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Correlation of Antenatal and Postnatal Umblical Coiling Index for Determining the Perinatal Outcome

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Abstract:
Objective(s): *To correlate antenatal early third trimester and postnatal UCI with perinatal outcome and to analyse if antenatal early third trimester UCI measurement could predict adverse perinatal outcome.* ***Method(s):*** *200 pregnant woman fulfilling the inclusion criteria are recruited into the study. PostnatalyUCI was calculated. Early third trimester fetal anatomic sonographic survey is done. The UCI index defined as reciprocal of distance between two adjacent coils.Hypocoiled cordswere those having UCI less than 10th centile, and hypercoiled cords those having UCI more than 90th centile. Data were analyzed in PRIMER and SPSS version 20 Statistical software. Results-In present study the mean AUCI was 0.39±0.09 and mean PUCI was 0.17±0.02The optimum cut off level for AUCI was 0.485 with SN 15%, SP 98%. A 0.185, area under the curve (AUC = 0.539) optimal cut-off value of PUCI, with a sensitivity of 19.8% and a specificity of 91.2%, was determined with SE 0.42. The association of AUCI with adverse perinatal outcome was statistically significant(p=0.011) Conclusion. Abnormal umbilical coiling index is associated with adverse perinatal outcome.*

Keywords: *hypercoiling umbilical cord, hypocoiling umbilical cord, umbilical coiling index(UCI)*

I. Introduction

The umbilical cord, also known as 'the birth cord' or 'funiculusumbilicalis' is the life line for the foetus developing inside the uterus, as it is the only means of supply of oxygen and nutrients to the foetus as well as removal of toxic wastes from the foetus, which is vital for its survival. As such any abnormality in the umbilical cord is very much likely to affect the well being of the foetus.

The most distinctive feature of the umbilical cord, the helical pattern of its vessels, was first recorded in 1521 by Berengarius. As reported by Edmonds[1]. Edmonds[1], in 1954, was the first to describe a method for quantification of cord coiling. He called it the 'index of twist', which was the ratio of twists to the length of the cord, giving positive and negative values to the twists if the direction of coiling changed from left to right, where sinistral turns counterbalance dextral turns. Strong[2], in 1994, was the first to simplify this method. He developed the ''umbilical coiling index", which is the ratio of twists to the length of the cord, irrespective of the direction of coiling.Later modifications of his work resulted in the concept of "Umbilical Coiling Index (UCI)" which is calculated by dividing the total number of coils by the total length of the cord immediately after delivery.

Antenatally coiling can be determined ultrasonographically.[2] Studies have established correlation between both high and low coiling third trimester Umbilical coiling index (UCI)and postnatal UCI(true UCI) with adverse perinatal outcome like preterm labor, IUGR, IUD, foetal distress.

Coiling of umbilical vessels develops as early as 28 days after conception and is present in about 95% of foetuses by 9 weeks of conception. The helices may be seen by ultrasound as early as the first trimester.[3]The number of twists seen in first trimester is roughly the same as seen in term cords. Since lengthening of cord occurs from the foetal end, perhaps coiling of cord represents a long term record of foetal well being.[4]

If the antenatal UCI is compared with true UCI results obtained after birth. A statistically significant correlation between aUCI (antenatal UCI) and true UCI was found with p value <0.001.6.The UCI measured in early third trimester is useful in predicting the birth of small for gestational age infant and may serve as a marker for subsequent growth restriction.[5]

The hypocoiling of umbilical cord during the earlr third trimester of pregnancy suggests the high risk of preterm delivery and hence delivery of low birth weight neonates and admission to NICU is high. Hypocoiling may give way to kinking and compression. The hypocoiled cords or UCI <10th percentile is associated with meconium staining, Apgar score at 1 min <4 and Apgar score at 5 min <7.Hypercoiling may give way to occlusion in cases with cord entanglement. The hypercoiled cord or UCI >90th percentile is also associated with intra uterine growth restriction.

