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RESEARCH ARTICLE

Umbilical coiling index as a predictor of adverse perinatal outcome

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Abstract

Objectives: To determine the association of umbilical coiling index measured postnatally with adverse perinatal outcome
Methods: In a prospective study of 600 pregnancies at 37-40 weeks gestation, the umbilical coiling index measured at birth by calculating the number of coils divided by the cord length in cm. The subjects were divided into normocoiled, hypocoiled and hypercoiled groups and were compared with the perinatal outcomes.
Results: The mean umbilical coiling index was found to be 0.27+_0.08 coils per cm. Compared with the normocoiled groups, hypocoiled and hypercoiled groups were significantly associated with fetal heart rate abnormalities, meconeum stained liquor, caesarean section rates, instrumental vaginal deliveries and low APGAR score at 5 minutes(P value were = or < 0.001). Low birth weight babies was found to be statistically significantly associated with hypocoiling (P<0.001) but not with hypercoiling (P<0.056).
Conclusion: Abnormal umbilical coiling index measured postnatally is associated with several adverse perinatal outcomes.

Introduction

The umbilical cord is the principal connection between the fetus and the placenta, providing the nutrients, oxygen and fluids necessary for life in utero. The cord and its constituent tissues, an outer layer of amnion, porous Wharton's jelly, two arteries and one vein, are designed to provide and maintain the blood flow to the developing fetus[1].

In recent years there has been increasing interest in cord coiling, as it is recognised that the cord represents the most vulnerable link between fetus and mother, since it lies free in the amniotic fluid and may easily be damaged[2,3]. This coiling property of cord vessels was described as early as in 1521 by Berengarius. In 1954, umbilical coiling was first quantified by Edmonds [4,5] who divided the total number of coils by the umbilical cord length in centimeters and called it "The Index of Twist". He assigned positive and negative scores to clockwise and anticlockwise coiling, respectively. Later, Strong et al [6] simplified by eliminating these directional scores and named it "The Umbilical Coiling Index"[4]

The integrity of the umbilical cord vessels is maintained by two principal factors: spiral coiling and Wharton's jelly. It is the spiraling of the vessels which is thought to provide stability against buckling or compression [2,3,6] .

The mechanism by which physiological coiling occurs still, however, remains undetermined, with speculation that it may be related to early fetal activity and hemodynamic factors (supported by the finding of increased coiling in the recipient twin in twin-to-twin transfusion syndrome), or other anatomical issues such as the presence of Roach muscle [7,8,9] . Given that such data exist, the question arises as to whether these are simply associations with no pathophysiological significance or whether the cord coiling pattern can lead directly to adverse pregnancy outcome[7,10].

At full term the umbilical cord has an average length of 55cm(the usual range is 30-100cm). The helical course of the umbilical vessels is clearly visible from 7wks postconception in 95% of fetuses. An umbilical coil is defined as one complete spiral of 360 degrees of the umbilical vessels around each other. Both sinistral and dextral spiral occur. Sinistral spiraling (left) is four to eight times more common than dextral spiraling(right)&a mixed pattern of spiraling may also be seen. In 2%-5% of the umbilical cords there is no spiraling at all[4,5].

Several papers have shown that the normal pattern of coiling is at a rate of one coil per 5cm, which equates to a coiling index of 0.2/cm [2,3,6].Cord coiling of <0.1/cm is considered hypocoiled while coiling >0.3/cm is hypercoiled.

A frequency distribution of umbilical coiling index (UCI) was done by Rana et al (1995) [11,12].They grouped the UCI as follows:

<10th percentile - Hypocoiled
10th-90th percentile – Normocoiled
>90th percentile – Hypercoiled

Throughout the entire pregnancy, the total length of umbilical cord is increased, and particularly, in the later period of pregnancy, the length of umbilical cord becomes longer every month by approximately 3 - 6 cm[13,14]. A tendency is that the UCI becomes smaller in the third trimester in comparison with the second trimester [13,15]. Nonetheless, the level of the lengthening of umbilical cord varies in each fetus, and thus the change of UCI is individual [13].The difference in coiling was described as an antenatal marker identifying fetus at risk, however the majority of pregnancies with overcoiled or undercoiled umbilical cords, as determined by the assessment of umbilical coiling index, have a normal outcome[7,16].This behooves us to re-evaluate our evidence for the association between abnormal cord coiling and adverse pregnancy outcome.

Patients and Methods:

This prospective analytical study was conducted at the department of Obstetrics and Gynecology in AL-Kadhymia teaching hospital from October 2010 to March 2011. Institutional review committee approval as well as patient 's written informed consent was obtained prior to conducting this study. A total number of 600 pregnant women at 37-40 weeks gestation were randomly chosen by a single observer (blinded for the pregnancy outcome) from those who got admitted to the labor ward.

