Umbilical Cord Length Index as a New Ultrasonographic Method for Prediction of Cord Abnormalities before Delivery

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Abstract

Background: The umbilical cord (UC) provides life support to the fetus.The length of UC is of great clinical relevance and is associated with a wide range of unfavorable obstetric outcomes.
Objectives: Evaluating the feasibility of sonographic measurement of the UC length index in predicting any adverse feto-maternal outcomes of an uncomplicated full-term pregnancy
Patients and Methods: This prospective cohort study was done on 369 pregnant women with a singleton pregnancy and ≥ 37 weeks of gestation. The UC length index was calculated by ultrasonography by counting UC rings in each amniotic fluid quadrant.
Results: Both groups of women, based on the occurrence of UC problems, had insignificant differences as regards the different characteristics of the studied women, UC length, and UC index. Meanwhile, the frequency of neck loops was significantly higher among women with UC problems (44.2% vs. 25.5%; p = 0.01). There were insignificant differences between different umbilical cord problems regarding UC length (p = 0.42) and UC index (p = 0.28).
Conclusion: The UC length index was not a statistically significant predictor of umbilical cord abnormalities.

Keywords: Umbilical cold abnormalities; Umbilical cord length index; Peripartum; Ultrasonography

DOI: 10.21608/SVUIJM.2023.170575.1615
***Correspondence:** asmaakhalaf21488@gmail.com
Received: 17 August,2023.
Revised: 12 September, 2023.
Accepted: 19 September, 2023
Published: 21 June, 2024
Cite this article as: Asmaa Khalaf Shindeen, Mahmoud Soliman Mouawad, Mahmoud Ibrahim AlRashidy.(2024). Umbilical Cord Length Index as a New Ultrasonographic Method for Prediction of Cord Abnormalities before Delivery. *SVU-International Journal of Medical Sciences*. Vol.7, Issue 2, pp: 146-155.

Introduction

The umbilical cord (UC) has remained a source of intrigue for centuries. Ancient and certain modern societies have attributed supernatural qualities to the cord itself. Regardless of UC's magical abilities, it has always been clear that it gives life support to the fetus **(Subashini et al., 2023)**.

The length and placement of the umbilical cord in the amniotic fluid has noteworthy clinical significance. The factors contributing to the variability in umbilical cord length remain uncertain; nevertheless, it is hypothesized that the length of the umbilical cord is influenced by the available room within the amniotic cavity for fetal movement and the tension exerted on the umbilical cord during such movements **(Njoku et al., 2019).**

Sangwan et al. (2011) propose that the presence of an excessively short or long umbilical cord (UC) may give rise to thrombosis or bleeding within the cord vasculature and the placental surface, ultimately resulting in thrombocytopenia or potential fetal death.

The assessment of the UC during prenatal ultrasonography provides valuable information regarding the well-being and growth of the developing fetus. Upon the identification of cord abnormalities, particularly those related to fetal or placental umbilical insertions, it is recommended to conduct a comprehensive fetal ultrasound examination.

Early detection and monitoring may reduce fetal mortality and aid in decision-making **(Krzyżanowski et al., 2019)**.

Several recent studies assessed UC length in the first and second trimesters of pregnancy. These have not yet been implemented into standard obstetric practice. Additionally, **Sahin et al., 2019a)** found that it was not possible to directly assess UC length in the third trimester.

The aim of this research was to determine if sonographic measurements of the indices of the length of the UC could be used to predict the length of the UC and the ability to detect any association between UC length and the peripartum adverse fetal outcome of a full-term, uncomplicated pregnancy.

Patients and Methods

This prospective cohort study was done on 369 pregnant women aged above 18 years and below 35 years who were ≥ 37 gestational weeks pregnant and admitted to the labor room at random.