To calculate the UCI immediately after delivery, the umbilical cord is evaluated for complete vascular coiling, and the umbilical cord length is measured with a tape, from its insertion into the placenta up to the

neonatal umbilicus. A complete vascular coil is defined as a 360 degree complete round coiling of the vasculature, and the total number of these complete vascular coils is determined. Then the total number of vascular coils is divided by the total length of the cord in centimeters in order to determine the umbilical coiling index (UCI). On ultrasonography, in two adjacent coils, the distance from the outer surface of the vascular wall to its next twist is measured and calculated (antenatal UCI = 1/distance in centimeters).

The generally accepted method of assessing the degree of the umbilical cord coiling is by calculation of the umbilical coiling index (UCI), defined as the number of complete coils per centimetre length of cord. Using this criterion, studies to date have been remarkably consistent in reporting of the normal UCI, which is around 0.2 in the postpartum setting following examination of the delivered placenta and umbilical cord (pUCI) and 0.4 when determined antenatally by ultrasonography (aUCI).[3]

An abnormal umbilical coiling index (UCI) in the form of hypocoiling or hypercoiling has been reported to be related to adverse foetal outcomes. It appears that hypocoiled cords are predominantly associated with an increased frequency of intrauterine death and low Apgar score.Hypercoiling was found to be associated with intrauterine growth restriction, foetal acidosis and asphyxia.[6]

II. Materials And Methods

It was a prospective study conducted at department of Obstetrics and Gynecology, Mahatma Gandhi Medical College And Hospital,rajasthan.India.200 booked singleton pregnancies fulfilling the below mentioned inclusion criteria, attending regular antenatal check up and willing for institutional deliveries were evaluated ultrasonographically for umbilical coiling index at the time of routine foetal anatomical survey and postnatally at the time of delivery.

Inclusion Criteria

- Maternal age between 18-35 years.
- Intrauterine Singleton live pregnancy.
- Foetal anatomic survey at 28-32 weeks period of gestation.
- Willing for Institutional delivery at mgh.

Exclusion Criteria

- Multifoetal gestation.
- Breech presentation and delivery, Preterm deliveries
- Intrauterine deaths
- Single umbilical artery.
- Pre-existing maternal diseases like Hypertension, Diabetes, and Chronic renal disease.
- Smoking and Drug abuse.Anomalous foetus.

Early third trimester foetal anatomic ultrasonographic survey was done. The distance in centimetres between two adjacent coils was measured from inner edge of arterial or venous wall to the outer edge of next coil along the ipsilateral side of umbilical cord. The umbilical coiling index defined as reciprocal of distance between two adjacent coils (antenatal UCI = 1/distance in cm.

Postnatally umbilical coiling index was calculated by dividing the total number of complete vascular coils in given cord by the total length of the cord in centimeters. Healthy women with term gestation with singleton pregnancy, irrespective of their parity, who were in active labour and were admitted to labour room were taken for the study. Umbilical cord was clamped and cut as close as possible to placental end . The umbilical cord is measured in its entirety, including the length of placental end of the cord and the umbilical stump of the baby. The number of the complete coils or spirals were counted from the neonatal end towards the placental end of the cord and expressed per centimeters. After this umbilical coiling index was calculated, by dividing the total number of coils, by the total length of cord in centimeters. After calculating the umbilical coiling index, perinatal factors like meconium staining, foetal weight, apgar score, ponderal index were correlated with it.

$$\text{Umbilical Coiling Index} = \frac{\text{Number of Coils}}{\text{Total length of the Umbilical Cord (cm)}}$$

III. Results

TABLE 1:Descriptive Statistics of the variables

Descriptive Statistics								
	N	Minimum	Maximum	Mean		Std. Deviation	Skewness	
	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic	Statistic	Std. Error
Age	200	18	35	26.37	0.31	4.44	.307	.172
aUCI	200	.13	.64	0.39	0.01	0.09	-1.036	.172
pUCI	200	.12	.23	0.17	0.00	0.02	.439	.172
Baby weight	200	1.2	3.5	2.54	0.03	0.44	-.547	.172
Apgar at 5 min	200	3	9	7.26	0.10	1.42	-1.593	.172

