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STUDY CONNECTIVE RELATION BETWEEN NATAL CORD COILS MEASURED BY ULTRASONIC WAVES IN (COMPLETE PREGNANCY) AND THE PREGNANCY RESULTS

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ABSTRACT

Background: The purpose of this study was to evaluate the prognostic significance of sonographic measurement of the umbilical coiling index in term pregnancy & it's a relation to pregnancy outcome. **Objectives:** This study was designed to measure the umbilical coiling index antenatally in term pregnancy (prior to the onset of uterine contractions) for a group of pregnant women and clarify the relationship between the umbilical coiling index and perinatal outcomes. **Study design**: a cross-sectional study. **Methods**: This study included (100) cases of pregnant women with uncomplicated, term, singleton pregnancies (free of labor pain), and all participants were examined by color Doppler ultrasound, during which umbilical cord cross-sectional area, umbilical vessels cross-sectional area, and umbilical coiling index were calculated and compared with Doppler parameters including umbilical vein blood flow volume, umbilical vein peak systolic velocity and umbilical artery pulsatility index. The ultrasound findings were correlated with intrapartum and neonatal outcomes. The Doppler parameters divided according to the umbilical cord cross-sectional area while regarding the perinatal outcomes, the studied sample divided into three groups according to umbilical coiling index values (hypercoiled, hypocoiled & normocoiled umbilical cord). **Results:** Our study revealed that: The cross-sectional area of the umbilical cord was below the 10^{th} percentile in 14% of fetuses. Birth weight and placental weight were in the lower limits in fetuses with the lean umbilical cord. Most of the umbilical cord parameters measured by ultrasound were of lower values in fetuses with the lean umbilical cord. Results of measurement of the umbilical coiling index showed that in 15% of fetuses, the umbilical coiling index was below normal values and in 9% of fetuses, the umbilical coiling index was above normal values and abnormal values of the umbilical coiling index were associated with adverse perinatal outcomes. There is a weak negative correlation between the umbilical coiling index and the neonatal birth weight and a moderate positive correlation between the umbilical vein blood flow volume and umbilical cord cross-sectional area.

KEYWORDS: Natal cord coils, ultrasonic waves, complete pregnancy, the pregnancy results.

INTRODUCTION

The umbilical cord also referred to as *Funiculus umbilicalis*or birth cord, might be, the only organ of the fetus that dies after the birth.[1] It contains usually two umbilical arteries and one umbilical vein, through which the fetal heart pumps blood to and from the placenta, in which supply of oxygen, exchange of nutrient and waste materials with the circulatory system of the mother takes place.[2] The UC has been considered as an important & huge source of information, useful to assess the well – being of the fetus & the outcome of pregnancy.[3]

For several decades, the morphological & morphometric aspects of the UC have been studied & retrospectively correlated with the perinatal outcome by pathologists after delivery. The advent of U/S has increased our knowledge & added a dynamic form of information in particular on the development of the fetus & it's supporting structures such as the placenta & the UC.[4]

However, an increasing clinical & experimental evidence shows that both prenatal morphology & morphometry of the UC & it's vessels may help in understanding the physiology of development as well as adaptive processes of the fetoplacental unit to pathologic insults.[5]

We have learned that the UC is not an inert structure which is suspended between the fetus & placenta but is actively involved in important processes, such as fetal growth restriction, preeclampsia, diabetes, stillbirth & chromosomal defects or genetic syndromes.[6]

An understanding of the embryology, anatomy & physiology of the umbilical cord, especially the vein, may lead to more comprehensive ultrasound imaging, heighten appreciation of the importance of this structure & encourage further research into this critical blood conduit.

Background

The primitive umbilical ring is the junction between amnion and embryonic ectoderm.[4] At the fifth week of development, structures passing through this ring are the connecting stalk containing allantois and umbilical vessels, yolk sac (vitelline duct) with vitelline vessels and the canal connecting intro and extraembryonic cavities.[4] Extra-embryonic mesoderm grows towards the center to form the chorionic cavity, a place which is occupied by the proper yolk sac.[4] During the development, the yolk sac rotates towards the implantation site.[4] The embryo then folds into the amniotic cavity.[4] Subsequent expansion of the amniotic cavity occurs at the expense of the chorionic cavity. Later amnion envelops the connecting stalk and yolk sac stalk together and that forms the primitive umbilical cord. During early development, 13-40 days post conception umbilical cord forms at the site of the connecting stalk, which joins the extraembryonic mesoderm to the embryonic disc.[5] Proximally the primitive umbilical cord also contains some intestinal loops. By the end of the third-month amnion has expanded in such a way that it comes in contact with chorion, obliterating chorionic cavity. The yolk sac shrinks and gets obliterated.[5] As the development progresses, the connecting stalk containing allantois, vitelline duct, and the umbilical vessels gets smaller in diameter and increases in length.[5] Later allantois and vitelline duct are obliterated. Umbilical vessels remain at the end of the development, which is surrounded by the Wharton's jelly.[6] There are two umbilical arteries, formed from two embryonic allantoic arteries. Initially, there are two allantoic veins but as the development progresses, within the first two months, the right allantoic vein disappears and only left forms the umbilical vein.[6]

