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An Observational Study on Evaluation of Postnatal Umbilical Cord Coiling Index and its Association with Selected Maternal Factors and Fetal Outcome

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Abstract: ***Introduction****: The factors contributing to the origin of umbilical cord coils, that is yet to be answered. The present study was undertaken to calculate the umbilical cord coiling index (UCI) postnatally in pregnant patients to identify the association with maternal high -risk factors of pregnancy and perinatal morbidity and mortality which will help in correlating maternal high-risk factors and fetal outcomes with UCI and thus can prove to be a valuable USG marker on the basis of present evidence gathered from this study.* ***Materials and Method****: 250 antenatal cases including preterm, term and post term coming to the Hospital who underwent vaginal delivery were studied. After delivery of the baby, umbilical cord coiling index (UCI) was calculated. This was further correlated with maternal high-risk factor (if any) and foetal outcome. A p value of <0.05 was considered statistically significant. Results: The mean UCI of the present study was 0.17±0.07 coils/cm. The cut off for 10th percentile was 0.0 8& the cut off for 90th percentile was 0.30. Pre-eclampsia and pregnancy induced hypertension was significantly more in hyper-coiled cords compared to normo-coiled. Both hyper-coiled and hypo-coiled cord was significantly associated with intrapartum foetal distress.* ***Conclusion****: These findings are corroborative of the fact that umbilical cord coiling is driven by certain maternal factors like anaemia in pregnancy, PIH, pre-eclampsia, oligohydramnios, while it is significantly associated with meconium -stained liquor, foetal distress and instrumental delivery as suggested by the present study. This opens up the avenue for UCI to act as predictive marker for assessing varied perinatal outcome.*

Keywords: Umbilical cord coiling index (UCI), Perinatal outcome, Pre-eclampsia, Oligohydramnios

1. Introduction

Although the umbilical cord is essential to the foetus's growth, health, and survival, no other area of the fetoplacental unit has blood vessels more susceptible to kinking, compression, traction, and twisting. Safety of these blood vessels is needed, and provided by Wharton's jelly, the amniotic fluid, and the helical pattern, or coiling, of the umbilical cord vessels. [1] The coiling of the umbilical vessels develops as early as 28 days after conception and is present in about 95% of foetuses at 7 weeks after conception. [2]

The factors contributing to the origin of these coils, that is yet to be answered. The hypotheses include foetal movements, active or passive torsion of the embryo, differential umbilical vascular growth rates, foetal hemodynamic forces and the arrangement of muscular fibres in the umbilical arterial wall**.** [1]

About the same amount of twists are detected in first trimester as in term cords. There is anything from 0 to 40 coils visible in total. It seems that umbilical coiling gives the umbilical unit turgor, resulting in a robust chord, yet flexible. Since lengthening of the cord occurs from the fetal end, perhaps coiling of the cord represents a long-term record of fetal well-being. [3]

Prior studies suggest an increase in obstetrical complications when there is abnormal cord coiling. [4, 5, 6, 7, 8] The outcomes, nevertheless, are unclear in a few ways. While some studies did not find a significant correlation, others did show one between abnormal cord coiling and meconium staining of amniotic fluid, preterm delivery, foetal death, growth restriction, foetal chromosomal or structural abnormalities, and operative delivery for foetal distress. These contradictory findings could be caused by confounding variables such widely differing reference values, a lack of blinding techniques, and a failure to do multivariate analysis.

The difference in coiling was described as an antenatal marker identifying foetus at risk. Although UCI can be calculated antenatally by ultrasonography (USG) but limited data is available as to its accuracy. The present study was undertaken to calculate the UCI postnatally in patients who delivered vaginally in SDN Hospital and to identify the association with maternal high-risk factors of pregnancy and perinatal morbidity and mortality. This will help us correlating maternal high-risk factors and fetal outcomes with UCI and thus can prove to be a valuable USG marker on the basis of present evidence gathered from this study.

