International Journal of Clinical Obstetrics and Gynaecology

ISSN (P): 2522-6614
ISSN (E): 2522-6622

www.gynaecologyjournal.com
2020; 4(1): 146-152
Received: 04-11-2019
Accepted: 08-12-2019

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To evaluate the antenatal umbilical coiling index in second trimester of gestation by sonography and postnatal umbilical coiling index in relation to pregnancy outcome

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DOI: https://doi.org/10.33545/gynae.2020.v4.i1c.454

Abstract
Background: The umbilical cord extends from the fetal umbilicus to the fetal surface of the placenta. Its diameter is 0.8 to 2.0 cm, with an average length of 55 cm and a range of 30 to 100cm. The umbilical cord is the life line of fetus as it supplies water, nutrients and oxygen. Its three blood vessels pass along the length of the cord in a helical or coiled fashion. A coil is defined as a complete 360° spiral course of umbilical vessels around Wharton's jelly. The umbilical coiling appears to confer turgor and compression-resistant properties to the umbilical unit, producing a cord that is strong but flexible. An abnormal coiling index has been reported to be related to adverse perinatal outcome.
Methodology: This prospective observational one year study was conducted on 250 women with singleton pregnancy, who were booked and scheduled to deliver at this institution. The antenatal umbilical coiling index (aUCI) done at 18 to 23 weeks of gestation. After delivery the UCI was determined. The sensitivity and the specificity of the sonography for detecting hypocoiling, normocoiling and hypercoiling was calculated. The correlation of aUCI and UCI with perinatal outcome were assessed and stastistical analysis done.
Observations: It was observed that in aUCI group, there were 22 (8.8%) hypocoiled cords, 204 (81.6%) normocoiled and 24 (9.6%) were hypercoiled cords. In UCI group, there were 25 (10%), 200 (80%) and 25 (10%) cords in the hypocoiled, hypercoiled and hypercoiled groups respectively. The sensitivity of the sonography for detecting hypocoiling, normocoiling and hypercoiling was 84%, 98.5% and 80% respectively. The specificity of the sonography for detecting hypocoiling, normocoiling and hypercoiling was 99.5%, 86% and 98.2% respectively. There was no significant association of antenatal as well as postnatal coiling pattern compared with the mode of delivery. There was significant association of LBW, fetal distress and meconium staining with both hypocoiled and hypercoiled groups as compared to the nomocoiled group. Although the percentage of neonates admitted to the neonatal intensive care unit (NICU) were more in the hypocoiled and hypercoiled group as compared to the normocoiled group but not statistically significant.
Conclusion: This study concludes that the hypocoiling and hypercoiling of the umbilical cord observed during fetal ultrasound anatomical evaluation in the second trimester is associated with small for gestation age neonates, fetal distress and low apgar scores and may have a bearing on increased interventional deliveries thus increasing the burden on NICU. This observation has been found to be similar to the umbilical coiling index at birth, thus it is suggested that second trimester ultrasound should include umbilical coiling index as one of the parameters of evaluation and this can be used as a potential predictor of adverse perinatal outcome.

Keywords: Umblical cord, wharton's jelly, turger, coiling, perinatal, meconium

Introduction
The umbilical cord, or funis, extends from the fetal umbilicus to the fetal surface of the placenta. Its diameter is 0.8 to 2.0 cm, with an average length of 55 cm and a range of 30 to 100cm [1]. The umbilical cord is the life line of fetus as it supplies water, nutrients and oxygen. Its three blood vessels pass along the length of the cord in a helical or coiled fashion. A coil is defined as a complete 360° spiral course of umbilical vessels around Wharton's jelly. In 1954, umbilical coiling was first quantified by Edmonds who divided the total number of coils by the umbilical cord length in centimetres and called it "The Index of Twist". He assigned positive

and negative scores to clockwise and anticlockwise coiling, respectively. Later, Strong *et al* simplified the coiling pattern by eliminating these directional scores and named it "The Umbilical Coiling Index". [2]

The origin of this coiling is not known. The hypotheses include fetal movements, differential umbilical vascular growth rates and fetal hemodynamic forces. Regardless of its origin, umbilical coiling appears to confer turgor and compression-resistant properties to the umbilical unit, producing a cord that is strong but flexible. [3, 4, 5] The twists begin to appear during the early part of the 8th week, and their final number is possibly attained soon after the 9th week of gestation. [7] The coils of the umbilical cord can be visualised with reasonable accuracy using ultrasonography and hence screening for any abnormal coiling index in the antenatal period can be done.

