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The association between umbilical cord coiling index and adverse perinatal outcomes at term pregnancies

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ABSTRACT

Objectives: The umbilical coiling index, calculated by dividing the total coil number to the cord length, is a representative parameter for umbilical cord coiling status. Recent studies have shown that abnormal umbilical coiling index is associated with adverse perinatal outcomes. Here, we aimed to determine this association at term gestation in our population.

Methods: A total of 98 singleton, term pregnant women were included in this prospective study. Demographic, obstetric features and perinatal outcomes of the patients were recorded. Patients were grouped according to the umbilical coiling index as hypocoiled, normocoiled and hypercoiled. Recorded parameters were firstly compared between normocoiled (n = 60) and abnormal coiled (n = 38) groups. Then, they were compared between normocoiled, hypocoiled (n = 20) and hypercoiled (n = 18) groups. Significantly different adverse perinatal outcomes were compared between normocoiled and other groups.

Results: Abnormal coiled group had an higher incidence of low fifth minutes Apgar scores, meconium-stained amniotic fluid, intrauterine growth restriction and acute fetal distress as compared to normocoiled group. No significant adverse perinatal outcome was detected between hypocoiled and normocoiled groups. Intrauterine growth restriction (p = 0.004), low Apgar scores (p = 0.046) and fetal distress (p = 0.038) and meconium-stained amniotic fluid were found to be more common in hypercoiled group than normocoiled ones.

Conclusions: Abnormal umbilical coiling is associated with adverse perinatal outcomes. Hence antenatal measurement of umbilical coiling index could be a useful parameter to determine high-risk pregnancies and can provide close monitoring for fetal well-being.

Keywords: Adverse outcome, perinatal outcome, term pregnancies, umbilical coiling index

The umbilical cord, the connecting tissue between the embryo and placenta, is vital for the well-being of the fetus. It has three blood vessels that provide all the nourishment for intrauterine life. It consists screw-shaped coils defined as the 360-degree spiral courses of vessels around Wharton jelly [1]. Although the main role of coils has not been fully elucidated, it has been claimed that the number of coiling could be related to adverse perinatal outcomes [2, 3].

The umbilical coiling index (UCI), which is calculated by dividing the coil number in the cord to the length of cord, is a representative parameter for umbilical cord coiling status [4]. According to UCI, umbilical cords have been classified as hypocoiled (UCI

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< 10th percentile), normocoiled (UCI between 10-90th percentile) and hypercoiled (UCI > 90th percentile) [5]. In the literature, it has been shown that hypocoiled cords were associated with fetal distress, fetal heart rate abnormalities, low Apgar scores, and meconium-stained amniotic fluid while hypercoiled ones were related to low birth weight, fetal distress, diabetes mellitus, preterm birth, low Apgar scores, and meconium-stained amniotic fluid [1, 4, 6-8].

To the best of our knowledge, there is a few data about the relationship between UCI and adverse pregnancy outcomes in our population. Here, we aimed to determine this association at term gestation.

METHODS

This is a prospective study conducted on a university-affiliated hospital. The present study was approved by the local ethics committee with an approval number of 196. Written informed consent was taken from all the participants. The inclusion criteria were as follows; being at ≥ 37th gestational week, having a singleton pregnancy, and live fetus. After being selected according to the inclusion criteria, a total of 98 term pregnant women were included into the study.

Age, gravida, parity, presence of gestational hypertension (GH), gestational diabetes mellitus (GDM), intrauterine growth restriction (IUGR), meconium-stained amniotic fluid were noted. Also, mode of delivery, delivery week, birth weight, fifth minutes Apgar scores, development of acute fetal distress, and requirement of neonatal intensive care unit (NICU) were recorded. Gestational age was calculated in two ways: the initial day of the last menstrual period for cases with regular menstrual cycles and first-trimester ultrasound for cases with irregular cycles or unknown last menstrual bleeding.

