} percentile ,no neonatal death was reported.36 participants who had cross sectional area of >90^{th} percentile, no neonatal death was reported. The association here is statistically significant (p value <0.01).

Out of 30 participants who had cord thickness of <10th percentile,3(10%) babies had neonatal death.447 participants who had cord thickness between 10th and 90th percentile ,no neonatal death was reported.

Discussion

In the present study the mean age is around 25.57±3.17 years. Our study had a mean age which is comparable to studies done by Sharma et al.[4] In the present study, 284(56.8%) participants were primigravida. Similar study which was done by Sharma et al[4] in 2018 showed that 208 (50.9%) participants were primigravida. But, the study done by Ndolo et al[5] in 2017 showed that maximum participants 384(89.3%) were multigravida.

In the present study,327(65.4%),31(6.2%) and 142(28.4%) participants had undergone spontaneous vaginal delivery, instrumental delivery and LSCS respectively which is in accordance with a similar study which was done by Ndolo et al[5] in 2017 which showed 279(64.9%),22(5.1%) and 129(30.0%) participants had undergone spontaneous vaginal delivery, instrumental delivery and LSCS respectively.Whereas the study which was done by Sharma et al in 2018[4] showed more instrumental deliveries than LSCS in the study.

In the present study, the mean, standard deviation, minimum, maximum, 10th percentile and 90th percentile of coiling index was found to be 0.71,0.10,0.47,1.11,0.56 and 0.83 respectively. The mean cross sectional area of umbilical cord, standard deviation,minimum,maximum,10th percentile and 90th percentile of the cross sectional area was found to be 1.58cm,0.37cm,0.62cm,3.46cm,1.13 cm and 2.02cm respectively. The mean cord thickness, standard deviation,minimum,maximum,10th percentile and 90th percentile was found to be1.40cm,0.17cm,0.9cm,2.1cm,1.2 cm and 1.6 cm respectively. The study done by Tahmasebi et al[6] showed themean,minimum,maximum,10th percentile and 90th percentile of coiling index was found to be 0.4,0.14,0.86,0.2451,0.5556 respectively. The mean,minimum,maximum,10th percentile and 90th percentile of the cross sectional area of umbilical cord was found to be 1.91cm,0.34cm,4.36cm,1.251cm and 2.787cm respectively .The mean,minimum,maximum,10th percentile and 90th percentile was found to be 1.54cm,0.66cm,2.36cm,1.256 cm and 1.850cm respectively. In another study, Arora et al[7] observed that mean UCI of 100 women was 0.56±0.01/cm. Minimum UCI was 0.17/cm and the maximum UCI was 1.67/cm. 12 (12%) women had hypocoiled cords (UCI<0.38/cm), 78 (78%) had normocoiled cords (UCI=0.38 0.82/cm) while the rest 10 (10%) had hypercoiled cords (UCI>0.82/cm). Ndolo observed that the range of the UCI was from uncoiled (0) to 1.49, with a median UCI of 0.43.[5] Normocoiling in their study was defined by an UCI between 0.21 and 0.59. Of the 430 coiling indices that were calculated, 324 (75%) were normocoiled, 45 (11%) were hypocoiled, and 61 (14%) were hypercoiled. In another similar study, Sharma et al found that mean umbilical coiling index (aUCI) was 0.43 ± 0.30 in (normocoiled group), 0.18 ± 0.4 (hypocoiled), and 0.53 ± 0.05 (hypercoiled group).[4] Women were grouped into Hypocoiled 84 (20.5%), normocoiled 188 (46%), and hypercoiled group 136 (33.3%).

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In the present study, 0(0.00%) participant who had hypocoiled cord,5(1.08%) participants who had normocoiled cords and 1(3.33%)participants who had hypercoiled cords were associated with con genital anomalies which was not statistically significant .In the study by Adesina et al[8], congenital abnormalities were not demonstrated in the hypocoiled group, whereas they occurred in both the normocoiled and hypercoiled groups with statistically significant difference (P = 0.009). However, the mean value of UCI in neonates with congenital abnormalities, 0.29 ± 0.12 was not statistically significant (P = 0.088).