An abnormal coiling index includes both hypocoiled cords (UCI < 10^{th} percentile) and hypercoiled cords (UCI > 90^{th} percentile). An abnormal coiling index has been reported to be related to adverse perinatal outcome [4, 5, 7]. Whilst UCI can be measured easily and reliably in the second trimester, these estimates do not accurately reflect the UCI at term. The earlier assumption that umbilical coiling does not alter after the initial formation of coils in the first trimester is incorrect; mixed patterns occur in about 25% of cases. These patterns develop during the second and third trimesters, presumably due to snarls in the cord, and influence the final coiling number and therefore their is relationship between the measurements of antenatal umbilical coiling index (aUCI) by sonography and umbilical coiling index (UCI) at delivery. [6]

Therefore, there is a possibility that aUCI may describe the umbilical coiling pattern in the second trimester accurately enough to be used as a predictor perinatal outcome, regardless of the discordance between aUCI and UCI values. So this study was conducted to predict perinatal outcome by ultrasound evaluation of abnormal umbilical cord coiling in second trimester of gestation and comparing it with umbilical coiling index at delivery along with the pregnancy outcome.

Material and Method

This prospective observational study was conducted in the Department of Obstetrics and Gynaecology, Kamla Nehru State Hospital for Mother and Child and the Department of Radio-Diagnosis, IGMC, Shimla, from 1st May 2011 to 30th April 2012 (one year study). Women with singleton pregnancy, who were booked and scheduled to deliver at this institution. Women excluded were; Multif *et al* pregnancy, gross fetal anomalies (e.g. congenital heart, lung, gastrointestinal, genitourinary anomalies), inadequate or an inappropriate longitudinal image of the umbilical cord to allow an accurate aUCI measurement, women with diabetes (both gestational diabetes and overt diabetes) and hypertension (including both pregnancy induced hypertension and chronic hypertension).

After an informed written consent

Detailed history as per proforma was taken. Gestational age of the pregnancy was determined. The patients `had fetal anatomic ultrasound survey at 18 to 23 weeks of gestation along with assessment of antenatal umbilical coiling index (aUCI). All sonographic examinations were performed with a scanning machine with harmonic capability equipped with a 5-MHz transducer. Dynamic color flow imaging was used to improve visualization of the umbilical coils if required.

1) The aUCI was calculated as a reciprocal value of the distance between a pair of coils (aUCI = 1/distance in cm). The distance between the coils was measured 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 mean of three readings was used for analysis. If one complete coil could not be visualised in one view, the largest segment of the cord without a complete coil was measured
2) After delivery the UCI was determined by dividing the number of umbilical cord twists with the total cord length. The cord was tied and cut as close to the placenta as possible. The umbilical cord was measured in its entire length, including the length of the placental end of the cord and the umbilical stump on the baby. The number of complete coils or spirals were counted from the neonatal end towards the placental end of the cord and expressed per centimeter.

Umbilical coiling index (UCI) = total number of complete vascular coils/ total length of the cord (centimetres).

3) **Variables retrieved were**
   a) Gestational age at which the second trimester ultrasound examination was performed.
   b) Gestational age at the time of delivery.
   c) aUCI and UCI at delivery.
   d) Mode of delivery.
   e) Indication of the interventional delivery (instrumental vaginal delivery including vaginal forceps, vaginal vacuum and cesarean delivery).
   f) Neonatal birth weight.
   g) Small for gestation age (SGA) neonates, defined as neonates with birth weight below 10^{th} percentile of the expected for their gestational age. [42]
   h) A presence of any meconium-stained amniotic fluid.
   i) The presence of fetal distress.
   j) Apgar score <7 at one minute.
   k) Neonates shifted to neonatal intensive care unit (NICU).
4) Umbilical coiling indices below the 10th percentile, above the 90th percentile, and between the 10th and 90th percentiles were defined as hypocoiled, hypercoiled and normocoiled respectively.

Stastistical analysis of the data

Statistical analysis was performed by the SPSS program for Windows, version 17.0. Continuous variables are presented as mean ± SD, and categorical variables are presented as absolute numbers and percentage. Continuous variables were compared using ANOVA. If the F value was significant and variance was homogeneous, Bonferroni multiple comparison test was used to assess the differences between the individual groups; otherwise, Tamhane's T2 test was used. Categorical variables were analyzed using the chi square test. For all statistical tests, a p value less than 0.05 was taken to indicate a significant difference.