A detailed examination was performed, management of these cases was done due to the universally accepted protocols, and patients were followed up closely during the peripartum period. After delivery of the baby (vaginal or cesarean section), the umbilical cord was tied and cut closer to the placenta. The length of the umbilical cord between the placental end and umbilical stump was measured without stretching. Then, the number of coils was counted. UCI was calculated by dividing the total number of coils by the total length of the cord. Patients were grouped according to the UCI values as hypocoiled (UCI < 10th percentile), normocoiled (UCI between 10-90th percentile), and hypercoiled (UCI > 90th percentile). A total of 60 normocoiled, 18 hypercoiled, and 20 hypocoiled cases were analyzed.

Recorded parameters were firstly compared between normocoiled and abnormal coiled (hypercoiled and hypocoiled) groups. After then, they were compared between normocoiled, hypocoiled and hypercoiled groups. Significantly different adverse perinatal outcomes were compared between normocoiled and other groups.

Statistical Analysis

Statistical analysis was performed by using SPSS Version 22.0. (IBM Corp. Released 2012. IBM SPSS Statistics for Windows, Armonk, NY: IBM Corp.) software. Shapiro Wilk test was used for assessing whether the variables follow normal distribution or not. Variables were reported as mean ± SD or median (minimum: maximum) values for continuous variables and percentage or frequency for categorical variables. Mann Whitney U test was used for two group comparison of non-normally distributed continuous variables while independent t-test was used for normally distributed ones. For comparison of hypocoiled, normocoiled and hypercoiled groups, one way ANOVA and Kruskal Wallis tests were carried out. Chi-square test and Fisher's exact test were performed for the comparison of categorical variables. The level of significance was set at $\alpha = 0.05$.

RESULTS

A total of 98 term pregnant women were included in the study. The study population was grouped into normocoiled (n = 60) and abnormal-coiled (n = 38) groups. The characteristics of normocoiled and abnormal coiled groups were demonstrated in Table 1. There was no significant difference between two groups in terms of age, gravida, parity, cord length, number of coils, the presence of GH, GDM, mode of delivery, delivery week, birth weight, low birth weight, and requirement of NICU. The abnormal coiled group had a higher incidence of low fifth minutes Apgar scores ($p = 0.029$), meconium-stained amniotic fluid ($p =$

Table 1. The characteristics of normocoiled and abnormal coiled groups

	Normocoiled (n = 60)	Abnormal coiled (n = 38)	*p* value
Age (years)	28 (19-37)	27 (20-42)	0.384
Gravida (n)	2 (1-5)	2.5 (1-5)	0.952
Parity (n)	1 (0-4)	1 (0-4)	0.688
Cord length (cm)	58 (40-70)	60 (40-70)	0.258
Number of coils (n)	8 (6-11)	7 (4-17)	0.927
GH, n (%)	12 (20)	6 (15.8)	0.797
GDM, n (%)	7 (11.7)	4 (10.5)	1.000
IUGR, n (%)	3 (5)	9 (23.7)	0.010
Mode of delivery, n (%)			0.844
Vaginal delivery	45 (75)	27 (71.1)	
Cesarean section	15 (25)	11 (28.9)	
Delivery week (week)	38 (37-40)	38 (37-40)	0.549
Birth weight (g)	3175 (2250-4100)	3325 (2300-4000)	0.481
Fifth minutes Apgar score < 7, n (%)	8 (13.3)	12 (31.6)	**0.029**
Low birth weight, n (%)	8 (13.3)	8 (21.1)	0.467
Meconium-stained amniotic fluid, n (%)	4 (6.7)	9 (23.7)	**0.034**
Acute fetal distress, n (%)	10 (16.7)	14 (36.8)	**0.043**
NICU requirement, n (%)	11 (18.3)	11 (28.9)	0.328

Data are shown as median (min-max), mean ± SD and n (%). GDM = gestational diabetes mellitus, GH = gestational hypertension, IUGR = intrauterine growth restriction, NICU = neonatal intensive care unit

0.034), IUGR ($p = 0.010$) and acute fetal distress ($p = 0.043$) as compared to normocoiled group.