In the present study,1(16.67%) participant who had hypocoiled cord had preterm delivery,63(13.58%) participants who had normocoiled cords had preterm delivery and 6(20.00%)participants who had hypercoiled cords had preterm delivery.The association here was not statistically significant(p value =0.61).The study which was done by Sharma et al[4] in 2018 showed 52(59%) preterm deliveries with hypocoiled cords,22(25.7%) preterm deliveries with normocoiled cords and 14(15.9%) preterm deliveries with hypercoiled cords which was statistically very significant(p value<0.001). Whereas, the study by Ndolo et al[5] in 2017 showed equal numbers of preterm deliveries(12 each) with abnormal cords and normal cords.

In the present study,1(16.67%) participant with hypocoiled cord,111(23.92%) participants with normocoiled cords and 22(73.33%) participants with hypercoiled cords had meconium stained liquor which was statistically significant.(p<0.01) Our study is comparable with the study which was done by Sharma et al[4] in 2018 which showed 4(13.3%) participants with hypocoiled cord, 4(13.3%) participants with normocoiled cords and 22(73.33%) participants with hypercoiled cords had meconium stained liquor which was statistically significant.(p<0.01) However the study which was done by Dakshayini et al[9] in 2012 showedno participants with hypercoiled cords with meconium stained liquor, thus showing meconium staining was significantly associated with hypocoiled cords(p<0.001).

Also in the present study, meconium stained liquor was seen in 24(68.57%) participants with <10th percentile of cross sectional area of umbilical cord and 22(73.33%)participants with <10th percentile of cord thickness which was statistically significant(p<0.01). This is comparable with the study done by Tahmasebi et al[6] in 2012 which also showed significant correlation between meconium stained liquor and small cross sectional area and small cord thickness.(p<0.001) On the contrary, Milani et al[10] did not observe any significant associationbetween Meconium stained liquor and coiling index. In their study, incidence of MSL was 7.7% among hypocoiled, 1.9% in normocoiled, and 0% in hypercoiled, p value = 0.08.

In the present study, it was seen that 1(16.67%) participant with hypocoiled cord, 102(21.98%)participants with normocoiled cords and 18(60%) participants with hypercoiled cords had low birth weight babies. This study was comparable to the study done by Dakshayini et al[9] in 2012 which showed participant 1(8.3%) with hypocoiled cord, 36(49.3%) participants with normocoiled cords and 11(73.3%) participants with hypercoiled cords had low birth weight babies. Both of the studies were statiscally significant (p value<0.01). But, the studies which were done by Sharma et al[4] in 2018 and Arora et al[7] in 2018, showed that hypocoiled cords were more prone to have low birth weight babies which is not in accordance with the findings of the present study.

In the present study, 21(60%) participants with <10th percentile of cross sectional area of umbilical cord and 18(60%) participants with <10th percentile of cord thickness were associated with low birth weight which was in accordance with the studies done by Tahmasebi et al[6] in 2011 and Udoh et al[11] in 2021.The present study was statistically significant(p value<0.01). However, Milani et al[10], did not observe any significant association between birth weight and coiling index. They observed that mean birth weight was 3.23 kg, 3.12 kg and 3.11kg among hypocoiled, normocoiled and hypercoiled respectively, p value = 0.54.

In the present study, it was seen that 0(0.00%) participant with hypocoiled cord, 1(0.22%) participants with normocoiled cords and 3(10.00%) participants with hypercoiled cords had babies with APGAR SCORE <7 at 5 mins which was statistically significant(p value<0.01). This study can be compared with the study done by Sharma et al[4] in 2018 which also showed 114(60%) of the participants who had hypercoiled cords had babies with low APGAR SCORE at 5 mins and was also statistically very significant (p value<0.001).However,the studies done by Dakshayini et al[9] in 2012 and Chholak et al[12] in 2017 showed that hypocoiled cords were associated with low APGAR SCORE at 5 mins which were also statistically significant(p value =0.025).

In the present study,3(8.57%) participants with <10th percentile of cross sectional area of umbilical cord and 3(10%) participants with <10th percentile of cord thickness were associated with low APGAR SCORE at 5 mins which is in accordance with the findings of the study done by Lee et al in 2020 (p value<0.01). However, when the 5-min Apgar scores were stratified according to the umbilical cord anthropometric percentiles, Tahmasebi et al[6] found that of the14 neonates with low Apgar scores, eight had normal umbilical cord thickness, seven had normal umbilical cross-sectional area, and 12 had normal UCI. Using the Pearson correlation test, we found no statistically significant correlation between 5-min Apgar scores and umbilical cord thickness (P=0.25, Pearson‘s r=0.076), umbilical cord cross-sectional area (P=0.442, Pearson‘s r=0.052), orUCI (P=0.648, Pearson‘s r=-0.031).