Observations

The mean age group of study subjects was 25.72 ± 4.72 year and out of 250 total subjects, 197 (78.8%) belonged to rural areas and 53 (21.2%) belonged to urban areas. Regarding gravidity, 109 (43.6%) were primigravidas, 88 (35.2%) second gravidas 37 (14.8%) third gravidas and the remaining 16 (6.4%) subjects were fourth gravidas. It was observed that in the antenatal umbilical coiling index group, there were 22 (8.8%) hypocoiled cords, 204 (81.6%) normocoiled and 24 (9.6%) were hypercoiled cords. In the postnatal umbilical coiling index group, there were 25 (10%), 200 (80%) and 25 (10%) cords in the hypocoiled, hypercoiled and hypercoiled groups respectively. The mean gestational age at ultrasound examination in the hypocoiled, normocoiled and hypercoiled groups was 20.08 ± 1.29 weeks, 20.32 ± 1.35 weeks and 20.69 ± 1.48 weeks respectively.

Table 1: Correlation of aUCI (antenatal) with UCI (postnatal)

		aUCI	UCI	aUCI confirmed at Delivery
Hypocoiled	no	22	25	21
	%	8.8%	10.0%	8.4%
Normocoiled	no	204	200	197
	%	81.6%	80.0%	78.8%
Hypercoiled	no	24	25	20
	%	9.6%	10.0%	8.0%

p < 0.0001

Table no. 1 shows that out of 22 (8.8%) hypocoiled on aUCI, 21 (8.4%) were confirmed visually as hypocoiled at delivery and one (4.5%) was hypercoiled. Out of 204 (81.6%) normocoiled cords on ultrasound, 197 (78.8%) were confirmed visually as normocoiled at delivery. Three cords (1.4%) were hypocoiled and four cords (1.9%) were hypercoiled at delivery. Out of 24 (9.6%) hypercoiledI on USG, 20 (8.0%) were confirmed visually as hypercoiled at delivery. One (4.1%) cord was found to be hypocoiled and three (12.5%) cords were found to be normocoiled at delivery.The correlation between the aUCI and UCI was highly significant (p <0.0001).The sensitivity of the sonography for detecting hypocoiling, normocoiling and hypercoiling was 84%, 98.5% and 80% respectively. The specificity of the sonography for detecting hypocoiling, normocoiling and hypercoiling was 99.5%, 86% and 98.2% respectively.

The mean gestational age at delivery in the aUCI group in the hypocoiled group, normocoiled group and hypercoiled group was 37.84 ± 1.79, 38.09 ± 1.44 and 38.51 ± 1.17 weeks respectively. The mean gestational age in UCI group at the time of delivery in the hypocoiled, the normocoiled and hypercoiled group was 37.71 ± 1.62, 38.10 ± 1.46 and 38.60 ± 1.14 weeks respectively. There was no association of antenatal or postnatal coiling pattern with the gestational age at delivery.

Table 2: aUCI and UCI Reiation to mode of delivery N=250

Umbilical coiling index groups	Mode of delivery		Hypo coiled	Normo coiled	Hyper coiled	Hypocoiled Vs Normocoiled	Hypercoiled Vs Normocoiled	Hypocoiled Vs Hypercoiled
aUCI	Spontaneous Vaginal delivery (n=149)	no	11	126	12	0.283	0.265	1.000
		%	50%	61.8%	50.0%			
	Instrumental vaginal delivery (n=46)	no	4	37	5	0.996	0.747	0.821
		%	18.2%	18.1%	20.8%			
	LSCS (n=55)	no	7	41	7	0.202	0.303	0.845
		%	31.8%	20.1%	29.2%			
UCI	Spontaneous Vaginal delivery (n=149)	no	12	121	16	0.243	0.670	0.190
		%	48%	60.5%	64%			
	Instrumental vaginal delivery (n=46)	no	6	35	5	0.656	0.760	0.713
		%	24%	17.5%	20%			
	LSCS (n=55)	no	7	42	6	0.461	0.863	0.508
		%	28%	21%	24%			