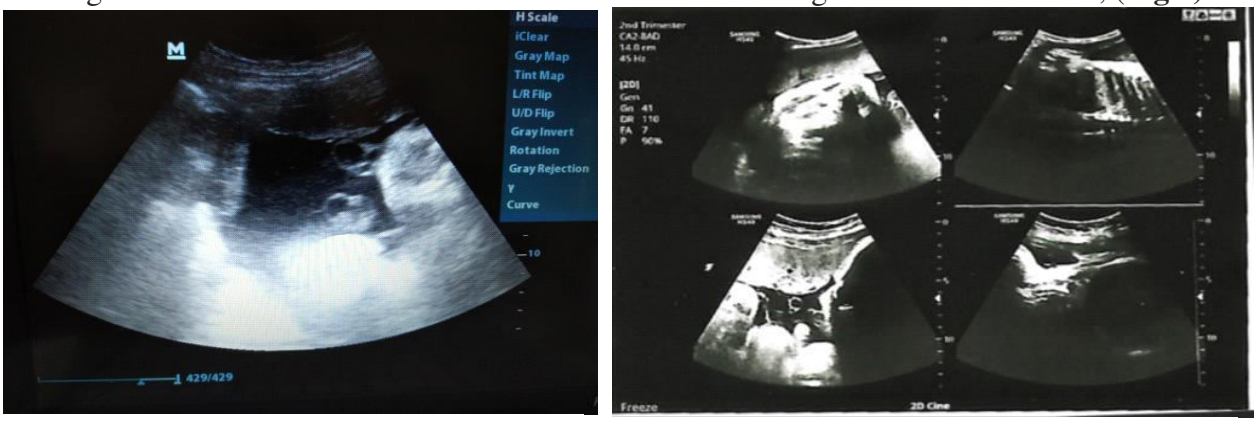
The study was done from August 2021 until March 2023 after approval from the Ethical Committee at South Valley University Hospital and Al Baliana Central Hospital, Suhag (Approval Code: SVU/MED/OBG024/1/21/7/216). The patient or the patient's relatives provided informed written permission.

Exclusion criteria were multiple pregnancies, premature rupture of membranes, amniotic fluid abnormalities,and major congenital anomalies.

All patients were subjected to a history taken, and all ultrasound assessments were conducted utilizing a Mindray DP-10 (China) instrument using a 3.5-MHz convex transducer probe. Fetal biometry was estimated utilizing the biparietal diameter (BPD), femur length (FL), and fetal abdominal circumference (AC) measurements, which were taken without fetal breathing or movements, and the amniotic fluid index was calculated using the sagittal view of the four amniotic fluid quadrants.

The placental site and fetal presentation were noted. The UC length index was developed by counting the UC rings in each quadrant of the amniotic fluid. Since the UC folds in amniotic fluid whenever its anatomical structure is taken into consideration, ultrasonography cannot

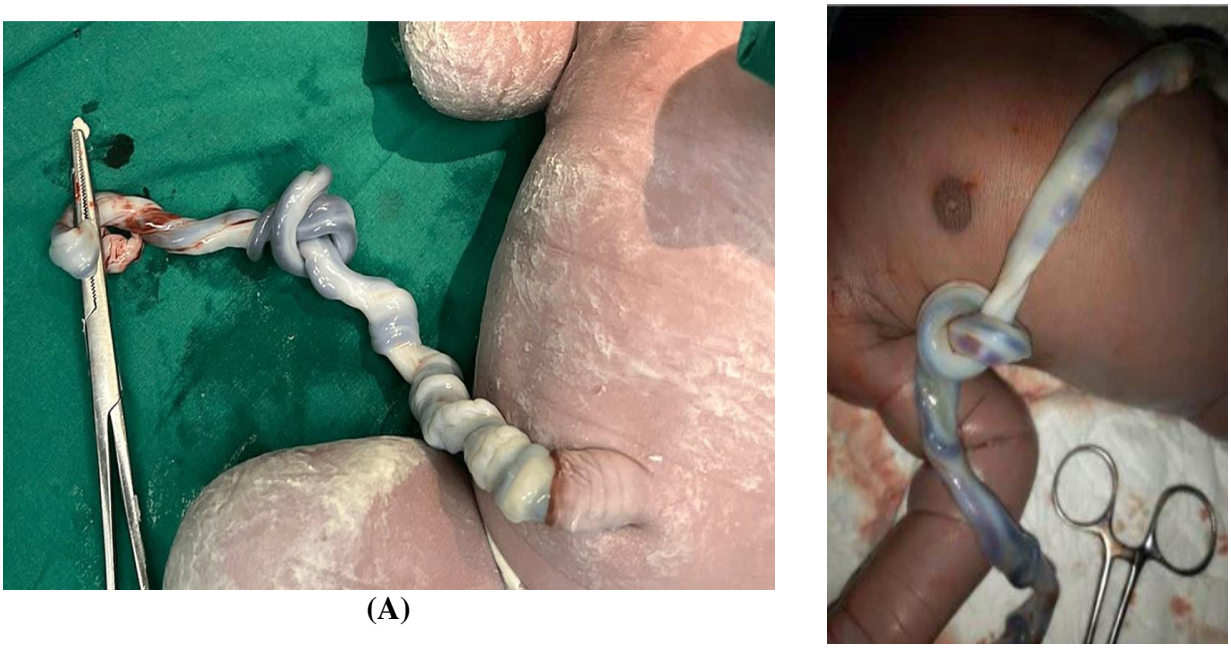
determine its whole length. The folds are seen as UC rings in the sagittal sections. The UC ring was considered accurate when it showed the typical view of one central large vein with two surrounding smaller arteries. The UC length index is calculated, (**Fig.1).**



