European Journal of Molecular & Clinical Medicine

ISSN 2515-8260 Volume 9, Issue 3, Winter 2022

ORIGINAL RESEARCH

Umbilical coiling index as a marker of perinatal outcome

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ABSTRACT

Introduction:The umbilical cord is vital for development, wellbeing and survival of the fetus and yet, it is vulnerable to kinking, compressions,traction and torsion which may effect the perinatal outcome. The total number of coils for any particular cord is believed to be established early in gestation.

Aim:To measure the umbilical coiling index postnatally and to study its association with adverse perinatal outcomes.

Materials and methods:Prospective Observational study in Department of Obstetrics and Gynecology , for a period of 1 year 6 months.120 cases carried out to calculate the UCI and correlate the relationship between the abnormal umbilical coiling index (hypo or hyper) and adverse perinatal outcome.

Results: Baseline characters were similar in the three groups. There was a significant difference between the hypercoiled and hypocoiled group with respect to the perinatal parameters like meconium staining, NICU admissions of the babies, low APGAR score at 1 minute, fetal distress and birth weights.

Conclusions:Both hypo and hypercoiling of cords had significant correlation with adverse fetal outcomes.

Keywords:umbilical coiling index, hypocoilling,hypercoiling.

INTRODUCTION

The umbilical cord or funis forms the connecting link between the fetus and the placenta through which the fetal blood flows to and from the placenta. The umbilical cord is the life line of the fetus as it supplies water, nutrients and oxygen to the growing fetus. The three blood vessels pass along the length of cord in helical or coiled fashion. The helical fashion of these umbilical vessels is termed as spiralcourse.[1]

A coil is defined as complete 360degrees spiral course of umbilical vessels around the Wharton's Jelly [1]. Umbilical coiling was first quantified by Edmonds who divided the total number of coils by umbilical cord length in centimeters and called it "The index of Twist". He assigned positive and negative scores to clockwise and anti clockwise

coilingrespectively[1,3] . Later, strong et al simplified by eliminating these directional scores and named it, "The umbilical coiling Index".[2]

An abnormal UCI includes both hypo coiled cords (i.e., cords with UCI < 10^{th} percentile) and hypercoiled cords (i.e., cords with UCI > 90^{th} percentile). An abnormal umbilical coiling has been studied in relation to adverse perinataloutcomes.[3]The present study has been undertaken to compare the perinatal outcome with the abnormal coiling of umbilical cord with respect to umbilical coiling index.

MATERIALS AND METHODS

Prospective Observational study in Department of Obstetrics and Gynecology, Government Medical College, Siddipetfor a period of 1 year 6 months (March 2018 to August 2019).Patients admitted in labour room in active labour fulfilling the study criteria.

INCLUSION CRITERIA

Women with term gestation irrespective of parity, singleton pregnancies, live fetus, spontaneous onset of labour, women in active labour, cephalic presentation.

EXCLUSION CRITERIA

twin gestation, preterm delivery**,** intrauterine death**,** anomalous baby**,** malpresentation, pre eclampsia,GDM**,** TOLAC**,** Elective Caesarean Sections

SAMPLE SIZE

120

Sample size is calculated using the formula

$$n \geq \frac{NZ^2_{1-\alpha/2}p(1-p)}{d^2(N-1)+Z^2_{1-\alpha/2}p(1-p)}$$

where n : Desired sample size
Alpha (α) : Type 1 error rate
p: Proportion
d: Marginal error rate
N: Population size
Substituting
Alpha (α) = 0.05
Proportion (p) = 53.3 % (53.3 % of Hypercoiled cords were associated with poor APGAR score at 5 minutes according to previous study [4])
Marginal error rate (d) = 10 %
N = 1000000
We get n = 96
Therefore we will be including minimum of 96 subjects as sample size in our study.
Minimal sample size being 96, patients fulfilling the study criteria during the study duration were 120. So the sample size was taken as 120.
Institutional and ethical committe approval was taken for the study. Pregnant women in active labour fulfilling the study criteria are included in the study.Patients were explained about the purpose of study and ensured strict confidentiality. Written informed consents were taken prior to the study. Following Helsinki Declaration on research bioethics, they were given the options not to participate in the study if they wished.