Umbilical cord anatomy

In a cross-section of the umbilical cord (Figure No. 4), which showed a white colored surface and two umbilical arteries and one vein attached to the vascular architecture of the placenta.[3]

These vessels are supported on the exterior by a protective gelatinous connective tissue known as Wharton's jelly, which consists of myofibroblasts and ground substance made largely from mucopolysaccharides, which protect the blood vessels inside.[7] There are no nerves or lymphatic vessels in the umbilical cord.[8] This combination of loose gel and contractile cells gives the umbilical cord tensile strength and umbilical vessels are protected against any pressure or compression.[8]

It contains one vein, which carries oxygenated, nutrient-rich blood to the fetus, and two arteries that carry deoxygenated, nutrient-depleted blood away.[8]

In some cases, one of the umbilical arteries may undergo atresia, aplasia or agenesis resulting in a single umbilical artery, with the left umbilical artery being absent more frequently.[9]

A single umbilical artery may be associated with aneuploidy fetus, or with intrauterine growth restriction and renal anomalies in euploid fetuses.[6]

Located within 3cm of the cord insertion into the placental surface, there is a 1.5-2cm long shunt between the umbilical arteries, termed the Hyrtl anastomosis.[10]

The functions of the Hyrtl anastomosis are to equalize pressure between the umbilical arteries before they enter the placenta & to act as a safety valve in case of placental compression or blockage of an umbilical artery.[8]

In most cases the umbilical arteries twist over the vein, however, in 4.2% of cases the vein may twist around straight or hypocoiled arteries.[2]

It is unusual for a vein to carry oxygenated blood and for arteries to carry deoxygenated blood (the only other examples being the pulmonary veins and arteries, connecting the lungs to the heart). However, this naming convention reflects the fact that the umbilical vein carries blood towards the fetus's heart, while the umbilical arteries carry blood away.[9]

The blood flow through the umbilical cord is approximately 35 ml/min at 20 weeks, and 240 ml/min at 40 weeks of gestation.[10] Adapted to the weight of the fetus, this corresponds to 115 ml/min/ kg at 20 weeks and 64 ml/min/ kg at 40 weeks.[10]

The umbilical arteries do not have an internal elastic lamina and the media of the artery is composed of peripherally arranged spiral muscles, while the adventitia found in other arteries is replaced by mucous connective tissue. The umbilical vein does have an elastic lamina and a thickened muscular layer with intermingling circular, longitudinal & oblique smooth muscle fibers.[3] Therefore, during the antenatal period, the protective elements for any umbilical cord are amniotic fluid, Wharton’s jelly and the helical coiling of the umbilical vessels.[11]

MECHANISMS OF BLOOD FLOW IN THE UMBILICAL VEIN

The placenta provides a large volume of blood awaiting transportation to the fetus. "The quantity of the blood flowing from the fetus to the placenta very nearly equals that flowing from the placenta to the fetus " & as such the fetus can be considered a closed system.[12]

Movement of oxygenated blood from the placenta to the fetus occurs by the following methods:

1) The umbilical cord vein pressure increases from 4.5mmHg at 18 weeks gestation to 6 mmHg at term & the blood pressure distending the umbilical vein is higher than that in the fetal IVC.[13] This gradient is due to at least two mechanisms :

a) Normal fetal heart contractions producing a pressure gradient between the atria & ventricles, which in turn diminishes the preload in the venous circulation & allows the blood in the umbilical vein to move towards the heart.[14]

b) Changes in abdominal & thoracic cavity pressures due to fetal breathing movements causing a pressure gradient between the umbilical vein & the ductus venous such that there is an increase in the velocity of the blood in the umbilical vein during inspiration.[12]

2) Passive pressure changes in the umbilical cord vein due to longitudinal distortion of the arteries with each fetal heartbeat. The pressure peaks in the umbilical cord artery & vein are out of phase by 180 degree which results in the addition of the effect of numerous, small pressure changes along the length of the cord & the subsequent movement of blood through the umbilical cord vein.[15]

UMBILICAL CORD LENGTH

The factors that affect and decide the length of the umbilical cord are still not well understood. Nevertheless, the available evidence suggests that; fetal movement producing the tensile force on the umbilical cord and genetic factors play an important role in deciding the length of the cord.[9]

Ideally, the measured length of the cord should include the part that attached with the placenta as well as the measurement of the part attached to the baby. As that the latter’s length can be variable depending on the condition of the baby on delivery, its length taken only on the part attached to the placenta will not be a true measurement of the cord.[11]

Throughout the entire pregnancy, the total length of UC is increased, & particularly, in the later period of pregnancy, the length of UC becomes longer every month by approximately 3-6 cm.[10]

Conditions restricting fetal movements such as skeletal dysplasia, amniotic bands, oligohydramnios, multiple pregnancies, uterine malformation usually have a short cord[12], that may lead to placental abruption, cord rupture & delayed fetal descent.

