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Umbilical cord coiling index as a marker of perinatal outcome

Pragati Jain[1,*], **Monika Aggarwal**[1], **Meenu V Ahuja**[2], **Surbhi Gupta**[3]

[1]*Dept. of Obstetrics and Gynecology, Lady Hardinge Medical College, New Delhi, India*
[2]*Dept. of Obstetrics and Gynecology, Fortis Hospital, New Delhi, India*
[3]*Dept. of Obstetrics and Gynecology, Jaipur Golden Hospital, Rohini, New Delhi, India*

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ABSTRACT

Introduction: The umbilical cord is very important for the well-being and survival of the fetus, however this is susceptible to compressions, kinking, traction and torsion which may influence the perinatal outcome and an abnormal umbilical coiling index has been related to adverse fetal and pregnancy outcomes.
Aim: To determine the umbilical cord coiling index (UCI) and compare its association with perinatal outcome in normal and complicated pregnancies.
Materials and Methods: It was a prospective observational study done on 200 patients at term (after 37 weeks) pregnancy, delivered either vaginally or by cesarean section. The umbilical cord coiling index was calculated. The mean coiling index of our study was 0.256+0.07 per cm. The outcomes measured were maternal age, parity, body mass index, hypertension in pregnancy, diabetes in pregnancy, amniotic fluid index, meconium staining of liquor, neonatal birth weight, Apgar score at birth, ponderal index, NICU admission. The coils were then divided into three categories on the basis of UCI and their association with the maternal and fetal outcomes were analyzed. Hypocoiled cords were those having UCI less than 10th centile, and hypercoiled cords those having UCI more than 90th centile. Statistical analysis was done by chi square test, Fishers exact test and the t test where applicable.
Results: Hypocoiled cords (UCI <10th centile) were associated with pregnancy induced hypertension (PIH), diabetes mellitus, meconium staining of liquor, low Apgar score, growth restricted fetus and NICU admission. Hypercoiled cords were associated with liquor abnormalities and low ponderal index.
Conclusion: Abnormal umbilical cord coiling index was associated with adverse perinatal outcomes.

1. Introduction

The umbilical cord forms connecting link between the placenta and the fetus. The umbilical cord is the lifeline for fetus as it supplies water, oxygen and nutrients to fetus. The three blood vessels run along the cord in helical or coiled fashion.[1] The helical fashion of umbilical vessels is termed as spiral course.[2] The umbilical cord plays critical role in the development and survival of the fetus, yet it is vulnerable to kinking, compressions, traction, and torsion which may affect the perinatal outcome.[3] The umbilical cord is protected by Wharton's jelly, amniotic fluid, helical patterns, and coiling of vessels.[4] One of the most important characteristics of the human umbilical cord, is the spiral course of its component blood vessels.[3] The coiling properties of umbilical cord were first described by Berengarius in 1521.[1] In 1954, umbilical coiling was first defined by Edmonds who divided the total number of coils by the umbilical cord length in centimeters and called it ‗The Index of Twist.[5] This is later simplified and termed as "umbilical cord coiling index" by Strong et al. A coil is of 360-degree spiral course of umbilical vessels around

* *Corresponding author.*
E-mail address: drpragati2802@gmail.com (P. Jain).

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Wharton's jelly.[1] Umbilical coiling index (UCI) is defined as the total number of coils divided by the total length of the cord in centimeters.[3] A frequency distribution of UCI was done by Rana et al[2] they grouped the UCI as follows: <10th percentile—hypocoiled, a percentage of cords with coils that lie below 10%; 10th–90th percentile—normocoiled; >90th percentile—hypercoiled or those cords that have coils more than normal and lie above 90% of all, and the abnormal UCI has been reported to be related to adverse fetal outcome.[1,2,6]