Table no, 2 shows: a UCI subjects; In the hypocoiled group 11 (50%) had spontaneous vaginal delivery, four (18.2%) instrumental vaginal delivery and the remaining seven (31.8%) were delivered by LSCS. In the normocoiled group, 126 (61.8%) had spontaneous vaginal delivery, 37 (18.1%) had instrumental vaginal delivery and 41 (20.1%) underwent LSCS. In the hypercoiled group 12 (50.0%) had spontaneous vaginal delivery, five (20.8%) had instrumental vaginal delivery and seven (20.1%) were delivered by LSCS. UCI subjects; in hypocoiled group, 12(52%) had spontaneous vaginal delivery, six (24%) had instrumental vaginal delivery and the remaining seven (28%) underwent LSCS. In the normocoiled group, 121 (60.5%) had spontaneous vaginal delivery, 35 (17.5%) had instrumental vaginal delivery and 42 (21%) were delivered by LSCS. In the hypercoiled group, 16 (64%) had spontaneous vaginal delivery, five (20%) had instrumental vaginal delivery and six (24%) underwent LSCS. There was no significant association of antenatal as well as postnatal coiling pattern compared with the mode of delivery.

Table 3: aUCI and UCI with Indications for Interventional Delivery

Umbilical coiling index groups	Indication for intervention		Hypo coiled	Normo coiled	Hyper coiled	Hypocoiled vs Normocoiled	Hypercoiled vs Normocoiled	Hypocoiled vs Hypercoiled
aUCI	Fetal distress (n=63)	no	9	44	10	0.042	0.028	0.958
		%	40.9%	21.6%	41.7%			
	Flexed breech (n=6)	no	1	4	1	0.434	0.485	0.949
		%	4.5%	2.0%	4.2%			
	NPOL (n=10)	no	0	9	1	0.315	0.956	0.333
		%	0.0%	4.4%	4.2%			
	Placenta previa (n=3)	no	0	3	0	0.567	0.550	-
		%	0.0%	1.5%	0.0%			
	Prolonged second stage (n=19)	no	1	18	0	0.492	0.129	0.291
		%	4.5%	8.8%	0.0%			
UCI	Fetal distress (n=63)	no	10	43	10	0.040	0.040	1.000
		%	40%	21.5%	40%			

	Flexed breech (n=6)	no	1	4	1	0.522	0.522	1.000
		%	4.0%	2.0%	4.0%			
	NPOL (n=10)	no	1	9	0	0.909	0.279	0.312
		%	4.0%	4.5%	0.0%			
	Placenta previa (n=3)	no	0	3	0	0.538	0.538	
		%	0.0%	1.5%	0.0%			
	Prolonged second stage (n=19)	no	1	18	0	0.397	0.118	0.312
		%	4.0%	9.0%	0.0%			

aUCI group subjects: In the hypocoiled group, the indication for interventional delivery was fetal distress in nine (40.9%) subjects, flexed breech in one (4.5%) subject, prolonged second stage of labor in one subject (4.5%) and non progress of labor (NPOL) in one (4.5%) subject. In the normocoiled group, 44 (21.6%) subjects had fetal distress, four (2.0%) flexed breech, nine (4.4%) non progress of labor (NPOL), three (1.5%) had placenta previa and 18 (18.8%) subjects had prolonged second stage of labor. On the other hand, in the hypercoiled group 12(50%) had interventional delivery and indication was fetal distress in 10 (41.7%) subjects, flexed breech in one (4.2%) subject and NPOL in one subject (4.2%).

IN UCI subjects: In hypocoiled, 10 (40%) had fetal distress, one (4.0%) flexed breech, one (4.0%) NPOL and one (4.5%) had prolonged second stage of labor. In the normocoiled group, 43 (21.5%) had fetal distress, four (2.0%) flexed breech, nine (4.5%) NPOL and three (1.5%) had placenta previa and 18 (9.0%) had prolonged second stage of labor. In the hypercoiled group, 10 (40%) had fetal distress, one (4.0%) flexed breech and no subject had NPOL, placenta previa and prolonged second stage of labor. Fetal distress was significantly associated with both hypocoiled (p =0.040) and hypercoiled (p=0.040) groups as compared to the nomocoiled group.

Neonatal Outcome: It was observed that all the 250 neonates were born alive.