Excessively long cords are associated with fetal entanglement, true knots, thrombi, cord prolapse & looping of the cord around the fetal neck.[12]

The tensile strength of the cord is directly proportional to the birth weight of the baby by approximately 2.5 times.[9]

Despite the fact that the length of the human's umbilical cord is variable, yet it normally ranged from (50 to 60 cm) at the neonatal age 35 weeks or older.[7]

Umbilical cord diameter

The umbilical cord diameter depends upon the number of vessels present, size of the umbilical vein and the fluid content of Wharton's jelly.[7] By what, factors determining the amount of water content in Wharton's jelly are not clearly understood.[7] The normal cord diameter is 1-2 cm and the cord can be edematous in clinical situations such as maternal diabetes mellitus, hydrops& twin to twin transfusion syndrome.[7] Fetal outcomes are better with increased jelly in the cord, while cords with reduced Wharton's jelly are more prone to compression and abnormal fetal heart rate pattern, an absence of Wharton's jelly around umbilical vessels have been reported to be associated with perinatal death.[8]

The diameter of the umbilical vein increases from 4.1mm at 20 weeks to 8.3 mm at 38 weeks of gestation.[10]

There is an increase in the cross-sectional area of the umbilical vein from 28mm at 24 weeks to a maximum of approximately 58 mm between 34-38 week, followed by a slight decline from the 39 the week.[9]

The area of the umbilical vein is approximately 30% larger than the combined areas of the arteries & as such the velocity in the vein is approximately half the velocity in either artery, with the velocity in the umbilical vein ranging from 10-22 cm/s.[10]

The diameter of umbilical arteries increases from 1.2+0.4mm at 16 weeks to 4.2+0.4mm at the term of gestation.[9]

The decline in cord diameter towards term is attributed to a reduction in the water content of Wharton's jelly.[8]

Experimental & clinical evidence suggest that Wharton's jelly play's a metabolically active role throughout pregnancy. The collagen fibrillar network of the Wharton's jelly, studied by scanning electron microscopy, shows the presence of a wide system of interconnected cavities consisting of canalicular – like structures as well as cavernous & perivascular spaces.[12]

This system of cavities may have an important role in facilitating a bidirectional transfer of water & metabolites between amniotic fluid & umbilical cord vessels through the Wharton's jelly.[12]

Modifications in the amount & composition of Wharton's jelly have been described in a number of pathological conditions, usually associated with a modification of the amniotic fluid volume & composition, occurring in pregnancy (i.e. hypertensive disorders, gestational diabetes).[11]

The reduction of the amount of Wharton's jelly may be the consequences of either extracellular dehydration or a reduction in extracellular matrix component.[10]

The sonographic cross-sectional area of Wharton's jelly can be computed by subtracting the vessels area from the cross-sectional area of UC.[14]

LEAN UMBILICAL CORD

"Thin cord is a dangerous cord & fat cord is a safe cord"

Pathologic studies & case reports demonstrated that a lean UC is associated with adverse pregnancy outcome, oligohydramnios & fetal distress.[16]

There is an association between the presence of a lean cord & the delivery of small for gestational age infant. Patients with a lean UC after 20 weeks of gestation had 4.4-fold higher risk of having small for gestational age infant than those with a normal UC.[17]

Wharton's jelly appears to serve the function of adventitia, which the UC lacks, binding & encasing the umbilical vessels. It has been speculated that the cells of Wharton's jelly appear to possess contractility comparable to that of smooth muscle cells & participate in the regulation of umbilical blood flow & that, at least in some cases, the reduction in fetal growth could be the consequence of Wharton's jelly decrease leading to hypoplasia of umbilical vessels.[18]

In fact, a reduction of wall thickness of umbilical cord arteries & vein has been found in intrauterine growth retardation (IUGR) infants with abnormal umbilical artery flow when compared to IUGR infants without increased umbilical artery resistance.[19]

Cumulative evidence suggests that an umbilical cord less than 10th centile for gestational age is a simple & early marker for small for gestational age infants & the occurrence of intrapartum complication.[17]

LARGE UMBILICAL CORD

Several reports have described a large UC associated with other fetal structural anomalies, such as UC tumor, urachal cysts, UC mucoid degeneration &omphalomesenteric cyst.[20] Generally, in these conditions, the morphology is altered in a limited portion of the UC.

However, a consistent association between an ultrasonographic large UC & the presence of a gestational diabetes mellitus has been reported. A large UC can be considered as an additional parameter useful to identify fetuses of a mother with some kind of glucose intolerance during pregnancy.[21]

Fetuses of patients with gestational diabetes have a large UC & this is mainly due to a higher content of Wharton's jelly. An alteration in the distribution of Wharton's jelly fibers with large empty spaces among them could be caused by an abnormal accumulation of fluid & plasma proteins within the Wharton's jelly, resulting in an increased permeability & hemorrhage due to increased oncotic pressure in the interstitial spaces of the Wharton's jelly.[22] This modification can be observed at 24 weeks, suggesting that the involvement of the UC in fetuses of diabetic mothers is a phenomenon that occurs early in pregnancy.