Patients in active labour with term gestation, irrespective of parity,with singleton pregnancies with live fetus admitted in labour room were observed in second and third stage of labour.
After separating the baby from umbilical cord, the cord was clamped and cut as close to the baby as possible.The umbilical cord was measured including both the placental end of the cord and umbilical stump on the baby side.Number of complete coils or spirals were countedand the direction of the coils noted from the placental end by placing the umbilical cord vertically.If the direction of the vessels on the anterior surface of the cord is towards the left hand side of the observer it is noted as Left sided coiling and Right sided coiling if the direction of the coils is towards right.
After this UCI was calculated by dividing total number of coils by the total length of the cord in centimetres.
UCI = Number of coils / total length of the cord (in cm)
Then perinatal parameters like birth weight, meconium staining, gender,fetal distress, NICU admission, APGAR score at 1 minute and 5 minutes, fetal growth restriction, direction of twist of coils were correlated with umbilical coiling index.
All the data regarding patients age , parity , Booked or Unbooked , Mode of delivery, UCI, type of coiling, direction of the coiling, gender of the baby, birth weight, meconium staining, APGAR score at 1 minute, APGAR score at 5 minutes,FGR, fetal distress and NICU admission were collected, data was entered into Microsoft excel sheet and was analyzed and results were calculated.

STATISTICAL ANALYSIS

Data analysis was performed by using SPSS (Statistical package for social sciences) version 20:0.Qualitative data variables expressed by using frequency and percentage (%).Quantitative data variables expressed by using descriptive statistics like mean, range, SD, Median.Chi-square test / Fisher's exact test was used to find the association with various qualitative data variables. P-value<0.05 considered as significant.

RESULTS

Table 1: Maternal variables in the study

Age in years	**Frequency**	**Percent**
18-20	6	5.0
21 – 25	55	45.8
26 – 30	50	41.7
> 30	9	7.5
Total	120	100.0
Booked or Unbooked		
B	96	80.0
UB	24	20.0
Total	120	100.0
Parity		
Primi	58	48.3
Multi	62	51.7
Mode of delivery		
Spontaneous vaginal delivery	78	65.0
Outlet forceps	10	8.3
LSCS	32	26.7

The total number of cases studied were 120.The maximum patients studied were distributed in the age groups of 21-25 years i.e ., 55 cases (45.8%) and 26-30 years i.e., 50 cases

(41.7%) . The minimum patients studied were in the age group of 18-20 years i.e ., 6 cases (5%). The patients in the age group and 31-35 years were 9 cases (7.5%).
Out of 120 patients, 96 (80%) were booked cases and 24 (20%) were unbooked cases.The number of primigravida were 58 (48.33%) and multigravida were 62 (51.67%).The number of patients delivered normally were 78 (65%) , by Outlet forceps were 10 (8.3%) and by LSCS were 32 (26.7%) .