Table No. 4: aUCI and Neonatal Variables N=250

Variables		Hypo coiled	Normo coiled	Hyper coiled	Hypocoiled vs Normocoiled	Hypercoiled vs Normocoiled	Hypocoiled vs Hypercoiled
		(n=22)	(n=204)	(n=24)			
Birth weight	< 2500 (n=79)	15	49	15	<0.0001	< 0.0001	0.686
		68.2%	24.0%	62.5%			
	2500-4000 (n=165)	7	149	9	<0.0001	< 0.0001	0.686
		31.8%	73.1%	37.5%			
	> 4000 (n=6)	0	6	0	0.415	0.394	-
		0%	2.9%	0			
Meconium stained	Yes (n=30)	6	20	4	0.015	0.301	0.384
		27.3%	9.8%	16.6%			
	No (n=220)	16	184	20			
		72.7%	90.2%	83.4%			
APGAR	< 7 (n=23)	5	15	3	0.016	0.376	0.361
		22.7%	7.4%	12.5%			
	> 7 (n=227)	17	189	21			
		77.3%	92.6%	87.5%			

In aUCI, 79 (31.6%) neonates were with low birth weight (<2500g), 165 (66%) with normal birth weight (2500-4000g) and 6 (2.4%) were >4000g. In the hypocoiled group, 15 (68.2%) were low birth weight, seven (31.8%) between 2500 and 4000 g. In the normocoiled group, 49 (24.0%) low birth weight, 149 (73.1%) had birth weight 2500- 4000 g and six (2.9%) neonates >4000g. In the hypercoiled group, 15 (62.5%) were low birth weight, nine (37.5%) between 2500 and 4000 g. There was highly significant association of the low birth weight group with both hypocoiling and hypercoiling patterns of the umbilical cord (p <0.0001 and p <0.0001 respectively). There were 12 (54.5%), 42(20.6% and 15 (62.5%) small for gestation age (SGA) neonates in the hypocoiled, normocoiled and hypercoiled groups respectively. SGA neonates were found to be significantly associated with both the hypocoiling and hypercoiling patterns of the umbilical cord as compared to the normocoiled group (p=0.0004 and p <0.0001 respectively). Meconium staining of amniotic fluid was found in 6 (27.3%), 20 (9.8 %) and 4 (16.6%) neonates in the hypocoiled, normocoiled and hypercoiled groups respectively.

It was observed that 5 (22.7%), 15 (7.4%) and 3 (12.5%) neonates in the hypocoiled, normocoiled and hypercoiled groups respectively had Apgar <7 at one minute. Hypocoiled cords were found to be associated with apgar score <7 at one minute as compared to normocoiled cords (p=0.016,significant). It was observed that the percentage of neonates admitted to the neonatal intensive care unit (NICU) were more in the hypocoiled and hypercoiled group (9.1% and 8.3% respectively) as compared to the normocoiled group (4.4%) but this difference was not statistically significant.

Table 5: UCI and Neonatal Variables N=250

variables		Hypo coiled	Normo coiled	Hyper coiled	Hypocoiled vs Normocoiled	Hypercoiled vs Normocoiled	Hypocoiled vs Hypercoiled
		(n=25)	(n=200)	(n=25)	P value	P value	P value
Birth weight (g)	<2500 (n=79)	16	48	15	<0.0001	0.005	0.390
		64%	24.0%	60%			
	2500-4000	9	146	10	0.0002	0.004	0.564

	(n=165)	36%	73%	40%			
	>4000	0	6	0	0.424	0.661	-
	(n=6)	0.0%	3%	0.0%			
Meconium Stained	Yes	7	19	4	0.006	0.312	0.306
	(n=30)	28.0%	9.5%	16.0%			
	No	18	181	21			
	(n=220)	72%	90.5%	84%			
APGAR	<7	5	16	2	0.048	1.000	0.221
	(n=23)	20%	8%	8.0%			
	>7	20	184	23			
	(n=250)	80%	92%	92%			