2. Materials and Method

The present cross- sectional observational study was carried out in the Department of Obstetrics & Gynaecology, Swami Dayanand Hospital, Delhi among 250 pregnant women.

Inclusion criteria consisted of patient aged 20-40 years, all pregnancy including pre-term, term and post term and all vaginal deliveries [normal, assisted instrumental or vaginal birth after caesarean (VBAC)].

Exclusion criteria comprised of patient age< 20years and >40 years and caesarean section.

Antenatal cases including preterm, term and post term coming to Swami Dayanand Hospital who underwent either normal vaginal/assisted instrumental vaginal / VBAC

delivery were studied. Details of patient that includes age, LMP, gravida, parity, socioeconomic history, detailed obstetric and menstrual history, past history and family history were taken. A complete general physical examination, obstetric examination and systemic examination was done. All relevant investigation at the time of admission to labour room including complete hemogram, blood group cross matching and any other if required was done. Progress of labour, FHR monitoring and vitals of patient were monitored as per protocol. Any intrapartum foetal distress was noted.

At the time of delivery, mode of delivery was observed. After delivery of the baby, umbilical cord was clamped and cut 2 centimetres away from umbilicus and further this length of 2 centimetres was added in final umbilical cord length and UCI was calculated.

Umbilical cord length was measured with a measuring tape in centimetres (figure 1) and numbers of spirals (coils) were counted and then umbilical cord coiling index (UCI) was calculated as:

Umbilical cord Coiling Index (UCI) =

$$\frac{\text{Total no. Of complete (360 °) vascular coiling}}{\text{Total length of cord in cm}}$$

Figure 1: Measurement of length of Umbilical cord in centimetres. **(Source: Swami Dayanand Hospital-Labour room)**