Strong et al.[7] had shown that in noncoiling cords, the still birth rate is about 8—10%, and similarly, an increased incidence of intrauterine growth restriction, oligohydramnios, fetal anomalies, fetal heart rate deceleration during labor, intervention due to fetal distress, meconium in amniotic fluid, preterm labor, low Apgar score, low PH of umbilical artery, and need to ICU for neonates and also gestational diabetes mellitus were observed in these straight cords Interestingly, increased vascular coiling is also accompanied by an increased incidence of adverse fetal outcome.[8]

2. Materials and Methods

It was a prospective observational study. An informed consent was taken prior to enrollment of patient in study. 200 singleton live babies with >37 weeks gestation born either by vaginal delivery or cesarean section in Department of Obstetrics and Gynecology, for a period of 1 year were included in the study. After separating baby from umbilical cord, taking care not to milk the cord (as it may affect the UCI), the umbilical cord was tied and cut nearest to placenta. Then the length of umbilical cord was measured, which also includes the length of the placental end and remaining stump on baby taking care that no excessive traction was given to the cord at the time of measurement. The number of complete coils and direction of coiling were noted starting from the neonatal end to the placental end. A coil is defined as a complete 360 degrees spiral course of all three umbilical vessels around the Wharton jelly. Umbilical coiling index was calculated by dividing the total number of the coils by the total length of cord in centimeters.

Hypocoiled cords were those with UCI less than 10th percentile and hypercoiled cords were those with UCI more than 90th percentile.

Maternal factors like Age, gravidity, BMI, gestational age at delivery was noted. Coiling index will be seen in normal as well as high risk pregnancy like diabetes mellitus, oligohydramnios, polyhydramnios and pregnancy induced hypertension. Then the relationship between UCI and neonatal factors like meconium staining of liquor, birth weight, Apgar score of neonates, ponderal index, NICU admission were evaluated.

Study protocol was approved by ethical committee of the institution.

Statistical analysis was done. Categorical variables were presented in number and percentage (%) and continuous variables was presented as mean ± SD and median. Odds ratio with 95% Confidence Intervals calculated for selected variables and their significance was tested. Univariate and Multivariate logisitic regression was used to assess the association between hypocoiling and hypercoiling and adverse pregnancy outcome.

Statistical tests were applied as follows-

1. Quantitative variables was compared using unpaired t-test/Mann-Whitney Test between two groups and Anova /Kruskal wallis test between three groups.
2. Qualitative variables were compared using Chi-Square test /Fisher's exact test.

A p value of <0 05 was considered statistically significant.

3. Results

Out of 200 patients 170 patient belonged to the age group 21-35 years (85%). Mean age was found to be 26.4(±4.63) years. In the study 108(54%) patients were primigravida and 92 (46%) were multigravida. Then the cases were categorized according to gestational age at delivery, it was found that majority of cases that is 125 (62.5%) delivered between 39-40^{+6} weeks. BMI of patients was also analyzed and it was found that high BMI was significantly associated with hypercoiling of cord (Table 1). In study of 200 cases, out of which 152 (76%) cases had normocoiling, i.e UCI between 10^{th} and 90^{th} percentile. Abnormal coiling was present in 48 cases. 25 (12.5%) cases had hypocoiling, i.e. UCI < 10^{th} percentile. 23 (11.5%) cases had hypercoiling, i.e. UCI > 90^{th} percentile. The mean UCI of our study is 0.256+0.07 per cm. In our study association between pregnancy induced hypertension and abnormal UCI was studied and it was found that 10 (41.67%) were having hypocoiling of cords, which was statistically significant (p value=<0.0001) (Table 1). Diabetes in pregnancy was also correlated with abnormal UCI and 6(31.55%) were found to have hypocoiled cords, which is statistically significant. Liquor abnormalities were also analyzed and it was found that oligohydramnios was significantly associated with hypocoiling which was seen in 3(25%) patients and polyhydramnios was significantly associated with hypercoiling which was seen in 6(40%) patients (Table 1).