According to data and test of normality applied observed all mentioned data were parametric data.
In my study the minimum aUCI was 0.13 and maximum aUCI was 0.64.
Minimum pUCI was 0.12 and maximum was 0.23.
Range-aUCI 0.13-0.64±0.09 ,pUCI 0.12-0.23±0.02

TABLE 2:Association of AUCI with adverse perinatal outcome

AUCI	Hypercoiling		Hypocoiling		Normal		Total
	No	%	No	%	No	%	No
Absent	37	50	1	14.29	76	63.87	114
Present	37	50	6	85.71	43	36.13	86
Total	74	100	7	100	119	100.00	200

Chi-square = 8.979 with 2 degrees of freedom; p = 0.011S
Hypocoiling was significantly associated with adverse perinatal outcome (85.71%)
The association of AUCI with adverse perinatal outcome was statistically significant(p=0.011)

TABLE 3:Association of PUCI with adverse perinatal outcome

PUCI	Hypercoiling		Hypocoiling		Normal		Total
	No	%	No	%	No	%	No
Absent	7	36.84	15	55.56	92	59.74	114
Present	12	63.16	12	44.44	62	40.26	86
Total	19	100.00	27	100.00	154	100.00	200

Chi-square = 3.645 with 2 degrees of freedom; p = 0.162

Hypercoiling was found more in babies with adverse Perinatal outcome.The association of PUCI with adverse perinatal outcome was statistically non significant(p=0.162)

Diagnostic performance of AUCI for the differential diagnosis of perinatal outcome at the optimal cut-off points of the ROC analysiscurves.Receiver operating characteristic (ROC) for aUCI showing (1-specificty) on the X axis and sensitivity on Y Axis exercising different cut off value to land at the choice ,the most apposite cut off point and which provide the greatest sum of sensitivity and specificity.Table 4 illustrate sensitivity, specificity, 1-specificity (False positivity rate) of AUCI at diverse level. The optimum cut off value was obtained by points of test values that grants the highest Youden Index that is (SN+SP)-1.

The optimum cut off level for aUCI was 0.485 with SN 15%, SP 98%. This level is excellent to use as a specific test. A ≥0.485 index under the curve (AUC = 0.505) optimal cut-off value of aUCI, with a sensitivity of 15% and a specificity of 98%, was determined with SE 0.044.

TABLE 4: depicts diagnostic performance of AUCI for the differential diagnosis of perinatal outcome at the optimal cut-off points of the ROC analysis curves.

Area Under the Curve				
Test Result Variable(s): aUCI				
Area	Std. Error[a]	Asymptotic Sig.[b]	Asymptotic 95% Confidence Interval	
			Lower Bound	Upper Bound
.505	.044	.895	.419	.592

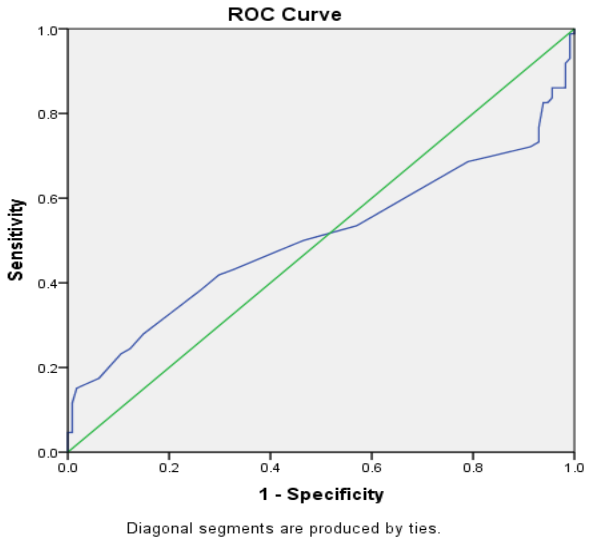

figure 1: ROC plot of AUCI in reference to perinatal outcome

TABLE 5 depicts diagnostic performance of PUCI for the differential diagnosis of perinatal outcome at the optimal cut-off points of the ROC analysis curves.