A sonographic large UC can be used in addition to estimated fetal weight (EFW) as a further marker that may facilitate the detection of fetal overgrowth, potentially improving the performance of U/S based policies for the management of suspected macrosomia.[23]

Umbilical Cord Coiling

The umbilical cord is a vital structure necessary for the survival of the fetus and also a fascinating structure that has caught the attention of obstetricians and pathologists. The most interesting feature of the umbilical cord is the degree to which the umbilical cord vessels exhibit a helical pattern or coiling within the Wharton’s jelly.[13] The origin, as well as the factors which influence the direction and the number of coiling within the Wharton’s jelly, is still subjects of interest to study.[14] However, the assumptions are that fetal movements, differential umbilical vascular growth rate, fetal hemodynamic forces, and directional arrangements of muscle fibers within the arterial wall may be the key determinants.[14] Many studies show the crucial role played by the chemical composition of the Wharton's jelly in cord coiling, especially the role of a compound called hyaluronan that aids the growth of the umbilical vessels & subsequent coiling.[26]

Umbilical cord coiling is observed by about 10 weeks of gestation and as a result, matches with the growth of umbilical cord. This, in essence, means that coiling develops in the presence of a high ratio of amniotic fluid volume to fetal size and hence the fetus achieves coiling by rotating with respect to the implanted placenta.[15] The coiled geometry of the UC largely affects umbilical blood flow that is vital for fetus's well- being & normal development.[27]

The results showed that the driving pressure for a given blood flow rate is increasing as the number of choices in cord structure increases.[15] The coiled structure is resulting in interwoven streamlines along the helix and wall shear stresses (WSS) with significant spatial gradients along the cross-sectional perimeter anywhere within the helical coil.[27] These gradients may have an adverse effect on the development of the fetus's cardiovascular system in cases with over coiling or under coiling characteristics, when the coils are more spread, the maximal WSS is significantly smaller.[28] Cases with twisted & overcoiled cords seem to yield very large values & gradients of WSS, which may place the fetus into high risk of abnormal development.[25]

The umbilical cord coiling together with Wharton's jelly is thought to provide mechanical support to the umbilical cord vessels which are otherwise more prone to kinking, compression, traction and torsion.[16]

The umbilical cord coiling is quantitatively assessed by the umbilical cord index, defined as the number of complete coils per the total length of the umbilical cord measured in centimeters.[17] By this definition, several studies have been consistent in reporting a normal UCI of about 0.2 in postpartum when the placenta and the umbilical cord are examined, and 0.4 when the examination is performed antenatally by sonography. At term, the normal umbilical cord vessels complete an average of 10 – 11 coils for the length of the umbilical cord inserted between the fetus and placenta.[18] In comparing abnormal and normal umbilical cord coiling at 10th and 90th percentiles for umbilical coil index[19], an abnormal umbilical cord coiling, described as hypo-coiled (under coiled) and hyper-coiled (over coiled) which are objectively classified as below the 10th percentile and above the 90th percentile respectively, exhibits a strong association with adverse fetal outcomes, like IUD, preterm labor, fetal distress, nuchal cord & fetal thrombotic vasculopathy.[17] Therefore early detection of abnormal cord coiling is an alert threshold of a potential cause of adverse fetal outcome at any future time of gestation.[15] In their study, the researchers observed that abnormal coiling occurred in most of the cases of fetal demise which could have been impossible to explain.[15,18,19]

AIM OF THE STUDY

1) To measure UCI antenatally using color Doppler ultrasound during 3rd trimester (prior to the onset of uterine contractions)

2) To evaluate antenatal UCI as a predictor of adverse pregnancy outcomes.

Patients and methods

Study design and settings

This cross-sectional study was conducted in the Obstetrics and Gynecology department at Al-Yarmouk Teaching Hospital in the period from 1st of February 2014 to 1st of February 2015.

The study sample

In this study, a total of 100 pregnant women with the uncomplicated, term (37 weeks completed) singleton pregnancies were selected in this prospective observational study prior to the onset of uterine contractions (free of labor pain).

Exclusion criteria

Pregnant women who had been excluded were those with:-

1. Complicated pregnancy (Diabetes mellitus, hypertensive disorders, renal diseases, ischemic heart diseases etc…).
2. Multiple pregnancies.
3. Preterm labor.
4. Any detectable structural fetal anomaly
5. Two vessels umbilical cord.
6. Amniotic fluid index <5cm or > 25 cm.
7. Delivery at another institution.

Methods and data collection

- Informed consents were taken from the patients and the study was approved by the Scientific Council of Obstetrics & Gynecology of the Iraqi Board.
- Full history obtained from each patient including demographic details (name, age, and occupation), history regarding her recent pregnancy (GA was calculated), past obstetrical history, past surgical and medical history, social and drug history.
- General physical, abdominal and pelvic examinations have been performed.