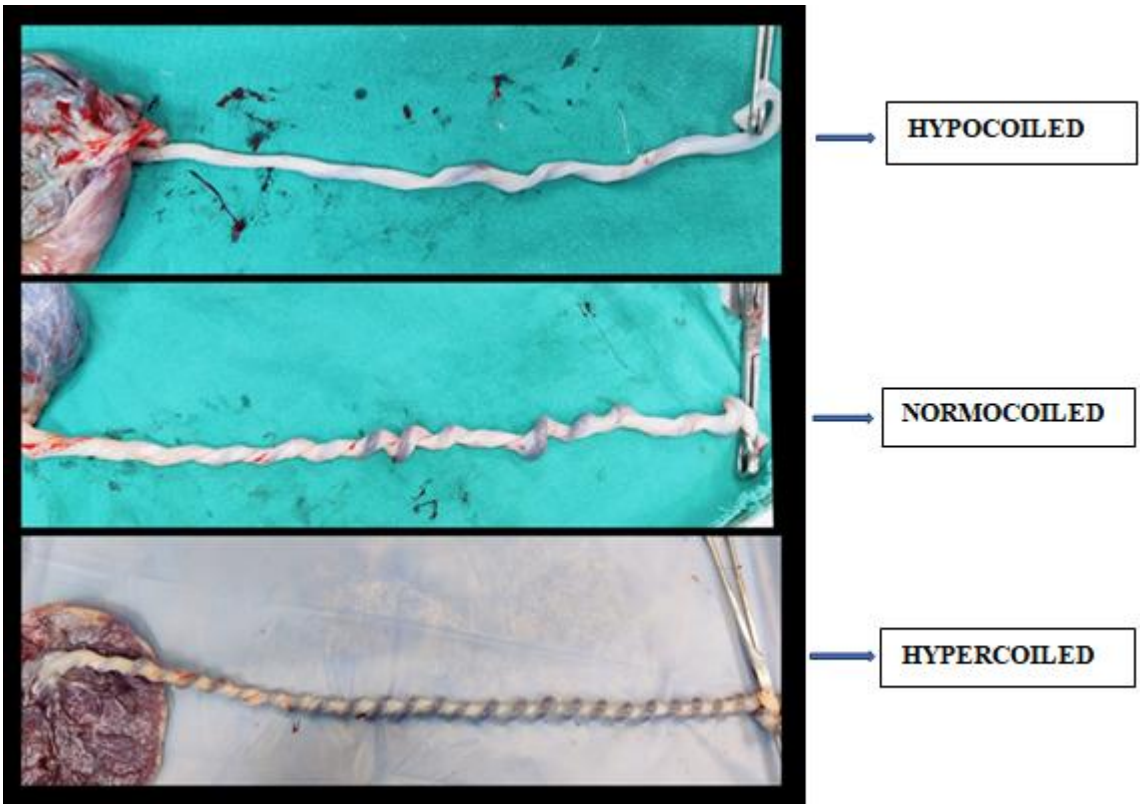

Figure 2: As per UCI -Hypo-coiled, Normo-coiled and Hyper-coiled umbilical cords. **(Source: Swami Dayanand Hospital -Labour room)**

According to UCI, it was observed whether it is normo-coiled (10^{th}-90^{th} centile), hypo-coiled (<10^{th} centile) or hyper-coiled (>90^{th} centile) (figure 2).This was further correlated with maternal high -risk factor (if any) and foetal outcome.

Maternal factors studied were age, gravida, gestational age, anaemia in pregnancy, hypertension during pregnancy (PIH/PE), gestational diabetes mellitus (GDM), oligohydramnios/ polyhydramnios, premature rupture of

membranes (PROM) and any other maternal medical disorder during pregnancy.

Intrapartum factors assessed were spontaneous / induced labour, meconium-stained liquor (MSL), foetal distress and mode of delivery – normal vaginal delivery/ assisted vaginal Delivery/VBAC. Neonatal factors assessed were APGAR score at 1min and 5 min, birth weight, admission to NICU and need for assisted ventilation.

The Statistical Package for Social Sciences (SPSS) version 21.0 was used for analysis after the data was entered into an MS Excel spreadsheet.

When the data sets were not normally distributed, the Unpaired t-test/Mann-Whitney test was used to assess the quantitative variables along with the result. Using Fisher's exact test and the Chi-Square test, qualitative variables were correlated. Both univariate and multivariate logistic regression were employed to identify the outcome's risk factors. P values less than 0.05 were regarded as statistically significant.

3. Results

Table 1: Distribution of Umbilical cord coiling index in study subjects

UCI	No.	%
Hypocoiled	22	8.8
Normocoiled	209	83.6
Hypercoiled	19	7.6
mean±SD	0.17±0.07	
Median (IQR)	0.18 (0.11-0.21)	
Range	0.04-0.36	
10^{th} percentile	0.08	
90^{th} percentile	0.30	

0.17±0.07 coils per centimeter was the average UCI (table 1). Of the 209 instances, 83.6% had normo-coiled cords, 22 had hypo-coiled cords (8.8%), and 19 had hyper-coiled cords (7.6%). The 10th percentile cutoff was set at 0.05. 22 patients with UCIs below the 10th percentile were classified as having hypocoiled umbilical cords. The 90th percentile cutoff was set at 0.30. Nineteen patients were classified as having a hypercoiled umbilical cord (UCI) exceeding the 90th percentile.