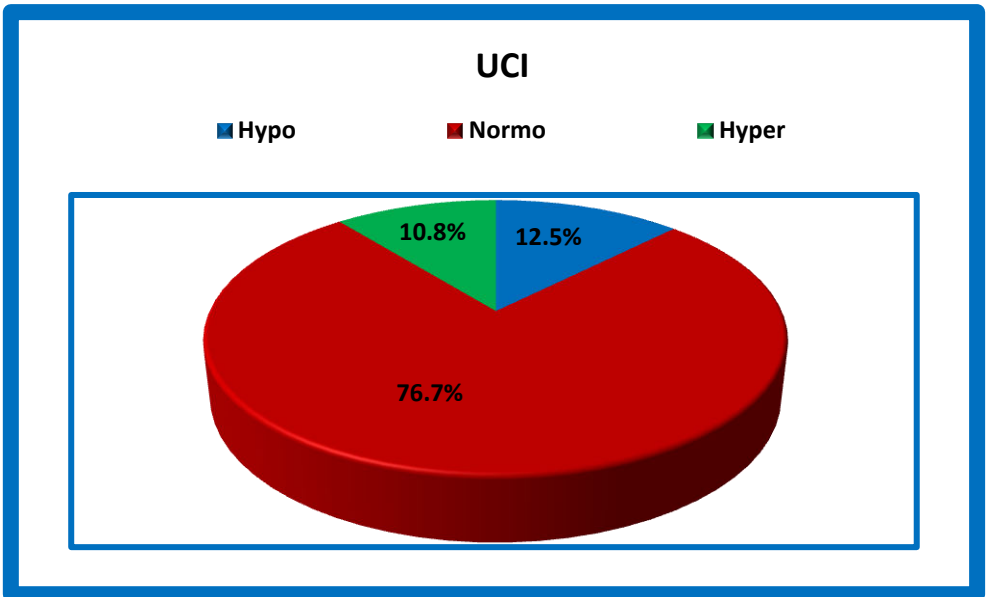
Table-2: Neonatal variables in present study

Birth weight	**Frequency**	**Percent**
< 2.5	16	13.3
2.5 - 3.5	86	71.7
> 3.5	18	15.0
Total	120	100.0
Baby sex		
Female	61	50.83
Male	59	49.17
APGAR 1 min		
< 4	7	5.8
≥ 4	113	94.2
APGAR 5 min		
< 7	10	8.3
≥ 7	110	91.7
NICU admission		
No	98	81.7
Yes	22	18.3
Direction of twist		
Sinistral	91	75.8
Dextral	29	24.2
Fetal growth restriction		
Yes	13	10.8
No	107	89.2
Fetal Distress		
Yes	28	23.3
No	92	76.7
Meconium staining		
No	94	78.3
Yes	26	21.7

The number of babies with birth weight <2.5kg are 16 (13.3%) , between 2.5-3.5 kg are 86 (71.7%) and > 3.5kg are 18 (15%) .Out of 120 babies 61 (50.83%) were female and 59 (49.17%) were male.Babies born with Apgar score at 1 minute <4 were 7 (5.8%) and ≥ 4 were 113 (94.2%).Babies born with Apgar score at 5 minutes <7 were 10 (8.3%) and ≥ 7 were 110 (91.7%).
Out of 120 babies , 22 (18.3%) were admitted in NICU and the rest 98 (81.7%). The twist of the cord was sinistral i.e., to the left side in 91 (75.8%) and it was dextral i.e., to the right side in 29 (24.2%). 13 (10.8%) had FGR and 107 (89.2%) had no FGR. 28 (23.3%) had fetal distress and the rest 92 (76.7%) had no fetal distress.The meconium stained liquor was found in 26 (21.7%) and clear liquor is seen in 94 (78.3%). Any concentration of liquor was taken into the criteria (thin or thick).
In the present study UCI < 10^{th} percentile is **<0.07**, UCI > 90^{th} percentile is**> 0.44**

The mean umbilical coiling index UCI is**0.26 ± 0.13**

Graph 1: Distribution of UCI



This table represent the study of 120 patients, out of which 92 (76.7%) had normocoiling i.e., UCI between 10th to 90th percentile. 15 cases (12.5%) had hypocoiling i.e., UCI < 10th percentile,13 (10.8%) had hypercoiling i.e., UCI >90th percentile.

Table -3: Correlation of maternal variables with UCI

Correlation of Age of mother with UCI	**Normocoiled**	**Hypocoiled**	**Hypercoiled**
18-34	90	15	13
≥ 35	2	0	0
P-value		0.56	0.59
Correlation of Booked / Unbooked cases with UCI			
Booked	73	14	9
Unbooked	19	1	4
P-value		0.19	0.41
Correlation of Parity with UCI			
Primi	41	10	7
Multi	51	5	6
P-value		0.11	0.53
Mode of delivery			
Spontaneous/Outlet forceps	78	2	8
LSCS	14	13	5
P-value		<0.001*	0.04

There is no statistical significance between UCI and age of the mother and Parity. There is statistical significance between UCI and Mode of delivery,Hypocoiled cords being more associated than hypercoiled cords.