All patients were examined by colored Doppler ultrasound (by the same person) using the medical system (GE healthcare, Austria GmbH & CoOG, Voluson E6) equipped with convex probe 3.5 MHz transducers, and the following data were collected: fetal bi-parietal diameter, head, and abdominal circumferences, as well as femoral length, were measured.

Operational definitions

Placental weight: below 450 (gm) was considered below the 10th percentile (for term pregnancy)[28], (measured after cutting of the umbilical cord).

Birth weight: it was divided into three categories according to their weight for gestational age at delivery [**<2500**(intra-uterine growth restriction), **2500-4000** and **>4000**] grams.[45]

Apgar score: for the 1st minute all neonates with a score <4 considered abnormal and needed resuscitation, while in the 5th minutes the score <7 considered abnormal.[46]

Statistical analysis

Each pregnant patient assigned a serial identification number. The data were reviewed, cleaned with double check entry into the computer using Statistical Package for Social Sciences (SPSS) version 20; then, it was coded by the researcher under the supervision of the academic supervisor and a consultant statistician.

- The continuous variables were presented as mean, standard deviation.
- The categorical variables were presented by (frequency and percentages in tables).
- Pearson's Chi-square test was used to assess the statistical association between categorical data.
- Independent t-test was used to assess the difference between the continuous variables.
- Pearson's correlation: a test was used to asses the correlation between the antenatal umbilical coiling index and fetal birth weight, also between antenatal umbilical cord cross-sectional area and it's vein blood flow volume.

A level of p-value less than 0.05 was significant

RESULTS

In the present study; Ultrasound examination was done for 100 participant women, it was shown that the cross-sectional area of the fetal umbilical cord at term was below the 10^{th} percentile or called as lean in 14% of them, and the other has a normal cross-section. As shown in figure 10.

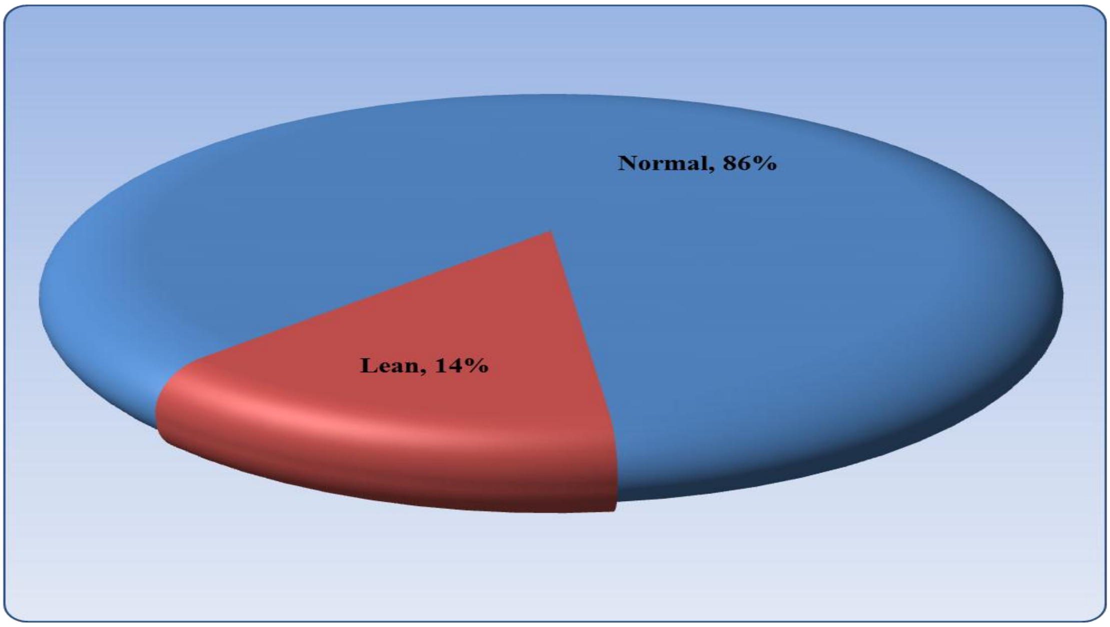

Figure 10: Prevalence of lean umbilical cord (<10^{th} percentile of it cross-section at term) in pregnant women, n=100.

Neither maternal nor gestational age of the pregnant women did show a statistically significant difference between normal and lean umbilical cord groups. As shown in (table 1).

Table 1: Differences of maternal and gestational age between normal and lean umbilical cord in pregnant women, n=100.

Variables	Normal umbilical cord (n=86) Mean±(SD)	Lean umbilical cord (n=14) Mean±(SD)	p-value[a]
Maternal age (years)	30.7±(5.1)	31±(4.3)	0.41 (NS)
Gestational age (weeks)	38.9±(1.6)	39.1±(2.9)	0.43 (NS)

[a] Independent t-test, NS=not significant at $\alpha \geq 0.05$.

Both neonates and their placentas of the normal antenatal umbilical cord patients were shown to be significantly heavier than those of lean umbilical cord, (p=0.008 and p=0.02) respectively. As shown in (table 2).