Table 2: Association of Umbilical cord coiling index with maternal factors

Maternal factors		Umbilical cord coiling index (UCI)			
		Hypocoiled	Normocoiled	Hypercoiled	P value
Maternal age	<35 years (n=240)	21(8.8 **%)**	200 (83.3%)	19 (7.9%)	1.0
	≥35 years (n=10)	1 (10%)	9 (90%)	0	0.35
Gravida	Primi (n=123)	9 (7.3%)	106 (86.2%)	8 (6.5%)	0.50
	Multi (n=127)	13 (10.2%)	103 (81.1%)	11(8.7%)	0.52
Term/preterm	Preterm (n=13)	4 (30.8%)	9 (69.2%)	0 (0%)	0.01
	Term (n=195)	16 (8.2%)	165 (84.6%)	14 (7.2%)	0.32
	Post-dated (>40 weeks) (n=42)	2 (4.8%)	35(83.3%)	5(11.9%)	0.01
Pregnancy Induced Hypertensions (PIH)	Normal (n=228)	21 (9.2%)	201 (88.2%)	6 (2.6%)	0.70
	PIH/PE (n=22)	1(4.5%)	8 36.4%)	13 (59.1%)	<0.001
Gestational diabetes mellitus (GDM)	Normal (n=247)	22 (8.9%)	206(83.3%)	19 (7.7%)	1.0
	GDM (n=3)	0(0%)	3 (100%)	0 (0%)	0.61
Premature rupture of membranes (PROM)	Normal (n=237)	20 (8.4%)	198 (83.5%)	19 (8%)	0.32
	PROM (n=13)	2 (15.4%)	11(84.6%)	0 (0%)	0.28
intrauterine deaths (IUD)	Normal (n=247)	20 (8.1%)	208(84.2%)	19 (7.7%)	0.02
	IUD (n=3)	2 (66.7%)	1(33.3%)	0 (0%)	0.61
Rh-ve	Normal (n=242)	22 (9.1%)	202(83.5%)	18 (7.4%)	0.37
	Rh-ve(n=8)	0 (0%)	7(87.5%)	1(12.5%)	0.59
Thyroid Disorder	Normal (n=247)	22 (8.9%)	206(83.4%)	19 (7.7%)	0.58
	Thyroid (n=3)	0 (0%)	3(100%)	0(0%)	0.61
Oligohydramnios	Normal (n=240)	20 (8.3%)	204(85%)	16 (6.7%)	0.20
	Oligohydramnios (n=10)	2 (20%)	5 (50%)	3(30%)	<0.01
Polyhydramnios	Normal (n=247)	22 (8.9%)	206(83.4%)	19 (7.7%)	0.58
	Polyhydramnios (n=3)	0 (0%)	3 (100%)	0(0%)	<0.01
Anemia	Normal (n=205)	8 (3.9%)	179(87.3%)	19 (8.8%)	<0.001
	Anemia (n=45)	14 (31.1%)	3066.7%)	1(2.2%)	<0.01

The relationship between maternal variables and the umbilical cord coiling index is shown in Table 2. The groups' associations were found using the chi-square test. There was no discernible correlation between the coiling index and the gravida or maternal age.

Out of 195 patients with term gestation, 16 (8.2%) had umbilical cords that were hypocoiled and 14 (7.2%) had cords that were hypercoiled. Out of 42 post-dated individuals (>40 weeks), 2 (4.8%) had hypocoiled umbilical cords, and 5 (11.9%) had hypercoiledones. Only 8.2% and 4.8% of term and post-term newborns, respectively, were hypo-coiled, compared to 30.8% of preterm neonates. Correlation which was statistically significant was found between preterm and hypo-coiling (p value = 0.01).

Pregnancy Induced Hypertension (PIH) was present in 22 cases. Out of which, 1 (4.5%) had hypocoiled & 13 (59.1%) had hypercoiled cords. In subjects with PIH/preeclampsia, hypercoiled cord were 59.1% while in normal subjects hypercoiled cord were 2.6% only. This difference was found significant statistically (p value <0.001).None of the patient with GDM had hypocoiled or hypercoiled umbilical cord.

In our study on intrapartum evaluation, Pre-Labour Rupture of Membranes (PROM) babies had a higher hypocoiled umbilical cord (15.4%) compared to normal babies (8.4%) but the difference was found statistically non -significant (p value =0.32).