Table-4: Correlation of neonatal variables with UCI

	Normocoiled	Hypocoiled	Hypercoiled
Correlation of Birth weight(kgs) of the baby with UCI			
<2.5	4	5	13
2.5-3.5	75	8	2
>3.5	13	3	3
P-value		<0.01*	<0.001*
Correlation of Gender of the baby with UCI			
Female	46	6	9
Male	46	9	4
		0.47	0.19
Correlation of Apgar score at 1 minute of the baby with UCI			
<4	2	4	1
>4	90	11	12
		<0.01*	0.26
Correlation of Apgar score at 5 minutes of the baby with UCI			
< 7	1	6	3
≥7	91	9	10
		<0.01*	<0.01*
Correlation of NICU admission of the baby with UCI			
Yes	8	9	5
No	84	6	8
		<0.01*	0.002*
Correlation of Direction of twist of the cord with UCI			
Sinistral	69	12	10
Dextral	23	3	3
		0.68	0.88
Correlation of FGR with UCI			
Yes	3	5	5
No	89	10	8
		<0.001*	<0.001*
Correlation of Fetal distress with UCI			
Yes	13	10	5
No	79	5	8
		<0.001*	<0.03*
Correlation of Meconium staining with UCI			
Yes	13	8	5
No	79	7	8
		<0.001*	<0.03*

There is statistical significance between UCI and Birth weights of babies, Apgar score at 1, 5 minutes, NICU admissions, Fetal growth restriction, Fetal distress and Meconium staining of liquor in Hypercoiled cords being more associated than hypocoiled cords.Butthere is no statistical significance between UCI and Gender of the babies and direction of the twist of the cord.

DISCUSSION

Several studies in the past have correlated the relationship between perinatal outcome and the UCI. The Umbilical coiling index was found to be an effective indicator of perinatal outcome.Women as per selection criteria were taken into the study. UCI was calculated by Strong et al formula , dividing the total number of coils by the total length of the cord in centimetres and the UCI obtained was correlated with various parameters.The UCI was correlated to the maternal factors like maternal age , parity, booked or unbooked cases, mode of delivery and perinatal factors like gender ,birth weight , Apgar score at 1 minute and 5 minutes, NICU admissions , meconium staining , fetal distress , fetal growth restriction and direction of twist of the cord.

The mean length of the umbilical cord in the study was 60.59 ± 10.23. The mean number of coils was 16.17± 8.29.The mean umbilical coiling index (UCI) in the study was 0.26 ± 0.13 which is consistent with the previous studies.The mean UCI in the study is comparable to the study done by Ezimokhai et al, Chitra et al and Sandeep kumaret al.[5,6,7]

In consideration of the abnormal versus normal coiling distribution in this study it was observed that 10^{th} percentile –hypocoiling (UCI < 0.07) and 90^{th}percentile –Hypercoiling (UCI > 0.44) were in agreement with the previous studies. Among 120 patients , 92 (76.7%) had normocoiling i.e., UCI between 10^{th} to 90^{th} percentile. 15 cases (12.5%) had hypocoiling i.e., UCI < 10^{th} percentile ,13 (10.8%) had hypercoiling i.e., UCI >90^{th} percentile.

The women included in the present study were in the age group ranging from 18-35 years.Majority of women were in the age group of 20-28 years. p value for hypocoiled cords was found to be 0.56 and for hypercoiled cords was found to be 0.59.There is no statistical significance between UCI and age of the mother.Ezimokhai et al.[5] Found hypercoiling to be associated with extremes of maternal age (< 20 and > 35).None of the other studies found age to be a significant factor .UCI was correlated with Booked and Unbookedcases.p value being 0.19 and 0.41 for hypocoiled cords and hypercoiled cords respectively,there is no statistical significance between UCI and Booked / Unbooked cases.UCI was correlated with Parity. p value being 0.11 and 0.53 for hypocoiled cords and hypercoiled cords respectively,there is no statistical significance between UCI and Parity. No significant association was found between UCI and parity in previous studies also. UCI was correlated with Mode of delivery. p value being 0.001 and 0.04 for hypocoiled cords and hypercoiled cords respectively,there is strong association between hypocoiling and LSCS rates compared to Hypercoiling which is consistent with the studies conducted by Ezimokhai et al and Nivedithapatil.[5,8]