In the hypocoiled group, 16 (64%) neonates were low birth weight, nine (36%) between 2500 and 4000g. In the normocoiled group, 48(24.0%) were low birth weight, 146 (73%) between 2500 and 4000 g and six (3%) neonates >4000g. In the hypercoiled group, 15(60%) neonates low birth weight, 10 (40%) between 2500 and 4000 g. Hypocoiled and hypercoiling patterns were significantly associated with low birth weght as compared to the normocoiling pattern (p<0.0001 and p=0.005 respectively).There were 13(52%), 40(20%) and 16(64%) SGA neonates in the hypocoiled, normocoiled and hypercoiled groups respectively. SGA neonates were found to be significantly associated with both the hypocoiling and hypercoiling patterns of the umbilical cord as compared to the normocoiled pattern (p=0.0006 and p<0.0001 respectively). Meconium staining of amniotic fluid was more commonly observed in both hypocoiled (28%) and hypercoiled groups (16%) as compared to the normocoiled group (9.5%), but the association was significant for the hypocoiled group as compared to the normocoiled group (p =0.006).
It was observed that Apgar<7 at one minute was in 5 (20%), 15 (8%) and 2 (8%) neonates in the hypocoiled, normocoiled and hypercoiled groups respectively. When compared with the normocoiled group Apgar < 7 at one minute was associated with hypocoiled group and was statistically significant (p= 0.048). It was observed that the neonates admitted to NICU were 2(9%), 10 (5%) and one (4%) in the hypocoiled, normocoiled and hypercoiled groups respectively (p>0.05).

Discussion

The umbilical cord is the major fetomaternal unit that provides communication between the placenta and the fetus. It may be prone to compression, tension, or torsion, with subsequent interruption of blood flow. Coiling is thought to provide a protective effect to these forces, thereby securing an uninterrupted blood supply to the fetus. An abnormal coiling index has been reported to be related to adverse perinatal outcome. In the present study the sensitivity of the sonography for detecting hypocoiling, normocoiling and hypercoiling was 84%, 98.5% and 80% respectively. The specificity of the sonography for detecting hypocoiling, normocoiling and hypercoiling was 99.5%, 86% and 98.2% respectively. Studies have shown a definite correlation of aUCI and UCI with perinatal outcome. Hence aUCI can be used as a predictor of perinatal outcome.
The mean gestational age at which ultrasound was performed in the present study was 20.0 ± 1.2wk, 20.3 ± 1.3wk and 20.6 ± 1.4wk in the hypocoiled, normocoiled and hypercoiled groups respectively which was comparable to the study by Predanic M *et al* [8] where the mean gestational age at ultrasound was 20.5±0.7wk, 20.4±0.9wk and 20.1±0.8wk in the hypocoiled, normocoiled and hypercoiled groups respectively. The mean gestational age at delivery was (37.84 ±1.79weeks, 38.09±1.44weeks, 38.51±1.17weeks in the hypocoiled, normocoiled and hypercoiled groups respectively) in the present study which was comparable to the study by de Laat M *et al* [9]. The mean gestational age at delivery in both the studies was term (37-42 weeks)

Table 6: aUCI and Mode of Delivery

Study group	aUCI	Mode of delivery					
		Spontaneous vaginal delivery		Instrumental vaginal delivery		LSCS	
		%	P	%	p	%	p
Predanic M *et al* (2005)	Hypocoiled	61.3%	>0.05	3.2%	>0.05	35.5%	>0.05
	Normocoiled	63.6%		6.4%		30.1%	
	Hypercoiled	70.4%	>0.05	7.4%	>0.05	22.2%	>0.05
Present study (2012)	Hypocoiled	50%	0.283	18.2%	0.996	31.8%	0.202
	Normocoiled	61.8%		18. 1%		20.1%	
	Hypercoiled	50%	0.265	20.8%	0.747	29.2%	0.303

In the present study, there was no significant association of the coiling pattern with the mode of delivery which was comparable to the study by Predanic M *et al* [8] (p >0.05). The incidence of instrumental vaginal delivery was higher in the present study (18.2%, 18.1% and 20.8% in the hypocoiled, normocoiled and hypercoiled groups respectively) in contrast to the study by Predanic M *et al* [8]. The incicence of cesarean delivery in the present study was comparable to the study by Predanic M *et al* [8]. When the modes of delivery were stratified according to the need for intervention and expeditious fetal delivery, because of a nonreassuring fetal heart status, larger number of interventional deliveries were observed in the hypo- and hypercoiled group of cords.