The inclusion criteria were: 1-singleton viable gestation 2- cephalic presentation 3- reliable gestational age 4-presence of a three –vessel umbilical cord. Patients were excluded if there was any fetal congenital anomaly or any maternal disorder or complication of pregnancy (e.g . diabetes mellitus, hypertension, heart disease, ..etc) that might interfere with fetal growth. Patients admitted for elective caesarean section were also excluded to avoid bias during computation of statistics.

Immediately after delivery, the umbilical cord was clamped and cut 5cm from the fetal insertion taking care not to milk the cord (as this might affect the umbilical coiling index). Then after spontaneous separation of the placenta, the rest of the cord from the cut end to the placental insertion was measured (in centimeters). This measurement was done without any delay, because the cord reportedly shrinks by as much as 7 cm in the first few hours after delivery [21]. No excessive traction was exerted on the cord at the time of measurement. Five cm was added to the length of the measured cord. A coil was defined as a complete 360 degree spiral coarse of the umbilical vessels around the warton 's jelly. Depending upon the direction of the course of vessels, umbilical cords were referred as clockwise, anticlockwise or straight. The umbilical coiling index was defined as the total number of complete vascular coiling divided by the total length of the cord in cm.

The centile values for umbilical coiling index were calculated. We defined hypocoiled cords as those with UCI<10^{th} percentile, hypercoiled cords as those with UCI>90^{th} percentile and normocoiled cords as those with UCI between 10^{th} and 90^{th} percentile.

Umbilical coiling index was correlated with intrapartum factors (including caesarean section, instrumental deliveries, abnormal fetal heart rate, meconeum stained liquor, postpartum hemorrhage) as well as with neonatal factors such as low APGAR score and low birth weight. Comparison was done with respect to the above chosen parameters between subjects having hypocoiled and hypercoiled cords with those having normocoiled cords. Data were analyzed using the chi square test, Fisher' s exact test and the t-test were applicable. Statistical significance was defined as P< or= 0.05 for all analysis.

Results:

We evaluated 600 umbilical cords at birth , the mean length of the umbilical cord was found to be 54.25+_9.2cm. The mean number of coils per umbilical cord was 8.89+_ 3.8. The mean umbilical coiling index was0.27+_0.08 coils per cm (Table 1).

Fetal heart rate abnormalities were associated with hypocoiling (26%) as well as with hypercoiling (23.57%) and this association was highly significant in both, P value were <0.001 (table2). Both hypocoiled and hypercoiled were

significantly associated with meconeum stained liquor , rates of meconeum stained liquor were 28.7% and 31.48% respectively ,P values were <0.001(table 2).
Caesarean section rates was significantly higher in the in the hypocoiled (18.37%)and hypercoiled (19.39%) groups when compared with normocoiled groups (62.24%) P values were 0.001 and <0.001 respectively (table2) .
Also there was significant association between instrumental vaginal deliveries and abnormal umbilical coiling, for hypocoiling instrumental delivery rate was34.7%, P value <0.001 , for hypercoiling the rate was 28.57%, P value <0.001(table2).
We found that there was statistically significant association between low APGAR score at 5 minutes and abnormal umbilical coiling (P value for hypocoiling was 0.001 and that for hypercoiling was <0.001 (table 3).
Low birth weight babies was found to be statistically significantly associated with hypocoiling, P value <0.001, but there was no significant association noted with hypercoiling, P value 0.056 (table 3).

Table-1- Umbilical coil characteristics

Umbilical coil characteristic	Number	Minimum	Maximum	Mean	Standard deviation
Length(cm)	600	30	100	54.25	9.2
Number of coils	600	4	36	8.89	3.8
Umbilical coiling index(coil per cm)	600	0.07	0.64	0.27	0.08

Table-2-Distribution frequencies of the three groups according to the intrapartum factors

Umbilical coiling index	Normal fetal heart rate N=477	Abnormal fetal heart rate N=123	P value
hypocoiled	43(9.01%)	32(26%)	<0.001
normocoiled	398(83.43%)	62(50.4%)	
hypercoiled	36(7.54%)	29(23.57%)	<0.001
Umbilical coiling index	Normal liquor N=492	Meconeum stained liquor N=108	P value
hypocoiled	44(8.94%)	31(28.7%)	<0.001
normocoiled	417(84.76%)	43(39.81%)	
hypercoiled	31(6.3%)	34(31.48%)	<0.001
Umbilical coiling index	Spontaneous vaginal delivery N=453	Caesarean section N=98	P value
hypocoiled	40(8.83%)	18(18.37)	0.001
normocoiled	381(84.11%)	61(62.24)	
hypercoiled	32(7.06%)	19(19.39)	<0.001
Umbilical coiling index	Spontaneous vaginal delivery N=453	Instrumental Delivery N=49	P value
hypocoiled	40(8.83%)	17(34.7%)	<0.001
normocoiled	381(84.11%)	18(36.73%)	
hypercoiled	32(7.06%)	14(28.57%)	<0.001

Table-3-Distribution frequencies of the three groups according to postnatal factors