Out of 3 intrauterine deaths, 2 (66.7%) babies had hypocoiled cord which was significantly higher than normal babies (8.1%). It shows that intrauterine death was significantly associated with hypocoiled umbilical cord. (p value 0.02).

No significant association was found between Rh-ve with hypocoiled or hypercoiled cord.

Among 10 ultrasound documented cases of Oligohydramnios, 20% was hypocoiled and 30% was hypercoiledumbilical cord. In subjects with oligohydramnios, hypercoiled cord were significantly higher (30%) compare to other subjects (6.7%) and correlation was found statistically significant.

Anaemia was prevalent in 45 cases, hypocoiled cord were significantly higher (31.1%) compare to other subjects (3.9%) and it was found significant statistically.

Table 3: Association of Umbilical cord coiling index with intrapartum factors

Intrapartum Factors		Umbilical cord coiling index (UCI)			
		Hypocoiled	Normocoiled	Hypercoiled	P value
Foetal distress	Normal (n=238)	18(7.6%)	204(85.7%)	16(6.7%)	0.01
	I/P foetal distress (n=12)	4(33.3%)	5(41.7%)	3(25%)	0.02
Meconium-stained liquor (MSL)	Normal (n=234)	11(7.7%)	201(85.9%)	15(6.4%)	0.01
	MSL (n=16)	4(25%)	8(50%)	4(25%)	<0.01
Mode of delivery	NVD (n=224)	19 (8.5%)	192 (85.7%)	13 (5.8%)	0.39
	Assisted (n=19)	3(15.8%)	11 (57.9%)	5 (26.3%)	<0.01
	VBAC (n=7)	0	6 (85.7%)	1 (14.3%)	<0.01
birth weight	<2.5 Kg (n=50)	5 (10%)	40(80%)	5(10%)	0.75
	2.5-4.0 Kg (n=195)	17(8.7%)	164(84.1%)	14(7.2%)	0.64
	>4 Kgs (n=5)	**0(0%)**	5(100%)	0(0%)	0.64

Table 3 reports association of umbilical cord coiling index with intrapartum factors. It was observed that among 12 cases that developed intrapartumfetal distress, hypocoiled was 33.3% and 25% was hypercoiled umbilical cord. In subjects with intrapartum foetal distress both hypocoiled (33.3%) and hypercoiled (25%) cords were more commonly observed compared to other with p value <0.05 which was statistically significant.

16 cases reported Meconium-stained liquor, among which 25% had hypocoiled and 25% had hypercoiled cord. In subjects with MSL both hypocoiled (25%) and hypercoiled (25%) cords were more commonly observed compare to other with p value <0.05.

On observing the association of UCI and mode of delivery, it was found that there were 19 assisted instrumental vaginal deliveries out of 250. Of these 3(15.8%) had hypocoiled & 5 (26.3%) had hypercoiledumbilical cords. 224 patients had normal vaginal delivery. Of these 19 (8.5%) had hypocoiled while 13 (5.8%) had hypercoiled umbilical cords. In subjects with assisted vaginal delivery hypercoiled cord were more common (26.3%) compared to other. Also, in subjects with VBAC, hypercoiled cord were more common (14.3%). On applying Chi-square test this association was found statistically significant. (p value <0.01).

No significant association between low birth babies and hypo or hyper coiling was found on applying Chi-square test.