(A) **(B)**

Fig.1. (A): Two umbilical cord rings are noted in this quadrant (red arrows), and (B): Shows the four amniotic fluid quadrants. Two umbilical cord rings are noted in quadrant three.

The gender of the newborn, the newborn weight (following cutting the chord within 30 minutes upon birth, the infant was weighted), fetal outcomes (determined by the Apgar score at one and five minutes), and the presence of any UC abnormalities, such as loops around the neck, trunk, shoulder, or true knots (**Fig.2**), were all assessed following delivery.



(A) **(B)**

Figure 2:True cord knot

Statistical analysis

SPSS (Statistical Package for Social Science, version 20, IBM, Armonk, New York) was used to gather and analyze the data. To ascertain if the data matched a normal distribution, the Shapiro test was applied. The mean and standard deviation (SD) of quantitative information with a normal distribution are represented and compared using the Student t-test (between two distinct means) and the ANOVA (between more than two distinct means) methods. The Mann-Whitney U test was utilized to compare quantitative data with an abnormal distribution reported as the median (minimum-maximum). Numbers (n) and percentages (%) were used to represent nominal data. Such data were subjected to the Chi2 test. The confidence level was maintained at 95%; hence, the P value was considered significant if < 0.05.

Results

The mean age of enrolled women was 27.50 years old, ranging between 18 and 48 years old. The parity range was between 0 and 8 times, with a median of three times. A history of cesarean section (CS) and abortion was found in 154 (41.7%) and 125 (33.9%) women, respectively. Five women had a history of stillbirth, and another three had a history of ectopic pregnancy. The majority (91.3%) of women had no medical risk factors. Meanwhile, 12 (3.3%) and 6 (1.6%) women were diabetic and hypertensive, respectively. Five women were obese, and another seven women had other comorbidities, (**Table. 1).**

Table.1. Baseline data for the studied women

Variables	N= 369
Age (years)	27.50 ± 5.84
Parity	3 (0-8)
Previous history of	
• **CS**	154 (41.7%)
• **Abortion**	125 (33.9%)
• **Stillbirth**	5 (1.4%)
• **Ectopic pregnancy**	3 (0.8%)
Medical comorbidities	
• **None**	337 (91.3%)
• **Diabetes mellitus**	12 (3.3%)
• **Hypertension**	6 (1.6%)
• **Obesity**	5 (1.4%)
• **Cardiac diseases**	2 (0.50%)
• **Others**	7 (1.9%)

Data expressed as mean ± SD or frequency (%). CS: cesarean section.