Table 2: Differences of birth and placental weight between normal and lean umbilical cord in pregnant women, n=100.

Variables	Normal umbilical cord (n=86) Mean±(SD)	Lean umbilical cord (n=14) Mean±(SD)	p-value[a]
Birth weight (gm)	3420±(516)	2996±(492)	0.008*
Placental weight (gm)	593±(135)	504±(118)	0.02*

[a] Independent t-test, *Significant at α (<0.05).

Concerning the comparison of the umbilical cord parameters between the normal and lean umbilical cord groups:

It was found that no statistically significant differences were revealed for cross-sectional area and the Pulsatility index of the umbilical artery.

Meanwhile, the umbilical coiling index for the normal group was significantly higher compared to that in the lean group (**p<0.001**).

The umbilical cord, and umbilical vein cross-sectional areas, as well as Wharton's jelly area, were shown to be significantly smaller in those with lean umbilical cord compared to normal with (**p<0.001**) for each.

Also, it was found that Umbilical vein blood flow volume and peak systolic velocity were significantly higher among the normal group (**p<0.001 and p=0.012**) respectively. As shown in (table 3).

Table 3: Differences of antenatal umbilical cord parameters according to their cross-sectional area, n=100.

Variables	Normal umbilical cord (n=86) Mean±(SD)	Lean umbilical cord (n=14) Mean±(SD)	p-value[a]
Antenatal coiling index	0.39±(0.08)	0.19±(0.09)	<0.001*
Cord cross-sectional area (mm^2)	204±(31.6)	86.5±(11.1)	<0.001*
Artery cross-sectional area (mm^2)	16.4±(5.2)	14.3±(5.6)	0.2(NS)
Vein cross-sectional area (mm^2)	50.5±(20.1)	33.4±(9.6)	<0.001*
Wharton's jelly area (mm^2)	135.1±(31.4)	36.3±(10.1)	<0.001*
UV blood flow volume (ml/min / Kg)	129.1±(19.7)	85.3±(16.9)	<0.001*
UV peak systolic velocity in cm/s	12±(2.6)	8.9±(3.9)	0.012*
Pulsatility index	0.78±(0.13)	0.79±(0.09)	0.72 (NS)

[a] Independent t-test; *significant at α <0.05, NS=not significant at $\alpha \geq$ 0.05.

Figure 11; shows the differences in the average of antenatal umbilical coiling indices between normal cross-sectional umbilical cord group (0.39) and lean group (0.19), this difference was shown to be highly statistically significant (**p<0.001**).

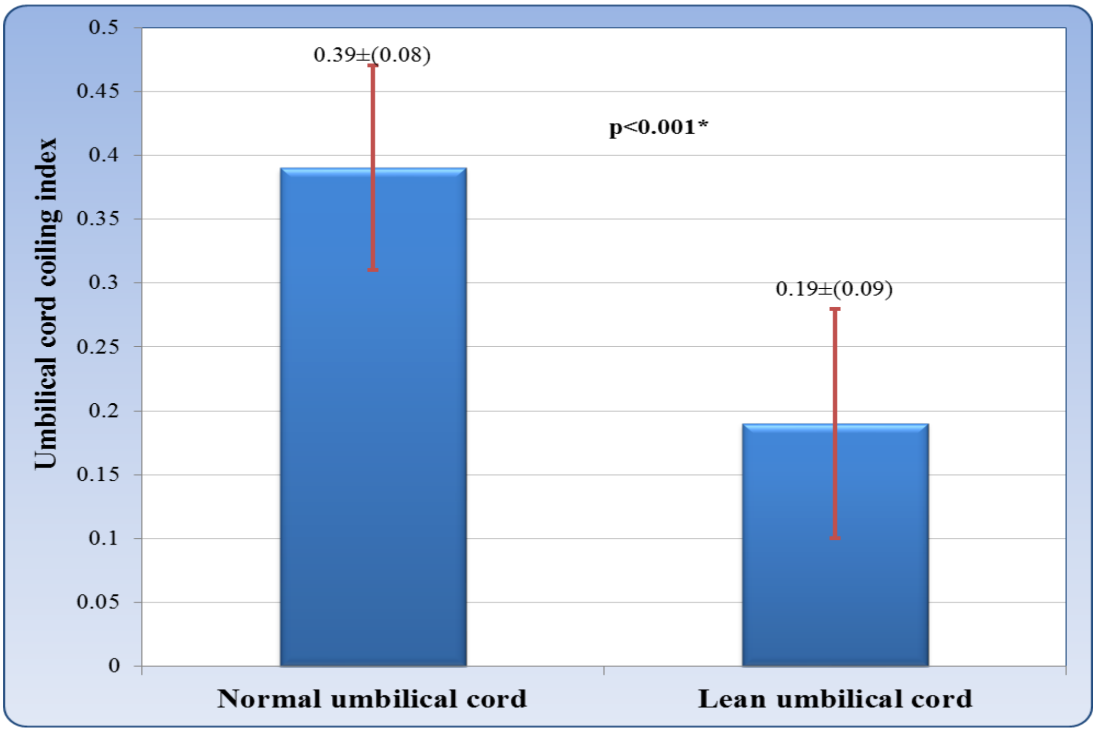

Figure 11: Comparison of Umbilical cord coiling index according to UC cross-sectional area, n=100.