Table 7: UCI and Mode of Delivery

Study group	UCI	Spontaneous vaginal delivery		Instrumental Vaginal delivery		LSCS	
		%	P	%	p	%	p
Ezimokhai *et al* (2000)	Hypocoiled	88.7%	>0.05	3.2%	>0.05	8.1%	>0.05
	Normocoiled	88.2%		4.5%		7.4%	
	Hypercoiled	66.2%	>0.05	5.9%	>0.05	27.9%	<0.05
Chitra T *et al* (2012)	Hypocoiled	66.7%		20.5%	0.188	12.8%	0.060
	Normocoiled	75.9%		16.2%		7.9%	
	Hypercoiled	62%		21%	0.110	17%	0.001
Present study (2012)	Hypocoiled	48%	0.243	24%	0.656	28%	0.461
	Normocoiled	60.5%		17.5%		21%	
	Hypercoiled	64%	0.670	20%	0.760	24%	0.863

The incidence of spontaneous vaginal delivery was comparable to the study by Chitra T *et al* [10] and this was in contrast to the study by Ezimokhai *et al* [11] where the incidence of spontaneous vaginal delivery was higher in all the groups. However when stratified according to the coiling pattern, this was not significant (p >0.05). The incidence of instrumental vaginal delivery in the present study was comparable to the study by Chitra T *et al* [10] and in contrast to the study by Ezimokhai *et al* [11] (p >0.05). In the present study, there was no association of the coiling pattern with the incidence of LSCS; this was in contrast to the study by Ezimokhai *et al* [11] and Chitra T *et al* [10] where hypercoiling was significantly associated with LSCS.

aUCI and Neonatal Variables

There was highly significant association of the low birth weight group neonates with both hypocoiling and hypercoiling patterns of the umbilical cord (p<0.0001 and p<0.0001 respectively) similar to the study by Predanic M *et al* [8] but in contrast to the study by Tahmasebi M *et al* [12]. However they observed that LBW was strongly associated with umbilical cord thickness and cross-sectional area below the 10^{th} percentiles (*P*<0.01 for both). It was observed that the meconium staining of amniotic fluid was significantly more associated with hypocoiled cords (p = 0.015) in contrast to the study by Predanic M *et al* [8]. Since hypocoiling of the cord is associated with increased incidence of fetal distress and small for gestation age infants and meconium staining of the liquor is also associated with these conditions, therefore it can be said that meconium staining of the liquor is associated with hypocoiling. There was no significant association of neonates being shifted to NICU and the antenatal umbilical cord coiling patterns in contrast to the study by Sung Jo Y *et al* [13].

UCI and neonatal variables

The incidence of low birth weight neonates was higher in the present study as compared to the study by Kashanian M *et al* [14] and Chitra T *et al* [10] There was significant association of the low birth weight neonates in both the hypocoiled and hypercoiled group (p <0.0001 and p = 0.005 respectively) comparable to the study by Chitra T *et al* [10] (p = 0.011 and p =0.001 respectively). Similarly, the incidence of small for gestation age neonates was comparable to study by Gupta S *et al*[15]. The abnormal coiling pattern (hypocoiled and hypercoiled cords) in the postnatal examination in the present study was associated (p= 0.0006 and p<0.0001 respectively) with small for gestation age infants in contrast to the study by Ezimokhai *et al*[11] who concluded that hypercoiled cords were significantly associated (p <0.05) with small for gestation age infants. Gupta S *et al* [15] observed that fetal growth retardation was not associated with the coiling pattern

In the present study meconium staining of liquor was significantly associated with hypocoiled cords (p = 0.006) similar to the study by Gupta S *et al* [15] (p <0.05) while Ezimokhai *et al* [11] concluded that hypercoiling of the cord was significantly associated with meconium staining. Similarly Apgar <7 at one minute was significantly associated with hypocoiling of the cord which was comparable to the study by Gupta S *et al* [15]

Conclusion

Abnormal umbilical cord coiling can be recognised during the fetal anatomic survey in the second trimester without significantly increasing the examination time. Regardless of the possible pathophysiologic condition of the abnormal cord coiling and its effect on the pregnancy and labor, this study concludes that the hypocoiling and hypercoiling of the umbilical cord observed during fetal ultrasound anatomical evaluation in the second trimester is associated with small for gestation age neonates, fetal distress and low apgar scores and may have a bearing on increased interventional deliveries thus increasing the burden on NICU. This observation has been found to be similar to the umbilical coiling index at birth, thus it is suggested that second trimester ultrasound should include umbilical coiling index as one of the parameters of evaluation and this can be used as a potential predictor of adverse perinatal outcome.

Conflict of interest

None declared

Financial disclosure

The facilities for the study were available in the hospital. The study was not be financed by any other agency/institution.

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