The mean gestational age was 37.95 weeks, the mean AFI was 14.04 cm, the mean UC ring was 2.98 cm, the mean UC length was 63.04 cm,, and the mean UC index was 3.52. Up to 27.6% of the studied women had neck loops and true knots, compared with 22 (6%). 43 (11.7%) women developed different forms of UC problems. The most frequently reported UC problem was meconium-stained syndrome (10%), while five women had placental separation and another four developed cord prolapse, (**Table.2**)

Table.2. Ultrasound evaluation and umbilical cord problems among the studied women

Variables	N= 369
Gestational age (week)	37.95 ± 1.30
AFI (cm)	14.04 ± 4.73
Umbilical cord ring	2.98 ± 1.30
UC length (cm)	63.04 ± 12.66
UC index	3.52 ± 1.22
Neck loops	102 (27.6%)
True knots	22 (6%)
Umbilical cord problems	
• **The total frequency of UC problems**	43 (11.7%)
• **Meconium-stained syndrome**	37 (10%)
• **Placental separation**	5 (1.4%)
• **Cord prolapses**	4 (1.1%)

Data expressed as mean ± SD or frequency (%). AFI: amniotic fluid index; UC: umbilical cord.

Cesarean section was done in 164 (44.4%) women either secondary to previous CS (42.3%), breech presentation (1.2%), gestational DM (0.60%), PROM (0.30%), or post-date (0.30%). Neonatal resuscitation was required in 107 (29%) neonates, while only four were admitted to the neonatal intensive care unit (NICU). (**Table.3).**

Table.3. Mode of delivery and outcome among the studied women

Variables	N= 369
Mode of delivery	
• **Vaginal delivery**	205 (55.6%)
• **CS**	164 (44.4%)
Indications of CS	
• **Previous CS**	156 (42.3%)
• **Breech presentation**	4 (1.2%)
• **Gestational diabetes mellitus**	2 (0.6%)
• **PROM**	1 (0.30%)
• **Post-date**	1 (0.30%)
• **Fetal weight (kg)**	3.08 ± 0.76
Apgar score	
• **1-minute**	9.14 ± 1.42
• **5-minute**	9.98 ± 0.21
Neonatal resuscitation	107 (29%)
Admission to NICU	4 (1.1%)

Data expressed as frequency (%) or mean ± SD. CS: cesarean section; PROM: premature rupture of membrane; NICU: neonatal intensive care unit.

Based on the occurrence of different UC problems, both groups of women had insignificant differences in different characteristics of the studied women, including UC length and UC index. The frequency of neck loops was significantly higher among women with UC problems (44.2% vs. 25.5%; p = 0.01), (**Table 4).**

Table.4. Characteristics of studied women based on the occurrence of UC problems

Variables	UC problems		P value
	No (n=326)	Yes (n= 43)	
Age (years)	27.44 ± 5.72	27.93 ± 6.75	0.60
Parity	3 (0-8)	2 (2-7)	0.48
Previous history			
• **CS**	139 (42.6%)	15 (34.9%)	0.21
• **Abortion**	108 (33.1%)	17 (39.5%)	0.25
• **Stillbirth**	5 (1.5%)	0	0.53
• **Ectopic pregnancy**	1 (0.30%)	2 (4.7%)	0.30
Medical comorbidities			0.28
• **None**	296 (90.8%)	41 (95.3%)	
• **Diabetes mellitus**	12 (3.7%)	0	
• **Hypertension**	4 (1.2%)	2 (4.7%)	
• **Obesity**	5 (1.5%)	0	
• **Cardiac diseases**	2 (0.60%)	0	
• **Others**	7 (2.1%)	0	
Gestational age (week)	37.93 ± 1.32	38.05 ± 1.21	0.59
AFI (cm)	14.15 ± 4.84	13.16 ± 3.73	0.19
Umbilical cord ring	3 ± 1.31	2.84 ± 1.21	0.44
UC length (cm)	62.98 ± 12.22	63.52 ± 15.11	0.79
UC index	3.54 ± 1.20	3.38 ± 1.22	0.40
Neck loops	83 (25.5%)	19 (44.2%)	0.01
True knots	20 (6.1%)	2 (4.7%)	0.51

Data expressed as mean ± SD or frequency (%). CS: cesarean section; GA: gestational age; AFI: amniotic fluid index; UC: umbilical cord. P value was significant if < 0.05.