In the consideration of umbilical cord coiling index as a comparison parameter; the results showed that more than three fourths of the examined umbilical cords at term (76%) were normal (between 10^{th} – 90^{th} percentile), while (15%) of them were Hypocoiled (<10^{th} percentile) and only (9%) of them were Hypercoiled (>90^{th} percentile). As shown in figure 12.

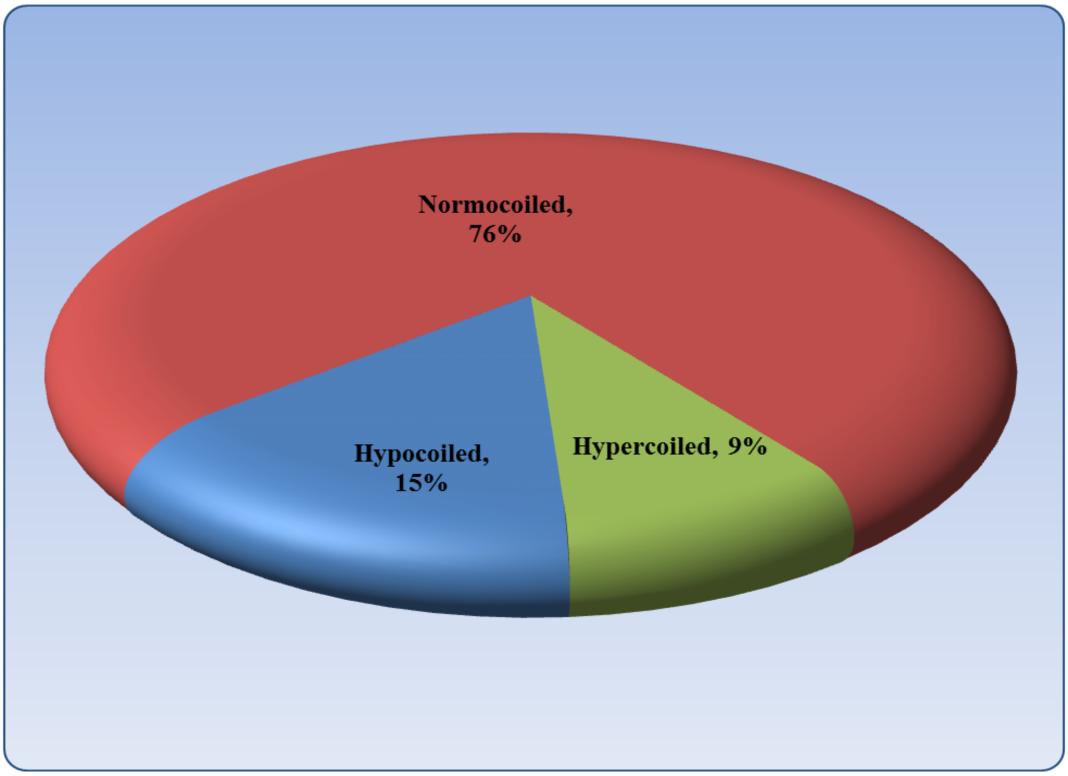

Figure 12: Distribution of the cases according to antenatal umbilical coiling index categories measured by ultrasonography, n=100.

Regarding the umbilical cord coiling index and its association with perinatal events, the results showed the following:

One third (33.3%) of Hypercoiled and (40%) of Hypocoiled cord neonates delivered with their amniotic fluid stained with meconium compared to only (9.2%) of those with Normcoiled cord, which means that meconium staining of the amniotic fluid is significantly associated with the abnormal values of UCI(**p=0.004**).

While all (100%) of those with Hypercoiled UC and (60%) of those with Hypocoiled UC delivered by cesarean section compared to (46.1%) of those with Normcoiled UC, which means that delivery by C/S is significantly associated with hyper & hypo- coiled UC groups(**p=0.008**).

Concerning the birth weight and its association with the coiling index, it was found that the majority of Normcoiled group (90.8%) were in the normal range while one third of Hypercoiled and one fifth of Hypocoiled groups were below 2500 gram (<10^{th} percentile of weight in term or IUGR) which means that low birth weight is significantly associated with the abnormal patterns of UC coiling (**p=0.023**).

Fetal heart rate abnormalities were also found to be significantly associated with hyper and hypocoiled umbilical cords (**p=0.029**).

The placental weight of one third (33.3%) of Hypercoiled group and (26.7%) of Hypocoiled group was below the 10^{th} percentile for their gestational age at term compared to only (7.9%) of Normcoiled group, this difference was statistically significant (**p=0.023**), which means that there is an association between the low placental weight and the abnormal values of UCI.