UCI was correlated with Gender of the babies.p value being 0.47 and 0.19 for hypo and hypercoiled cords respectively, there is no statistical significance between UCI and Gender of the babies which is consistent with previous studies.UCI was correlated with Birth weight of the new born. p value being 0.01 and 0.001 for hypocoiled cords and hypercoiled cords respectively,there is statistical significance between UCI and Birth weights of babies, Hypercoiled cords being more associated than hypocoiled cords. Literature has found a consistent association between Hypercoiled. and LBW babies as shown by Rana et al. and de Laat et al.[2,9]However the authors were unable to give a satisfactory explanation for this association.

UCI was correlated with Apgar score at 1 minute of the baby. 7 (5.8%) babies had Apgar at 1 minute <4 of which 57.1% had hypocoiled cords , 28.6% had normocoiled cords and 14.3% had hypercoiled cords. 113 (94.2%) babies had Apgar at 1 minute ≥ 4 of which 9.73% had hypocoiled cords, 79.65% had normocoiled cords and 10.62% had hypercoiled cords. p value being 0.01 and 0.26 for hypocoiled cords and hypercoiled cords respectively,there is statistical significance between Hypocoiled cords and Apgar score at 1 minute. Studies done by Gupta S et al and Padmanabhan et al showed that in

Hypocoiledgroups there were significantly low Apgar scores which is consistent with our study.[1] UCI was correlated with Apgar score at 5 minutes of the baby. 10 (8.3%) babies had Apgar at 5 minutes < 7 of which 60% had hypocoiled cords , 28.6% had normocoiled cords and 14.3% had hypercoiled cords. 110 (91.7%) babies had Apgar at 5 minutes ≥ 7 of which 8.2% had hypocoiled cords, 82.7% had normocoiled cords and 9.1% had hypercoiled cords. p value being 0.01 for both hypocoiled cords and hypercoiled cords ,there is statistical significance between UCI and Apgar score at 5 minutes. In previous studies done by Monique WM et al. , Gupta S et al. and Padmanaban LD et al. , it was found that Hypocoiled group was associated with low Apgar score at 5 minute i.e., < 7. [1,9,10]

Out of 120, 22 (18.3%) babies required NICU care , of which 9 (40.9%) had hypocoiled cords 8 (36.4%) had normocoiled cords and 5 (22.7%) had hypercoiled cords. p value being < 0.01 and 0.002 for hypocoiled cords and hypercoiled cords respectively,there is statistical significance between UCI and NICU admissions of the babies,hypercoiled cords more associated than hypocoiled cords.In previous studies done by Sandeep kumar, Priyanka Gaikwad, ShayestaRahi abnormal coiling (hypocoiling and hypercoiling) is associated with NICU admissions. [7,11,12]

UCI was correlated with Direction of the twist of the cord. . p value being 0.68 and 0.88 for hypocoiled cords and hypercoiled cords respectively, there is no statistical significance between UCI and Direction of the twist of the cord . The ratio of direction of twist between left to right is 3.14:1.In previous studies done by Strong TH et al.[13] The ratio of direction of twist between left to right was 7:1 and in a study by Monique WM et al , the ratio is 4:1.[9] This can be explained by the fact that the right umbilical artery is usually larger than the left umbliical artery which is postulated by Simpson.