Area Under the Curve				
Test Result Variable(s): pUCI				
Area	**Std. Error[a]**	**Asymptotic Sig.[b]**	**Asymptotic 95% Confidence Interval**	
			Lower Bound	**Upper Bound**
.539	.042	.347	.456	.622

ROC curve analysis was performed to determine the optimal cut-off values of significant variables PUCI detected between perinatal outcome (Fig 2). A 0.185, area under the curve (AUC=0.539) optimal cut-off value of PUCI, with a sensitivity of 19.8% and a specificity of 91.2%, was determined with SE 0.42.

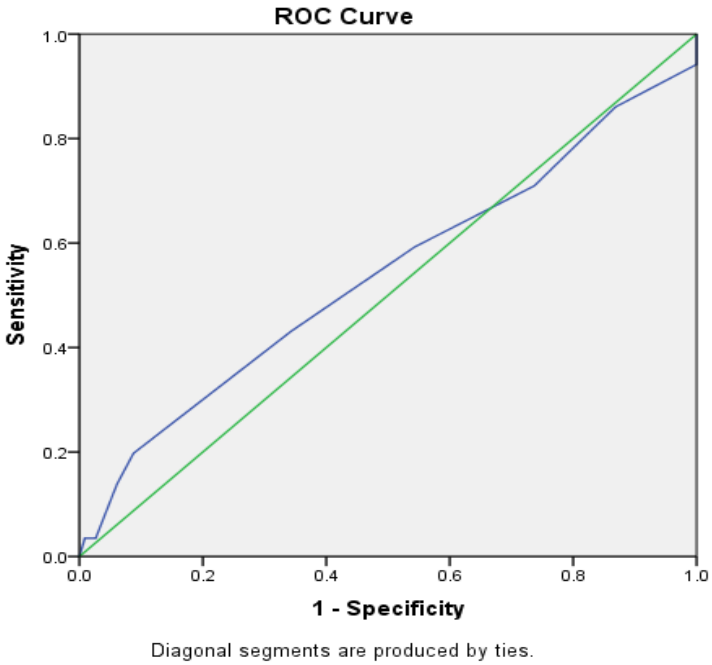

Figure 2:ROC plot of PUCI in reference to perinatal outcome

TABLE 6: Association of APGAR at 1 min with AUCI

AUCI	Hypercoiling		Hypocoiling		Normal		Total
	No	%	No	%	No	%	No
≤5	11	14.86	5	71.43	13	10.92	29
6	0	0.00	1	14.29	4	3.36	5
7	39	52.70	1	14.29	53	44.54	93
8	22	29.73	0	0	43	36.13	65
9	2	2.70	0	0	6	5.04	8
Total	74	100.00	7	100	119	100.00	200

Chi-square = 28.915 with 8 degrees of freedom; $p < 0.001$S
Hypocoiling was more associated with apgar score less than 5 as compared to hypercoiling.
The correlation between APGAR at 1 min and AUCI was statistically significant ($p<0.001$)

TABLE 7:Association of APGAR at 1 min with PUCI

PUCI	Hypercoiling		Hypocoiling		Normal		Total
	No	%	No	%	No	%	No
≤5	6	31.58	6	22.22	17	11.04	29
6	1	5.26	1	3.70	3	1.95	5
7	8	42.11	14	51.85	71	46.10	93
8	3	15.79	6	22.22	56	36.36	65
9	1	5.26	0	0.00	7	4.55	8
Total	19	100.00	27	100.00	154	100.00	200

Chi-square = 11.867 with 8 degrees of freedom; $p = 0.157$ NS
The correlation between APGAR at 1 min and PUCI bothhypercoiling and hypocoiling was statistically non significant ($p=0.157$)

TABLE 8:Association of IUGR with AUCI

AUCI	Hypercoiling		Hypocoiling		Normal		Total	
IUGR	No.	%	No.	%	No.	%	No.	%
Present	6	8.11	2	28.57	5	4.20	13	6.5
Absent	68	91.89	5	71.43	114	95.80	187	93.5
Total	74	100.00	7	100.00	119	100.00	200	100

Chi-square = 6.960 with 2 degrees of freedom; $p = 0.03$S
Hypercoiling 6(8.11%). was found more in IUGR babies as compared to Hypocoiling 2 (28.57%).
The association of IUGR with AUCI was statistically significant ($p=0.03$)