Perinatal factors were also studied and correlated with abnormal UCI. Out of 43 patients who had meconium staining of liquor, 24(55.81%) were having hypocoiling of cords which was a significant association (p value <0.001). 30 babies showed low Apgar score at birth, in which 9(30%) were having hypocoiled cords. 27 babies were having low birth weight (<2.5 kgs),19 (70.3%) were having hypercoiled cords. 21(14.7%) babies had hypercoiling of cord and also low ponderal index, which was shows moderate statistical

Table 1: Antenatal factors and their association with abnormal coiling

Antenatal factors	Normocoiled	Hypocoiled	Hypercoiled	P value
PIH	11(45.83%)	10(41.67%)	3(12.5%)	<0.0001
Diabetes	10(52.6%)	6(31.5%)	3(15.7%)	0.019
Liquor abnormalities				
(i) Oligohydramnios	7(56.3%)	3(25.0%)	2(16.6%)	0.001
(ii) Polyhydramnios	6(40.0%)	3(20.0%)	6(40.0%)	0.0001

significance. 41 babies had NICU admission, out of which 16(39.2%) had hypocoiling of cords (Table 2).

4. Discussion

Umbilical cord serves a paramount role in fetal intrauterine persistence and is the most vulnerable part of fetal anatomy. Umbilical cord architecture has varying relationships between artery and vein. The difference indicates subtle blood flow change and vulnerability that alter fetal circulation.[9] An abnormal umbilical coiling Index (UCI) includes both hypocoiled and hypercoiled cords. The pattern of coiling develops during the middle trimester and it changes as pregnancy advances. The mean UCI in our study was 0.256±0.7per cm. Mean length of cords was 59.25 cms and average number of coils were 14.96, with minimum being 2 and maximum being 32 coils. Mean UCI of various studies was analyzed and our result was found to be close to study by Chitra et al.[10] and Ezimokhai M et al.[8] A recent meta-analysis showed the normal UCI to be 0.17± 0.009 completed spirals per cm. In consideration of the abnormal versus normal coiling distribution in our study, it was observed that 10th percentile – hypocoiling (UCI < 0.05) and 90th percentile – hypercoiling (UCI >0.43) were in agreement with the previous studies.

The result of our study regarding hypertension in pregnancy revealed a significant association with hypocoiled cords (41.6%), this was found by Chitra T et al.[10] and Gupta S et al[1] too, although Larco V et al[6] and Strong TH et al.[7] found that hypertension in pregnancy might be related with normocoiling. The coiled umbilical cord, because of its elastic properties, is able to resist external forces that might compromise the umbilical vascular flow. The coiled umbilical cord acts like a semi erectile organ that is more resistant to snarling torsion, stretch, and compression than the noncoiled one. This might explain the association of hypocoiling with preeclampsia. In the study by Diwakar et al.,[11] they have done antenatal detection of UCI and found that hypertension in pregnancy was associated with hypocoiling. In the present study significant association was found between hypocoiling and diabetes mellitus. In similar study by Najarajan G et al[12] among 385 women, 27 had diabetes mellitus and they also showed significant association between diabetes mellitus and hypocoiling. While the study by Mustafa SJ et al.[13] showed association between hypercoiling and diabetes mellitus, but there are no proper theories to explain the association, and no other studies had shown this association, so further research is needed in this area. Kashanian M et al.[14] found oligohydramnios to be significantly associated with both hypocoiled and hypercoiled, but in our study, after analyzing amniotic fluid index among 200 pregnant women, it was found that oligohydramnios was significantly associated with hypocoiling, whereas polyhydramnios had association with hypercoiling, so our result are akin to the results of study by Gupta S et al[1] and Mustafa et al.[13] Results of our study can be explained by Edmond's hypothesis which states that twist of the umbilical cord is a result of the rotatory movement imparted to the embryo, and hence more is the amount of liquor amnii, more is the rotatory movement of the fetus and more will be the coiling. The converse will be true for oligohydramnios.