Table 4: Association of Umbilical cord coiling index with neonatal factors

Neonatal factors		Umbilical cord coiling index (UCI)			
		Hypocoiled	Normocoiled	Hypercoiled	P value
APGAR at 1 minute	<7 (n=45)	7 (15.6%)	31 (68.9%)	7 (15.6%)	0.07
	>7 (n=205)	15 (7.3%)	178 (86.8%)	12(5.9%)	0.05
APGAR at 5 minute	<7 (n=35)	7 (20%)	24(68.%)	4 (11.4%)	0.01
	>7 (n=215)	15(7%)	185 (86%)	15 (7%)	0.35
assisted ventilation	No (n=217)	17 (7.8%)	88 (86.6%)	12(5.5%)	0.16
	Yes (n=33)	5(15.2%)	21 (63.6%)	7 (21.2%)	<0.01
With NICU Admission	No (n=230)	18 (7.8%)	196 (85.2%)	16(7%)	0.06
	Yes (n=20)	4 (20%)	13(65%)	3(15%)	0.19
Congenital anomaly	No (n=249)	21(8.4%)	209 (83.9%)	19(7.6%)	0.001
	Yes (n=1)	**1(100%)**	0(0%)	0(0%)	0.77
onset of labour	Spontaneous (n=187)	**16 (8.6%)**	166(88.8%)	5(2.7%)	0.80
	Induced (n=63)	**6(9.5%)**	43(68.3%)	14(22.2%)	<0.001

Table 4 shows association of umbilical cord coiling index with neonatal factors. No significant association was found between APGAR scores at 1 min. Among 250 cases, 35 cases showed APGAR scores < 7 at 5 min and among those 35, 7 (20.0%) had hypocoiling, 24 (68.6%) had normocoiling, while 4 (11.4%) cases showed hyper coiling pattern, p-values were < 0.05.

Babies who needed assisted ventilation had significantly higher hypercoiled cord (21.2%) compare to others and had

statistically significant association with UCI (p value < 0.01) as per Chi-square tests.

In new-borns admitted to the neonatal intensive care unit (NICU), on applying Chi-square test there was no significant association of NICU admission with hypo or hyper-coiling cords. In our present study only 1 subject had congenital anomaly which was having hypocoiled cord. As per Chi - square test (p value-0.001)

In subjects with induced onset of labour hypercoiled cord was found in 22.2% subjects while in subjects with spontaneous onset only 2.7% had hypercoiled cord. This association was found statistically significant (p value <0.001) by Chi-square test.

4. Discussion

The present study was conducted with an aim to assess the prevalence of normo-coiled, hypo-coiled and hyper-coiled umbilical cord in the sampled population of new-born and correlate the umbilical cord coiling index with the different maternal high-risk factors, including foetal outcomes.

The morphology of the umbilical cord undergoes changes with advancing gestational age, the umbilical cord vessels changing rapidly from a predominantly parallel to a twisted or coiled one. After 14 weeks of gestation, merely $9.6 \pm 5.8\%$ of umbilical cords are remain uncoiled.[14] Prevalence of non-coiled cords and poorly coiled cords range from 4% to 5%. [15] The present study found the prevalence of hypo-coiled umbilical cord to be 8.8% and hyper-coiled cords to be 7.6%. The study revealed normo-coiled umbilical cord to be 83.6%, that correlated well with several studies like Mustafa et al, [7] Chholak et al, [16] Ezimokhai M et al [5] where the prevalence of normo-coiled umbilical cord varied from 84.11 to 75.67%.

The normal umbilical cord coiling index (UCI) is generally stated to be 0.17 (+/- 0.009) spirals completed per cm. [17] The mean UCI of the present study was 0.17±0.07 coils/cm. The cut off for 10^{th} percentilewas0.08& the cut off for 90^{th} percentile was 0.30. Rana et al [14] found the mean UCI as 0.19, while De Laat MW et al [17] had calculated the mean UCI to be 0.17 coils/cm. In the study done by Ercal et al [15] mean UCI was 0.20 & that in the study of Strong et al [9] was 0.21, varying between 0.17 to 0.21cm. However, Ezi-mokhai et al [5] recorded the mean UCI as 0.26 + 0.09.

No significant difference in the coiling of umbilical cords in the older females who were pregnant at more than 35 years of age were noted. The maternal age may have a bearing on the coiling of Umbilical Cords as seen in the study by Ezimokhai M et al [5] where the hyper coiling was seen significantly more in the age group of more than 35. However, in the present study there was no significant association of the maternal age with the UCI.