There was no significant difference in the UC length and UC index between the women who had meconium-stained syndrome, placental separation, or cord prolapse, (**Table 5).**

Table.5. Characteristics of studied women based on different UC problems

Variables	Meconium-stained syndrome	Placental separation	Cord prolapses	P value
UC length	66.38 ± 14.73	55.20 ± 12.05	59.50 ± 12.12	0.42
UC index	3.41 ± 1.17	2.70 ± 1.09	4 ± 1.73	0.28

Data expressed as mean ± SD. UC: umbilical cord. P value was significant if < 0.05.

Discussion

While intermittent cord obstruction has been linked to intrauterine brain damage, complete cord occlusion frequently results in fetal death. Fetal discomfort is significantly influenced by uterine compression and vasospasm. A thorough inspection of the UC frequently reveals substantial lesions that may be related to these processes. As obstetricians, we are aware of this when cord problems severely shorten fetal life **(Balkawade and Shinde, 2012)**.

According to estimates, UC problems account for 10% or more of intrauterine mortality in the USA and are linked to clinically severe placental disease **(Baergen et al., 2001)**. The likelihood of unfavorable outcomes for the mother and the newborn linked with placental and cord anomalies has recently gained more attention **(Vintzileos et al., 2015; Ebbing et al., 2017; Ebbing et al., 2013)**.

In case studies, excessively long cords have been linked to chord tangles, emergency births, fetal mortality, placental fetal thrombotic vasculopathy, and an increased probability of neurological problems **(Weiner et al., 2015; Taweevisit and Thorner, 2010)**. Fetal abnormalities, fetal discomfort, and possibly placental abruption have all been linked to a short chord **(Olaya-C and Bernal, 2015; Georgiadis et al., 2014; Krakowiak et al., 2004)**. Despite the fact that anomalous cord lengths are associated with poor outcomes, there is a lack of population-based research and reference ranges, and studies rarely establish normal cord lengths. **(Weiner et al., 2015; Krakowiak et al., 2004)**.

It is not unusual for there to be concerns about fetal distress or a fetus that fails to descend appropriately during labor. Such intrapartum problems frequently go unexplained. This mystery could be explained by complications related to long or short UC. A delay in the second stage of labor, an erratic fetal heart rate, a ruptured UC, an inverted uterus, birth hypoxia, and cord herniation have all been linked to too-short cords. Unexpected difficulties during birth are linked to very lengthy UC, including cord prolapse, torsion, and real knot entanglement around the fetus. Fetal discomfort, fetal abnormalities, and respiratory distress are all on the rise **(Balkawade and Shinde, 2012)**.

Our research stated that the mean age of enrolled women was 27.50 years, ranging between 18 and 48 years old. The parity range was between 0 and 8 times, with a median number of three times. A history of CS and abortion was found in 154 (41.7%) and 125 (33.9%) women, respectively. Five women had a history of stillbirth, and another three women had a history of ectopic pregnancy. The majority (91.3%) of women had no medical risk factors. Meanwhile, 12 (3.3%) and 6 (1.6%) women were diabetic and hypertensive, respectively. Five women were obese, and another seven women had other comorbidities. The mean gestational age was 37.95 weeks, the mean AFI was 14.04 cm, the mean UC ring was 2.98 cm, the mean UC length was 63.04 cm, and the mean UC index was 3.52.

A similar study was conducted by Balkawade and Shinde **(Balkawade and Shinde, 2012)** to research the relationship between fetal characteristics and UC length. Study of fetal outcome using the 1- and 5-minute Apgar scores. The length of the cord ranged from 24 to 124 cm. The average length of the cord was slightly greater than that found in our research (63.86 15.69 cm). The group with chord lengths between 51 and 60 cm (27.4%) had the highest percentage of instances. Sahin et al. **(Sahin et al., 2019b)** carried out similar research to identify the occurrence of both long and short UC preceding delivery in full-term, uncomplicated pregnancies. A novel technique was used to assess UC lengths by ultrasonography, and the results were compared to postnatal UC lengths. The corresponding mean indices for normal, short, and long UC were 5.36, 2.96, and 6.98, respectively.

Abbas et al. (2021) carried out a similar investigation to see whether the sonographic assessment of the UC length index could accurately predict UC lengths and subsequent birth problems. By counting the UC rings in each quadrant of the amniotic fluid, the sonographic assessment

of the UC length indices was computed. The UC lengths were determined in cm after the fetus was delivered using a flexible measuring tape. Any UC anomalies, such as neck loops and true knots, were noticed at delivery.