TABLE 9:Association of IUGR with PUCI

PUCI	Hypercoiling		Hypocoiling		Normal		Total	
IUGR	No	%	No	%	No	%	No	%
Present	0	0.00	4	14.81	9	5.84	13	6.5
Absent	19	100.00	23	85.19	145	94.16	187	93.5
Total	19	100.00	27	100.00	154	100.00	200	100

Chi-square = 4.501 with 2 degrees of freedom; $p = 0.105$NS.Hypocoiling was more in IUGR babies while no IUGR babies were there with hypercoiledcords.The association of IUGR with PUCI was statistically non significant($p=0.105$)

TABLE 10:Association of Birth weight with UCI

	Baby Weight	N	Mean	Std. Deviation	P Value LS	1vs2	2vs3	1vs3
AUCI	Hypercoiling	74	2.52	0.42	0.014S			
	Hypocoiling	7	2.09	0.68		S	S	NS
	Normal	119	2.58	0.42				
PUCI	Hypercoiling	19	2.47	0.63	0.726NS			
	Hypocoiling	27	2.55	0.45		NS	NS	NS
	Normal	154	2.55	0.41				
	Total	200	2.54	0.44				

In AUCI, mean birth weight was 2.52±0.42 in hypercoiling, 2.09±0.68 in hypocoiling,2.58±0.42 in Normal. In PUCI, mean birth weight was 2.47±0.63 in hypercoiling, 2.55±0.45 in hypocoiling, 2.55±0.41in Normal.Association of birth weight with AUCI index was observed significant ($p=0.014$) .Association of birth weight with PUCI was found to be statistically non significant ($p=0.726$)

IV. Discussion

In present study the mean aUCI was 0.39±0.09 and mean pUCI was 0.17±0.02.Maximum and minimum aUCI were 0.13 and 0.64 respectively. Maximum and minimum pUCI were 0.12 and 0.23 respectively.

TABLE 11:maximum and minimum values of umblical coiling index in our study

	Maximum	Minimum	Mean	Range
aUCI	0.64	0.13	0.39 ± 0.01	0.13-0.64 ± 0.09
pUCI	0.23	0.12	0.17 ± 0.00	0.12-0.23 ± 0.02

TABLE 12:Comparison of aUCI among different studies

Year	Study	Mean aUCI
1999	Otsubo*et al 7*	0.39 ± 0.03 coils/cm
2001	Shimon Degani*et al*[8]	0.42 ± 0.12 coils/cm
2005	MladenPredanic*et al*[9]	0.403 ± 2 SD coils/cm
2005	Perni*et al*[9]	0.40 ± 0.10 coils/cm
2006	De Laat*et al*[10]	0.30 ± 0.09 coils/cm
2015	Present Study	0.39 ± 0.01 coils/cm

TABLE 13:Comparison of pUCI among different studies

1993	Strong*et al* [11]	0.21 ± 0.07
1995	Rana*et al* [12]	0.19 ± 0.1
1996	Ercal*et al* [13]	0.20 ± 0.1
2000	Ezimokhai*et al* [14]	0.26 ± 0.09
2005	de Laat*et al* [10]	0.17 ± 0.009
2015	Presentstudy	0.17 ± 0.00

In our study the vaue of antenatal umblical coiling index is similar to that obtained by Otsubo et al[7] which is 0.39 ± 0.01 coils/cm.whileumblical coiling index calculated after delivery was 0.17 which was same as obtained by de Laat et al [10]

Hypocoiling has resulted in more LBW(<2.5 kg) babies (71.43%). No significant association was observed (p value >0.05) with AUCI.No significant association was observed (p value >0.05) with P UCI. Mean birth weight was significantly lower in hypocoiled cords as compared to hyper coiled and normal coiled cords. (P=0.014S).T. Chitra et al 2011[20] found that LBW (birth weight <2.5 kg) was significantly associated with both hypocoiled (P = 0.011) and hypercoiled (P =0.001).27 Literature has found a consistent association between hypercoiled and LBW babies, as shown by Ranaet al[12]and de Laat et al. [10]