The present research aimed at finding correlation of the coiling of umbilicus with selected maternal factors and perinatal outcome to substantiate the claim, that non-coiled and hypo-coiled cord has a direct correlation with adverse foetal outcome. The hypothesis could be due to the decreased coiling that is associated with decrease flow in the umbilical vessels and decreased blood supply to the foetus causing a variety of adverse perinatal outcome. [18]

It was observed that pre-term birth was significantly found more in pregnancies with hypo-coiled cord (p value-0.01). Similar findings were noted by Chitra T et al[6] in their study, who found a significant association between preterm labour and hypocoiled umbilical cord (P = 0.004). Strong et al, [9] Ercal et al [15] also observed the association between preterm labour and hypo-coiled umbilical cord.

We also found that pre-eclampsia and pregnancy induced hypertension was significantly more in hyper-coiled cords compared to normo-coiled. However, in the study by Mustafa et al, [7] Gupta et al, [19] Ezimokhai M et al[5]and Olaya CM et al, [20] it was found to be associated more with hypo-coiled cord. This differing association could be attributed to the increased proportion of normo-coiled subjects in the present study. On the other hand, Mittal et al [21] found no significant association between the coiling of umbilicus and pregnancy induced hypertension. The coiling of umbilical cord confers elastic properties and provides the ability to resist external forces that might compromise the umbilical vascular flow. The coiled umbilical cord is more resistant to torsion, stretch, and compression than the non-coiled one. [10, 19]. This might explain the association of hyper-coiling with preeclampsia. Effect of hyper-coiling on uteroplacental circulation has been further studied by Dutman and Nikkels, who examined placentas of intrauterine died foetuses and found link between hyper-coiling and foetal thrombosis. [22]

In the present research we did not find any significant association between UCI and GDM, and PROM, which was contrary to the findings of the other studies, Ezimokhai M et al[5] who found a significantly high prevalence of GDM in non-coiled cord while Mittal et al [21] found no significant difference in the presence of PROM in any of the hypo-coiled and non-coiled cord similar to our study.

Oligo-hydramnios was seen significantly more associated with hyper coiled cord, a finding corroborated by other studies in the past. Mustafa S J et al [7] showed presence of oligo-hydramnios to be significantly more in both hypo and hyper-coiled cord cases. They also found polyhydramnios to be significantly more in hyper-coiled cords, similarly Chitra et al[6] also found oligohydramnios to be significantly associated with hyper and hypo-coiled cases however they registered polyhydramnios to be significantly more associated with hyper-coiled cord. Mittal et al [21] found oligohydramnios significantly more in hypo-coiled compared to hyper-coiled. The pathological reason of oligohydramnios with the coiling of umbilical cord has not been studied in detail by the previous studies. Probable explanation can be given by an experiment by Georgious et al [23] in which a significant inverse relationship was seen between coiling index and the minimum weight required to occlude venous perfusion. So, hypo-coiling may give way to kinking and compression, whereas, hyper-coiling may give way to occlusion in cases with cord entanglement. Therefore, in hyper-coiled cases blood flow to the foetus

will be reduced, thus reducing glomerular filtration rate and reduced amniotic fluid resulting in oligohydramnios.