The first minute Apgar score failed to show a statistically significant association with the abnormal umbilical coiling index categories; in contrast to the fifth minute score which show a statistically significant association with the abnormal modalities of umbilical coiling, as (33.3% and 22.2%) of neonates with Hypocoiled and hypercoiled umbilical cords respectively were had low score compared to only (9.2%) of those with Normcoiled umbilical cord.

(44.4%) of Hypercoiledand & (40%) of Hypocoiled UC groups were admitted to NICU compared to only (13.2%) of Normcoiled group, so admission to the Neonatal intensive care unit was found to be significantly associated with the abnormal values of UCI(**p=0.009**). as shown in (table 4).

Table 4: Comparison of perinatal events according to antenatal umbilical coiling index categories measured by ultrasonography, n=100.

Variables	Hypocoiled (n=15) No. (%)	Normcoiled (n=76) No. (%)	Hypercoiled (n=9) No. (%)	p-value[¥]
Meconium stained amniotic fluid				
Yes (n=16)	6 (40.0)	7 (9.2)	3 (33.3)	0.004*
No (n=84)	9 (60.0)	69 (90.8)	6 (66.7)	
Mode of delivery				
NVD (n=47)	6 (40.0)	41 (53.9)	0 (0.0)	0.008*
CS (n=53)	9 (60.0)	35 (46.1)	9 (100.0)	
Fetal heart rate				

Abnormal (n=8)	3(20.0)	3(3.9)	2(22.2)	0.029*
Normal (n=92)	12(80.0)	73(96.1)	7(77.8)	
Birth weight (gm)				
<2500 (n=12)	3 (20.0)	6 (7.9)	3 (33.3)	
2500-4000 (n=85)	10 (66.7)	69 (89.5)	6 (66.7)	0.023*
>4000 (n=3)	2 (13.3)	1 (2.6)	0 (0.0)	
Placental weight (gm)				
<450 (n=13)	4(26.7)	6(7.9)	3(33.3)	0.023*
≥450 (n=87)	11(73.3)	70(92.1)	6(66.7)	
APGAR score 1st minute				
<4 (n=14)	5 (33.3)	8 (10.5)	1 (11.1)	0.065 (NS)
≥4 (n=86)	10 (66.7)	68 (89.5)	8 (88.9)	
APGAR score 5th minute				
<7 (n=14)	5 (33.3)	7 (9.2)	2 (22.2)	0.04*
≥7 (n=86)	10 (66.7)	69 (90.8)	7 (77.8)	
Neonatal intensive care unit admission				
Yes (n=20)	6 (40.0)	10 (13.2)	4 (44.4)	0.009*
No (n=80)	9 (60.0)	66 (86.8)	5 (55.6)	

¥ Pearson's chi-square test, NVD= normal vaginal delivery, CS= caesarean section, *significant at α <0.05, NS=not significant at α >0.05.

DISCUSSION

The umbilical cord is the major feto-maternal unit that provides communication between the placenta and the fetus. However, it is a part of the fetal anatomy and may be prone to compression, tension, or torsion, with subsequent interruption of blood flow.[45] It is thought that coiling provides a protective effect to these forces, therefore securing uninterrupted blood supply to the fetus. The true etiology of umbilical coiling is unclear, but it is thought to result from the fetal movement as well as unequal vascular growth.[46]

In the present study;we found that 14% of the participated pregnant women have lean umbilical cord, which was higher than what was founded by Di-Naro et al,[28] in the study that carried out in Italy 2001, as only 10.3% of the studied sample had lean umbilical cord and another study from Switzerland which was conducted by Raio et al[37] in 2003, who reported that lean umbilical cord was prevalent among 11.2% of the study participants; meanwhile it was 15.5% in a study conducted at 2011 in Egypt by El-Behery et al.[41]

The results of our study revealed that neither maternal age nor gestational age at the delivery showed a significant correlation with the UC area, which was in agreement with a previous study carried out in Italy[28] among 116 pregnant women in 2001, and a study that conducted in Switzerland 2003byRaio et al[37], among 252 patients, and another study that conducted by-Behery et al[41], in Egypt at 2011 among 280 pregnant women, all these studies reach to the similar results.

Our study also showed that the risk of low birthweight and low placental weight were inversely correlated with UC cross-sectional area; this was in the same line with studies from Italy[28], India[50], Iran[47] and Egypt.[41]

CONCLUSIONS

For antenatal assessment of umbilical cord parameters and its effects on the perinatal outcomes:

- The parameters of the umbilical cord were significantly lower in patients with the lean umbilical cord.
- The abnormal umbilical coiling index categories were shown to be significantly associated with most of the adverse perinatal outcomes; like (Meconium stained liquor, emergency cesarean section delivery, low birth weight, fetal heart rate abnormalities, low Apgar score at 5th min. and neonatal admission to NICU).
- The antenatal umbilical coiling index was shown to decrease with an increment of fetal weight.
- The cross-sectional area of the umbilical cord directly correlated with the blood flow volume of the umbilical vein.

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