In the present study , Out of 120, 13 (10.8%) babies had FGR , of which 38.5% had hypocoiled cords, 23% had normocoiled cords and 38.5% had hypercoiled cords. p value being < 0.001 for both hypocoiled cords and hypercoiled cords ,there is strong statistical significance between UCI and Fetal growth restriction. In previous studies by Monique WM et al and Georgiou AM et al, Hyper coiled cords were associated with IUGR.[9,14]

UCI was correlated with Fetal distress. Out of 120, 28 (23.3%) babies had Fetal distress , of which 35.7% had hypocoiled cords, 46.4% had normocoiled cords and 17.9% had hypercoiled cords. Rest 92(76.7%) babies had no Fetal distress. p value being < 0.001 and 0.03 for hypocoiled cords and hypercoiled cords respectively ,there is statistical significance between UCI and Fetal distress , Hypocoiled cords more associated than hypercoiled cords.

Non reassuring fetal heart patterns were found to have a highly significant association with both hypocoiled and hypercoiledcords.Literature has found a consistent association between intrapartum FHR decelerations and abnormal UCI. Strong et al..[13] found FHR decelerations to be associated with both hypocoiled and hypercoiled cords. According to them , hypocoiled and hypercoiled cords are less flexible or more prone to kinking and torsion which makes them less tolerant to withstand the stress of labour. Rana et al. and Ercal et al. found FHR decelerations to be significantly associated with hypocoiled cords.[12, 15] Rana et al. explained that coiling provides turgor and compression resistant properties to the cord which becomes compromised as the cord becomes hypocoiled.[12]

UCI was correlated with Meconium staining of liquor. Out of 120, 26(21.7%) had Meconium stained liquor , of which 30.8% had hypocoiled cords, 50% had normocoiled cords and 19.2% had hypercoiled cords. Rest 94(78.3%) did not have any Meconium staining of liquor , of which 7.45% had hypocoiled cords , 84.04% had normocoiled cords and 8.51% had hypercoiled cords. p value being < 0.01 and 0.03 for hypocoiled cords and hypercoiled cords respectively ,there is statistical significance between UCI and Meconium staining of liquor , Hypocoiled cords more associated than hypercoiled cords.

Gupta S et al. and Strong et al. found that in hypocoiled cords meconium staining of the liquor was significantly higher than in those with normocoiled group.[1,13] In other study done by Padmanaban LD et al. it was found that meconium staining was significant in hypercoiled cords.[10]

According to Reynolds, umbilical coiling contributes to the venous return of the fetus. The pulse pressure of the two umbilical arteries in the coiled cords generates a pumping mechanism with the umbilical vein which enhances the venous blood flow. Hence more coiling leads to increased venous flow. Thus in hypocoiling there is decreased venous flow.On the other hand, when hypercoiling occurs, there is compression of the vein and increased turbulence in the arteries which as a result decreases both arterial and venous flow.

LIMITATIONS OF THE STUDY

- Single centre study
- Sample size in our study was low
- Preterm , anomalous babies and IUD's were excluded

CONCLUSION

The mean length of the umbilical cord in the study was 60.59 ± 10.23. The mean number of coils was 16.17 ± 8.29. The mean umbilical coiling index (UCI) in the study was 0.26 ± 0.13.The UCI was correlated to the maternal factors like maternal age , parity, booked or unbooked cases, mode of delivery and perinatal factors like gender ,birth weight , Apgar score at 1 minute and 5 minutes, NICU admissions , meconium staining , fetal distress , fetal growth restriction and direction of twist of the cord.

Hypocoiling(UCI < 10^{th} percentile) is associated with more Operative deliveries (LSCS) , Low Birth weights , Low APGAR score at 1 minute , Low APGAR score at 5 minutes , NICU admissions , Fetal growth restriction , Fetal distress , Meconium staining of liquor.Hypercoiling(UCI > 90^{th} percentile) is associated withOperative deliveries (LSCS) , Low Birth weights , Low APGAR score at 5 minutes , moreNICU admissions , Fetal growth restriction , Fetal distress , Meconium staining of liquor.

Both hypo and hypercoiling of cords had significant correlation with adverse fetal outcomes . Thus, antenatal detection of the coiling index can identify fetus at risk and thus help in further management and timely intervention.

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