Patients were also divided into three subgroups as hypercoiled (n = 18), normocoiled (n = 60) and hypocoiled (n = 20) groups. The characteristics of normocoiled, hypercoiled and hypocoiled groups were shown in Table 2. No statistically significant difference was detected with regard to age, gravida, parity, cord length, the presence of GH and GDM, mode of delivery, delivery week, birth weight, low birth weight and NICU requirement. As it was expected, number of coils and UCI were statistically significantly different between three groups. Moreover, the incidence of IUGR ($p = 0.005$), low Apgar scores ($p = 0.036$), acute fetal distress ($p = 0.030$) and meconium stained amniotic fluid ($p = 0.013$) were significantly different between three groups. These significantly different outcomes were compared between two groups (normocoiled- hypercoiled and normocoiled- hypocoiled) and presented in Table 3. The incidence of IUGR was 5% in normocoiled group, 15% in hypocoiled group, and 33.3% in hypercoiled group. This incidence was not significantly different between normocoiled and hypocoiled groups ($p = 0.162$) while it was statistically significantly different between normocoiled and hypercoiled groups ($p = 0.004$). Low Apgar scores were present in 13.3% of normocoiled cases, 30% hypocoiled cases and 33.3% in hypercoiled ones. Significant difference was only detected in the comparison of normocoiled and hypercoiled groups ($p = 0.046$). Similar to those, the incidence of acute fetal distress and meconium-stained amniotic fluid were significantly higher in hypercoiled group as compared to normocoiled group ($p = 0.038$ and $p = 0.008$, respectively). The incidence of acute fetal distress was 16.7% in normocoiled group, 35% in hypocoiled group and 38.9% in hypercoiled group while the incidence of meconium-stained amniotic fluid was 6.7%

Table 2. The characteristics of normocoiled, hypercoiled and hypocoiled groups

	Normocoiled (n = 60)	Hypercoiled (n = 18)	Hypocoiled (n = 20)	*p* value
Age (years)	27.82 ± 4.64	27.72 ± 6.42	26.65 ± 3.62	0.639
Gravida (n)	2 (1-5)	3 (1-5)	2 (1-5)	0.248
Parity (n)	1 (0-4)	1 (0-4)	1 (0-3)	0.401
Cord length (cm)	58 (40-70)	60 (50-70)	60 (40-70)	0.503
Number of coils (n)	8 (6-11)	14 (12-17)	5.5 (4-7)	< 0.001
Umbilical coiling index	0.15 (0.12-0.16)	0.24 (0.23-0.28)	0.10 (0.06-0.11)	< 0.001
GH, n (%)	12 (20)	3 (16.7)	3 (15)	0.934
GDM, n (%)	7 (11.7)	2 (11.1)	2 (10)	1.000
IUGR, n (%)	3 (5)	6 (33.3)	3 (15)	**0.005**
Mode of delivery, n (%)				0.853
Vaginal delivery	45 (75)	13 (72.2)	14 (70)	
Cesarean section	15 (25)	5 (27.8)	6 (30)	
Delivery week (week)	38 (37-40)	38 (37-40)	38 (37-40)	0.726
Birth weight (g)	3175 (2250-4100)	3325 (2300-4000)	3400 (2350-4000)	0.308
Fifth minutes Apgar score < 7, n (%)	8 (13.3)	6 (33.3)	6 (30)	**0.036**
Low birth weight, n (%)	8 (13.3)	6 (33.3)	2 (10)	0.125
Meconium-stained amniotic fluid, n (%)	4 (6.7)	6 (33.3)	3 (15)	**0.013**
Acute fetal distress, n (%)	10 (16.7)	7 (38.9)	7 (35)	**0.030**
NICU requirement, n (%)	11 (18.3)	7 (38.9)	4 (20)	0.193

Data are shown as median (min-max), mean ± SD and n (%). GDM = gestational diabetes mellitus, GH = gestational hypertension, IUGR = intrauterine growth restriction, NICU = neonatal intensive care unit requirement

in normocoiled group, 15% in hypocoiled group and 33.3% in hypercoiled group. No significant difference was detected between normocoiled and hypocoiled groups in terms of acute fetal distress and meconium-stained amniotic fluid (p = 0.114 and p = 0.358, respectively).