Hypercoiling 6(8.11%). was found more in IUGR babies as compared to Hypocoiling 2 (28.57%).The association of IUGR with AUCI was statistically significant (p=0.03).Hypocoiling was more in IUGR babies while no IUGR babies were there with hypercoiledcords.The association of IUGR with PUCI was statistically non significant(p=0.105) .Saksh et al 2014[21] demonstrated a significant association between IUGR babies and hypercoiling (P = 0.000). Ezimokhaiet al1[14]and de Laat et al1[15] obtained a similar result in their studies. However Strong et al[18] and Machin et al[17] found IUGR to be associated with hypocoiling. They summarized that since adequate coiling prevents compression of the cord, hypocoiling in the long run results in reduced fetoplacental circulation, thus resulting in growth restriction. Monique et al[15] also found that hypocoiling was associated with small for gestational age infants.

Hypocoiling was more associated with apgar score less than 5 as compared to hypercoiling.The association between low APGAR at 1 min and AUCI was statistically significant (p<0.001).More cases were observed in hypercoiling group with apgar<5(1 min) in PUCI.

Hypocoiling was significantly associated with adverse perinatal outcome (85.71%) .The association of AUCI with adverse perinatal outcome was statistically significant(p=0.011).Hypercoiling was found more in babies with adverse Perinatal outcome.The association of PUCI with adverse perinatal outcome was statistically non significant(p=0.162).

TABLE 14:Studies Examining aUCI or pUCI Umbilical Cord Coiling Index and Adverse Pregnancy Outcomes

Study	Type	N	Hypocoiled	Hypercoiled
De Laat*et al* (2007)[15]	pUCI	565	IUD, fetal anomaly, low APGAR Score at 5 min	IUD, PTB, fetal anomaly, FTV, hypoxia, low birth weight
De Laat*et al* (2006) [10]	aUCI	81	-	Low Birth Weight
Kashanian*et al* (2006)[16]	pUCI	699	Low APGAR Score at 5 min, AFI < 5	Low APGAR Score at 5 min, AFI < 5, meconium, low birth weight
De Laat*et al* (2006)[10]	pUCI	885	IUD, PTB, trisomy, low APGAR Score at 5	Asphyxia, pH < 7.05, SGA, trisomy, SUA

Study	Type	N	Hypocoiled	Hypercoiled
			min,velamentous cord insertion.	
Predanic*et al* (2005)[9]	aUCI	294	Low birth weight, meconium, fetal distress	Low birth weight, meconium, fetal distress
Degani*et al* (2001)[8]	aUCI	124	Low birth weight	-
Ezimokhai*et al* (2000)[14]	pUCI	657	-	Meconium, low birth weight, fetal distress
Machin*et al* (2000)[17]	pUCI	1329	IUD, fetal distress, low birth weight	IUD, fetal distress, low birth weight, FTV
Otsubo*et al* (1999)[7]	aUCI	253	Abnormal insertion	-
Strong *et al* (1996)[11]	pUCI	200	Nuchal cord	-
Ercal*et al* (1996)[13]	pUCI	147	Meconium, fetal distress, low APGAR Score at 5 min	-
Rana*et al* (1995)[12]	pUCI	635	Fetal distress	PTB
Strong *et al* (1994)[18]	pUCI	100	Aneuploidy, Meconium, fetal distress	CTG abnormalities

V. Conclusion

Umblical coiling index was found as important predictor of adverse perinatal outcome.antenally calculated abnormal UCI was found with some perinantal complications in neonates. We found significant increase in the risk for a intra uterine growth restricted babies and interventional delivery for non-reassuring foetal status if hypercoiling was observed on ultrasonography. Also babies with low birth weight and NICU admissions had hypocoiled or hypercoiled cords at birth.Thus we can use UCI values determined ultrasnographically as predictor of adverse perinatal outcome and appropriate measures can be taken to prevent morbidity and mortality of neonates.To conclude, abnormal umbilical coiling index is associated with several adverse antenatal and neonatal features. The association shows wide variations among the various studies done so far.

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