Umbilical coiling index	Normal APGAR N=492	Low APGAR N=108	P value
hypocoiled	62(11.42%)	13(22.8)	0.001
normocoiled	430(79.19%)	30(52.63%)	
hypercoiled	51(9.39%)	14(24.56%)	<0.001
Umbilical coiling index	Normal birth weight N=520	Low birth weight N=80	P value
hypocoiled	55(10.57%)	20(25%)	<0.001
normocoiled	412(79.23%)	48(60%)	
hypercoiled	53(10.19%)	12(15%)	0.056

Discussion:

The umbilical cord and its vital blood vessels are the most vulnerable part of the fetal anatomy. The total number of coils for any particular cord is believed to be established early in the gestation [3, 17]. The role of umbilical cord coiling is not clear, nonetheless, it is thought to play a role of protecting the umbilical cord from external forces such as tension, pressure, stretching or entanglement [18, 19].

The aim of this study was to find the relationship between the umbilical coiling index and perinatal outcome.

In consideration of the abnormal versus normal coiling distribution in our study, we observed that 10th and 90th percentiles for UCI were in agreement with the previous studies [12, 20, 21, 22, 23].

The mean UCI in our study was 0.27 +_ 0.08 which was similar to the study done by Ezimokhai et al (2001)[24],however it was higher than those reported by Ercal et al (0.20+_0.1) [20], Strong et al[6](0.21 ± 0.07), and by Rana et al [12](0.19 ± 0.1).

A metaanalysis done by DeLaat showed that the normal coiling index to be 0.17 ± 0.009 completed spirals per centimeter [23]. We were not able to ascertain as to why our mean UCI was higher than that of the other workers. However, a difference in the antenatal UCI and UCI at birth has been reported [22].This could be explained by a sonographic error in the sampling of different umbilical cord segments with discordant coiling pattern or by the possibility of a dynamically evolving UCI with advancing gestational age[22].

FHR variations were found to have a highly significant association with both hypocoiled and hypercoiled. In both instances, p value was less than 0.001. Literature has found aconsistent association between intrapartum FHR decelerations and abnormal UCI. Strong et al [21] and de Laat el al [23] found FHR decelerations to be associated with both hypocoiled and

hypercoiled cords. Mechanisms by which this could be mediated include the possibility that undercoiled cords may be more susceptible to acute kinking and therefore abrupt and marked cessation of blood flow; in the case of hypercoiled cords, flow dynamic principles and studies suggest that flow through a coiled tube should be associated with greater resistance to flow than through a straight tube [10].

Meconium staining of the amniotic fluid was found to have a significant association with both hypocoiled (p<.001) and hypercoiled (p<0.001). This finding was similar to those noted in studies done by Strong et al [6,21]and Ezimokhai et al [25], although they didn't offer a specific explanation for this observation.

Degani et al[26] now that a coiled umbilical cord with the support of Wharton 's jelly is thought to be more resistant to torsion , stretching and compression. However, several studies[6,12,27,28,29] have noted that hyper-coiled cords correlated with poor perinatal outcome such as meconium staining of amniotic fluid at birth and fetal growth restriction. One of these studies has reported that hyper-coiled cords are less flexible or more prone to kinking, torsion in labor, thus leading to hypoxia.

Others reported that increasing UCI may be potentially beneficial by increasing umbilical blood flow, probably as a result of localized pulsometer effects, but further increased coiling may predispose to compression-mediated flow reduction and possible predisposition to

the development of fetoplacental vascular thromboses[30].

Indeed, over-coiling alone, even in the absence of cord stricture, has been documented at autopsy in 23% of fetal deaths[31].

Workers found higher incidence of instrumental deliveries and operative intervention for fetal distress **[21, 22, 32]** among fetuses with abnormal coiling compared to those with normocoiled cords. These findings are in agreement with the present study.

An initial low APGAR (<6 at 5 minutes) was found to have a significant relationship with both hypocoiled and hypercoiled (compared to those with normocoiled groups) in our study. The p values were 0.001 and <0.001 respectively. A similar result was obtained by Shalu gupta et al [4] and Kashanian et al [33].

Birth weight was found to be significantly associated with hypocoiled group but not with the hypercoiled group and this disagree with other literature that found a consistent association between hypercoiled and LBW babies, as shown by Rana et al[12], Raio et al [34] and de Laat et al [35]. However, the authors were unable to give a satisfactory explanation for this casual association.

If the umbilical coiling index can be measured adequately antenatally, it seems justifiable to conduct large prospective studies addressing the question of whether abnormalities in umbilical coiling index can identify cases that warrant intensified fetal monitoring both in the antenatal period and during labor.In the future ultrasonographic evaluation of the umbilical cord and the umbilical coiling index may become an integral part of fetal assessment in high risk pregnancies.

Conclusion

As a result we conclude that the umbilical coiling index has a strong relationship with perinatal outcome.

Recommendation

We recommend further studies to determine whether umbilical coiling index measured antenatally can be used as a marker for identifying the fetus at risk

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