In the present study, it was seen that 3(50%) participants with hypocoiled cord, 57(12.28%) participants with normocoiled cords and 11(36.67%) participants with hypercoiled cords had babies who needed NICU admission.This was comparable to the study which was done by Sharma et al[4] in 2018 which also showed 42(33.8%) of the participants had babies who needed NICU admission after birth. Both of the studies were statistically significant (p<0.01) However Dakshayini et al[9] conducted a study in 2012 did not show any statistically significant correlation between coiling index and NICU admission.

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In the present study, 11(31.43%) participants with <10th percentile of cross sectional area of umbilical cord and 11(36.67%) participants with <10th percentile of cord thickness were associated with NICU admission which was statistically significant (p value<0.01).It was comparable with the findings of the study done by Lee et al[13] in 2020. On the other hand, NICU admission rate was not found to be significantly associated with coiling index in the study by Milani et al.[10] In their study, NICU admission rates were 15.4%, 21.5% and 22% among hypocoiled, normocoiled and hypercoiled cases, p value = 0.66.

In the present study, it was seen that 0(0%) participant with hypocoiled cord, 0(0%)participant with normocoiled cords and 3(10%) participants with hypercoiled cords had neonatal death which was statistically significant(p value<0.01).However, Dakshayini et al[9] in 2012 showed that 1(8.3%) participant with hypocoiled cord had neonatal death which was not statistically significant. Monique et al observed that hypocoiling of the cord was associated with fetal death.[14] Strong et al found that incidence of fetal death in noncoiled group was significantly more with p value 0.05.[15]

In the present study no IUFD was seen associated with abnormal cord indices, however,the study done by Udoh et at[11] in 2021 showed 21 cases of IUFD whose umbilical cord diameter was 2 SD below the mean.

In our sample, we observed that the incidence of gestational diabetes mellitus was significantly higher among those cases who had coiling index <10thpercentile (hypocoiled had 50% GDM), as compared to 10th to 90th and >90th percentile, p value < 0.05. The most prevalent pattern of coiling in pregnancies complicated by diabetes were non-coiling and hypercoiling. [16] Najafi et al observed that the aUCI value in non-GDM parturients was 0.4± 0.31 at 18-23 weeks of gestation and 0.29 ± 0.11 at 37-41 weeks of gestation and in GDM group was 0.32 ± 0.19 and 0.25 ± 0.11 respectively.[17] The aUCI value was lower in GDM group than non-GDM pregnancy in both trimesters. Feyi-Waboso also presented that GDM had significant association with the risk of abnormal coiling index.[18]

In the present study, it was seen that 1 (16.7%) participant with hypocoiled cord, 14(3%) participants with normocoiled cords and 6(20%) participants with hypercoiled cords had associated Pregnancy induced hypertension as a comorbidity. This is comparable to the study which was done by Milani et al[10] in 2019.Both of the studies were statistically significant (p value<0.05).Similar observations have been made with respect to pregnancy induced hypertension as well. Lv et al observed that using the cut offs both at the 0.75th quantile to define high umbilical cord coiling (≥0.28 coils/cm) and high umbilical artery pulsatility index means of mean (≥1.30), respectively, a graded increase in BP level was observed from patients with both low, either high and both high categories.[19] Moreover, umbilical cord hypercoiling (≥0.3 coils/cm) was significantly correlated with night-time DBP with an average increase of ∼5 mmHg from the 0.05th to 0.70th quantiles.

Conclusion

Cord indices such as coiling index, cross sectional area and cord thickness have a great impact on the fetal outcome. Cord measurements during first and third trimester are difficult, hence the assessment of cord indices are preferably done in the second trimester along with the late anomaly scan. It has been proved that abnormal cord indices are very strongly associated with adverse perinatal outcome and maternal complications. Hence, USG in the second trimester has a very potential value in screening theseadversities .To conclude, a more robust study with a greater margin of sample size in a large ethnic group should be undertaken to evaluate and standardize cutoffs for cord indices during the second trimester, so that these standard values can be incorporated in the routine screening protocol of any adversefetomaternal outcome.

Limitations

There are a few limitations of this study: This was a single centre study. So the results of our study might notbe generalizable to other geographic regions. Longer follow up of the neonates could not be done to know their long term consequences. One of the major limitation of this study was the lack of Wharton‘sjelly area assessment as possible predictor of fetal outcomes.

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