In our study, 43 cases had meconium staining of liquor, out of which 55.81% had hypocoiling, which shows meconium staining was significantly associated with hypocoiling. In the study by Gupta S et al[1] and Strong TH et al.,[7] it was found that hypocoiling and meconium staining had significant association. In another study by Attala et al[15] they correlated vascular coiling with umbilical cord pH and perinatal outcome and found no relation between vascular coiling and meconium staining of liquor and other adverse intrapartum events, whereas Sahoo K et al[16] found that meconium staining of liquor was associated with hypercoiling. Though clear explanation has not been given by any one, but meconium staining with hypocoiled cords can be explained with the fact that acute kinking may led to sudden hypoxia in fetus. Low Apgar score significantly associated with hypocoiling in the present study, and similar observation were found in studies by Patil NS et al.,[17] Agrawal S et al.[18] and Monique et al.[19] UCI was correlated with birth weight of babies. 27 (13.5%) had low birth weight (<2.5 kgs), 70.3% had hypercoiling which shows that low birth weight was significantly associated with hypercoiling. In similar study by Monique WM et al.[19] 885 patients were studied and hypercoiling was associated with low birth weight. Rana et al[2] and de Laat et al[20] also shows similar results. However, none of the authors has given clear explanation.

Hypercoiling of cord had moderate significance with low ponderal index in our study. As fetal growth restriction babies have low ponderal index, hypercoiled cords are associated with both fetal growth restriction and low

Table 2: Perinatal factors and their association with abnormal coiling

Perinatal factors	Normocoiled	Hypocoiled	Hypercoiled	P value
Meconium staining of liquor	16(37.21%)	24(55.8%)	3(6.4%)	<0.0001
Low Apgar score (<4)	20(66.7%)	9(30.0%)	1(3.3%)	0.004
Low birth weight (2.5kg)	7(25.9%)	1(3.0%)	19(70.3%)	<0.0001
Low ponderal index (<4)	105(73.9%)	16(11.2%)	21(14.7%)	0.065
NICU admission	10(24.3%)	16(39.2%)	15(36.5%)	0.01

ponderal indices. Patil N.S. et al[17] also showed significant association of hypercoiling with low ponderal index.

In the present study babies admitted to NICU were 41 out of which 16(39.02%) had hypocoiling P value being <.0001 strongly suggest that NICU admission was significantly associated with hypocoiling**.** Monique WM et al.,[19] found that hypocoiling of the cord was associated with NICU admissions. Whereas, in another studies by Jain D et al,[21] and Mittal A et al.,[22] hypercoiling was found to be significantly associated increased NICU admissions.

This study showed that the abnormal umbilical cord coiling index and adverse perinatal outcome were significantly associated. Although, data available till date shows wide variation among various studies. UCI can be calculated in antenatal period using Doppler that will categorize the patients into normal and abnormal coiling and predict the maternal and fetal outcome and further suitable management.

5. Conclusion

Umbilical coiling index was found to be an important predictor of adverse perinatal outcome. The adverse events that were reported in mothers who had abnormal coiling index were hypertension in pregnancy, diabetes mellitus, and meconium stained liquor and whereas the adverse events that were reported among the neonate were low Apgar score and respiratory distress warranting them for NICU admission. To conclude, abnormal umbilical coiling index is associated with several adverse antenatal and neonatal events. It seems that the vascular coiling of the cord is an important entity and, in the future, if antenatal identification of hyper- or hypo-coiled cords becomes accurate, it may be correlated with adverse perinatal outcome, but more conclusive studies are still necessary.

6. Source of Funding

None.

7. Conflict of Interest

None.

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Author biography

Pragati Jain, Senior Resident https://orcid.org/0000-0001-6040-2755

Monika Aggarwal, Senior Resident

Meenu V Ahuja, Consultant

Surbhi Gupta, Consultant

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