DISCUSSION

The present study revealed that abnormal coiling is related to IUGR, low fifth minutes Apgar scores, higher incidence of meconium-stained amniotic fluid and acute fetal distress. Hypercoiled groups have a higher incidence of IUGR, low fifth minutes Apgar scores, acute fetal distress, and meconium-stained amniotic fluid while hypocoiling was not associated with these adverse outcomes as compared to normocoiled group. No statistically significant relationship was found between GH, GDM, low birth weight, NICU requirement, and abnormal coiling.

The umbilical cord has a vital role in fetal development. It has coils and it was composed of helical-shaped umbilical vessels and Wharton's jelly [8]. Umbilical coils are thought to protect the umbilical cord from external pressure [9, 10]. It has been suggested that abnormal coiling is associated with acute and chronic adverse events such as growth restriction, acute fetal distress, and fetal demise [4]. Abnormal blood flow or thrombus are mostly claimed mechanisms for these adverse events [1].

In 1994, Strong *et al*. [4] defined UCI for umbili-

Table 3. The subgroup comparisons of normocoiled, hypercoiled and hypocoiled groups

	Normocoiled (n = 60)	Hypocoiled (n = 20)	*p* value	Normocoiled (n = 60)	Hypercoiled (n = 18)	*p* value
IUGR, n (%)	3 (5)	3 (15)	0.162	3 (5)	6 (33.3)	**0.004**
Fifth minutes Apgar score < 7, n (%)	8 (13.3)	6 (30)	**0.102**	8 (13.3)	6 (33.3)	**0.046**
Acute fetal distress, n (%)	10 (16.7)	7 (35)	**0.114**	10 (16.7)	7 (38.9)	**0.038**
Meconium-stained amniotic fluid, n (%)	4 (6.7)	3 (15)	0.358	4 (6.7)	6 (33.3)	**0.008**

Data are shown as median (min-max), mean ± SD and n (%). IUGR = intrauterine growth restriction

cal cord coiling, and then Rana *et al*. [5] defined hypocoiled, normocoiled and hypercoiled groups according to UCI. From 1994 to recent years, many study have suggested that abnormal cord coiling is associated with adverse perinatal outcomes. Contrary to these, some studies reported no association between adverse perinatal outcomes and abnormal cord coiling [4, 6, 7, 11-13].

In a meta-analysis searching 24 studies and 9553 pregnant women, hypocoiled cords were reported to be associated with preterm birth, fetal distress, meconium-stained amniotic fluid, low Apgar scores, fetal growth restriction, need for NICU, fetal death and fetal heart rate anomalies [14]. Strong *et al*. [4] reported that hypocoiled cords are associated with aneuploidy, meconium-stained amniotic fluid, and fetal distress. In another study, hypocoiling was found to be associated with low Apgar scores in 130 umbilical cords [15]. Similarly, de Laat *et al*. [7] and Kashanian *et al*. [13] supported the relationship between low Apgar scores and hypocoiling in their study. In a study of Patil *et al*. [16], higher incidence of meconium-stained amniotic fluid was found in addition to low Apgar scores. Some studies have suggested a significant association between hypocoiling and hypertensive disorders [6, 12, 17]. In contrary, Shilpa *et al*. [18] and Mittal *et al*. [19] did not find any relationship between hypocoiling and GHT. Likewise, Shilpa *et al*. [18] did not find any association between hypocoiled cords and GDM. Ezimokhai *et al*. [12] reported significant association between hypocoiling and GDM. Contrary to all these studies, Kumar *et al*. [8] and Ndolo *et al*. [20] reported no significant association between hypocoiled cords and adverse perinatal outcomes. Also, we found no relationship between adverse perinatal outcomes and hypocoiling in our study. We suggest that these conflicting results could be dependent on study population.