While non-coiled cord is susceptible to compression by external forces which might hinder the normal umbilical flow causing significant foetal distress a hyper-coiled cord may also result in compression of the umbilical vein and consequent compromise of the placento-foetal blood flow. [5] The finding in our study seems to corroborate this theory as both hyper-coiled and hypo-coiled cord was significantly associated with intrapartum foetal distress. It may be manifested as meconium-stained liquor (MSL), which showed a significant relation with hypo and hyper-coiled cord in the present study. Similar findings has been noted by Mustafa S J et al, [7] Chholak et al, [16] Chitra et al [6] and Mittal et al [21] where MSL was found to be a proxy marker of foetal distress. Sharma R et al [4] however showed no significant association between abnormal coiling of cord with foetal distress but showed significantly increase in the meconium-stained liquor cases in hyper-coiled cord as compared to normal and hypocoiled, the finding was different from other studies in the past where a clear association was found in the foetal distress and abnormal coiling. Patil et al [24] in their study found MSL to be significantly associated with hypo-coiled cord and not hyper-coiled cord cases. As opposed to these findings MSL was significantly more associated with Non-coiled and hyper-coiled cords in the study by Ezimokhai M et al. [5]

In our study we found a significant association between assisted vaginal (instrumental delivery) and hyper-coiled UCI. Chitra et al [6] registered a significant increase in LSCS in hyper-coiled cases however they did not register any difference in the instrumentation in hypo-coiled and hyper-coiled cases. Ezimokhai M et al [5] and Mittal et al [21] also showed increased risk of LSCS in hypo-coiled and hyper-coiled cases contrary to the study by Sharma R et al [4] who found a significantly increased instrumentation during delivery in cases with hypo-coiled cord. The reason for high instrumental delivery incidence in the cases with abnormal coiling of cord is not properly studies and is still obscure. Besides, our study also noted a significant association between the induction of labour and hyper-coiled cord.

The study also showed that while 1 min APGAR score was not significantly different in any category of cases, the 5-minute APGAR score differed significantly in the groups and in our study was associated with both hypo-coiled and hyper-coiled umbilical cords, but had statistically significant association with hypo-coiled UCI. The findings were similar to the other studies [16, 6, 7] that found a low APGAR score in both hypo-coiled and hyper-coiled cases. Mittal et al [21] and Patil et al [24] however did not find any significant difference in the incidence of poor APGAR score in patients. Explanation for the same could be given by analysing the anatomy of umbilical cord. Hypo-coiled umbilical vessels can get compressed by torsion or external pressure as coils in umbilical cord most likely prevent umbilical vessels from any external compression [19] thereby prevents any occlusion to foetal blood flow.

Congenital anomalies were seen significantly more in hypocoiled cases (p value-0.001) in our study, a finding contrary to Chitra et al [6] and De laat et al [17] where anomalies were significantly more associated with hyper-coiled cases. Study by Ezimokhai M et al [5] however showed a significantly more congenital anomalies in hypo-coiled cases as compared to normal and hyper-coiled similar to finding of our study.

One of the interesting results in the present research was the presence of significant association between maternal anaemia and hypo-coiled umbilical cords (p value-<0.001). The association has not been extensively studied in the past, however there have been few research which has seen this relation like Kalem et al [25] who did not find any significant association between the maternal Hb and UCI, while in the study by Steinl et al [26] hyper-coiling was associated with significantly lower serum ferritin when compared to normo-coiling. This avenue calls for further exploration, as it will be an interesting to assess how maternal ferritin is associated with umbilical coiling index, as at present the literature on this topic is scarce.

The present study did not find any significant association between UCI and maternal risk factors such as Rh-negative pregnancy, GDM, thyroid disorder, polyhydramnios, PROM. Also, no significant association was found between UCI and birth weight, NICU admission, APGAR 1-minute.

The majority of the conditions which are associated with the abnormal coiling can be explained by the discordant blood supply to the developing foetus. The medical disorders of pregnancy however are not explainable.

5. Conclusion

These findings are corroborative of the fact that umbilical cord coiling is a very good predictor of perinatal outcome in terms of meconium -stained liquor, foetal distress, instrumental delivery and can also be associated with maternal risk factors like pre eclampsia, pregnancy induced hypertension, oligohydramnios and anemia as suggested by the present study. This opens up the avenue for UCI to act as an effective prognostic marker for assessing varied perinatal outcome if incorporated in antenatal ultrasonography screenings.

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