Our study reported that up to 27.6% of the studied women had neck loops and true knots, compared to 22 (6%). A total of 43 (11.7%) women developed different forms of UC problems. The most frequently reported UC problem was meconium-stained syndrome (10%), while five women had placental separation and another four women developed cord prolapse. Apgar score (1 min) was 9.14 ± 1.42 and (5 min) was 9.98 ± 0.21. Balkawade and Shinde **(Balkawade and Shinde, 2012)** reported that Nuchal coiling had been observed in 207 instances (20.7%) of the total. The frequency of nuchal coiling is 36 instances (67.9%) in cases with a long chord, 1.7% in instances with a short cord, and 19.1% in instances with normal cord lengths. According to Abbas et al. **(Abbas et al., 2021)**, ten instances (3.3%) had short UCs, and their mean UC length indices were 1.9±0.51. There were 269 normal UC instances (89.7%). They have a 3.27±1.07 mean UC length index. There were 21 (7%) long UC instances, and the mean UC length index was 5.09±0.86.

Our study reported that cesarean sections were done in 164 (44.4%) women either secondary to previous CS (42.3%), breech presentation (1.2%), gestational DM (0.60%), PROM (0.30%), or post-date (0.30%). Neonatal resuscitation was required in 107 (29%) neonates, while only four neonates were admitted to the NICU. Abbas et al. **(Abbas et al., 2021)** reported that 264 instances (88%) had been delivered by CS, whereas 36 instances (12%) had been delivered vaginally.

According to **Balkawade and Shinde, (2012)**, patients with cord problems had a higher prevalence of surgical interference. CS was carried out for every instance of cord prolapse. A Chi-square test was used to determine the significance, and it revealed that it was statistically significant ($p < 0.05$).

Our study reported that both groups of women, based on the occurrence of UC problems, had insignificant differences in their characteristics ($p > 0.05$). Also, both groups had insignificant variations as regards UC length ($p = 0.40$). Meanwhile, the frequency of neck loops was substantially greater among women with UC problems ($p = 0.01$). There were insignificant differences between different UC problems as regards UC length ($p = 0.42$) and UC index ($p = 0.28$). Similar to our findings, Atalla et al. **(Atalla et al., 1998)** discovered no connection between the UC indices and intrapartum FHR slowdowns, meconium staining of the amniotic fluid, or delivery method. Balkawade and Shinde's results vary from ours. According to **Balkawade and Shinde, 2012)**, the mean chord length was 60.37 ± 15.69 in instances without nuchal cords and 77.24 ± 15.71 in instances with nuchal cords. The mean chord length was longer in UC with nuchal cords than it was in instances without nuchal cords. The Z test was used to determine significance, and the results were very significant ($p < 0.001$).

In contrast to what we found, Abbas et al. **(Abbas et al., 2021)** observed that neonates with lengthy UC had considerably higher rates of neck loops and true knots—11 (52.3%) and 6 (20.6%) instances, respectively ($P = 0.001$). Placental separation, however, was noticeably more common in patients with short UC (2/20%) ($P<0.001$). Additionally, **Sarwono et al., 1991)** demonstrated that the risk of problems rose linearly with the length of the cord. In addition, Rayburn et al. **(Rayburn et al., 1981)** and Greenhill **(Greenhill, 1962)**

showed a statistically significant ($p < 0.001$) correlation of complications of the cord with a rise in the length of the cord (i.e., long cords). Also, Sahin et al. **(Sahin et al., 2019b)** reported that a novel ultrasonographic technique called UC length index calculation might be utilized for predicting both long and short UC throughout routine amniotic fluid assessment in full-term pregnancies.

Limitations: It is a single center study, no comparable group was included. Investigation of a limited number of complications No diagnostic test analysis was done on the UC length or UC length index to predict complications.

Conclusion

There were insignificant differences between different UC problems as regards UC length and UC index. Neck loops were the only parameter that was statistically significantly associated with UC problems.

Financial support and sponsorship: Nil

Conflict of Interest: Nil

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