The other confounding factor explaining these different results is the timing of UCI measurement. In studies searching UCI by sonography in the early second trimester, hypocoiled cord was found to be associated with IUGR whereas no association was detected in terms of preterm birth, low Apgar scores, meconium-stained amniotic fluid, and abnormal fetal heart rate [1, 21]. According to the mid-second trimester studies, hypocoiled cords were associated with fetal growth retardation, preterm birth, low birth weight, increased NICU admission, and nonreassuring fetal conditions [1, 22]. In the third trimester, fetal growth retardation and interventional delivery were related to hypocoiling [7]. In a study of Kumar [8], UCI was calculated after delivery for term pregnancies and no significant association was found between hypocoiled cords and adverse perinatal outcomes. In our study, we calculated UCI after delivery and found no significant association for adverse outcomes. These differences could depend on the differences in measurements and sample size of the studies.

A meta-analysis revealed that hypercoiled cords are associated with preterm birth, fetal distress, low Apgar scores, meconium-stained amniotic fluid, fetal anomalies, fetal heart rate anomalies, IUGR, and fetal death [14]. Studies searching the relationship between hypercoiling and adverse perinatal outcomes in the mid-second trimester claimed that hypercoiling is related to fetal growth retardation and nonreassuring fetal status [22]. In late second trimester, hypercoiled cord was not associated with adverse outcomes while it was associated with fetal growth restriction and interventional delivery in the third trimester [1, 7]. In a study performed after delivery at term pregnancies, hypercoiling was found not to be associated with adverse perinatal outcomes [8]. In contrast to this study, we found a relationship between hypercoiling and adverse perinatal outcomes such as low fifth minutes Apgar scores, acute fetal distress, IUGR, and meconium-stained amniotic fluid after delivery at term pregnancies.

Hypercoiling could be related to placental maturation defects and adverse outcomes via reducing pressure in terminal capillaries and altering angiogenesis in the placental bed. Another mechanism of this relationship could be fetal vascular obstruction [23]. Ezimokhai *et al*. [12] found fetal growth restriction to be related to hypercoil cords. The contrary to this study, Devi *et al*. [24] reported no association between fetal growth restriction and hypercoiling. A study searching hypercoiling in IUGR fetuses found no association from Turkey [25]. Similar to fetal growth retardation, acute fetal distress was found to be associated with hypercoiling in previous studies [4, 13, 24, 26]. This condition could be associated with resistance in blood flow [27]. In addition to these, Devi *et al*. [24] found low Apgar scores in hypercoiled cases. Moreover, the relationship between low Apgar scores and hypercoiling was supported by Gupta *et al*. [6], Kashanian *et al*. [13] and Chitra *et al*. [17].

Limitations

The present study has some limitations. First, it has a small sample size and all data were obtained from a single center. Second, sonographic UCI measurement is not present for any trimester of pregnancy. Last, the thickness of Wharton's jelly is associated with adverse perinatal outcomes. Thus, the lack of measurement of Wharton's jelly is another limitation.

CONCLUSION

Abnormal umbilical coiling is associated with adverse perinatal outcomes. Hence antenatal measurement of the umbilical coiling index could be a useful parameter to determine high-risk pregnancies and can provide close monitoring for fetal well-being.

Authors' Contribution

Study Conception: BAB, EZY; Study Design: BAB; Supervision: BAB; Funding: EZY; Materials: BAB; Data Collection and/or Processing: BAB; Statistical Analysis and/or Data Interpretation: BAB; Literature Review: EZY; Manuscript Preparation: BAB and Critical Review: EZY.

Conflict of interest

The authors disclosed no conflict of interest during the preparation or publication of this manuscript.

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