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THE ULTRASONIC WAVE'S TECHNOLOGY IN (COMPLETE PREGNANCY) OF PREGNANT WOMEN

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ABSTRACT

Background: It is usually attached near the center of the placenta, from where the umbilical vessels ramify under the amnion and pass into the placenta[3], but it may be eccentric or marginal **Objectives:** This study was designed to measure the umbilical coiling index antenatally in term pregnancy the ultrasonic wave's technology in (complete pregnancy) of pregnant women. **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. **Results:** Our study revealed that: 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.

KEYWORDS: The ultrasonic wave's technology, complete pregnancy.

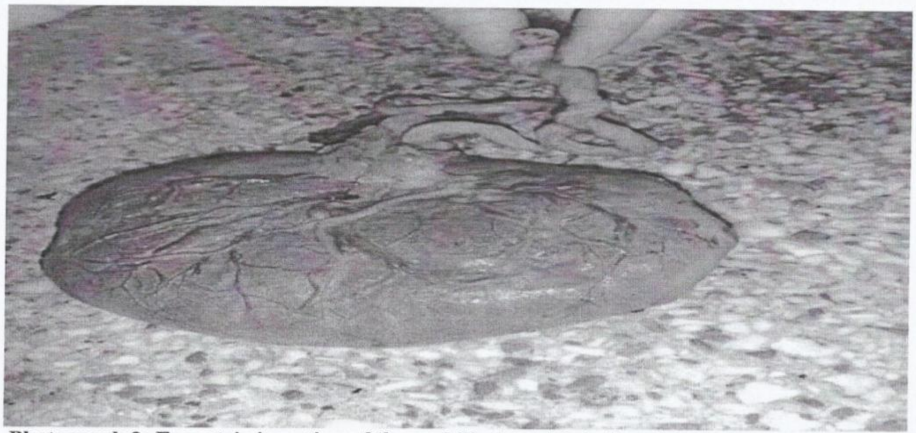
INTRODUCTION

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

It is usually attached near the center of the placenta, from where the umbilical vessels ramify under the amnion and pass into the placenta[3], but it may be eccentric or marginal. (As shown in figures 1, 2 & 3).



Photograph 2: Eccentric insertion of the umbilical cord into the placenta.

Photograph 3: Marginal insertion of the umbilical cord into the placenta.

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 3-6cm.[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 10-22cm/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]

Umbilical Cord Coiling Index

The coiling property of cord vessels was described as early as in 1521 by Berengarius.

Umbilical cord coiling was first described in terms of the number of coils in 1954 by Edmonds[22] as “The index of Twist”. The coiling pattern was described as negative for anti-clockwise and positive for clockwise coiling. Later studies[23] defined coiling as the term “The Umbilical coiling Index” (UCI). UCI was determined by so-called Strong’s formula by dividing the total number of complete umbilical vascular coils by the umbilical cord length (in centimeters), UCI was reported as 0.21 ± 0.07 coils/cm, there being at least one coil in every 5[24] centimeters of the cord. Therefore hypo-coiling of the umbilical cord will be defined as UCI below the 10th percentile (i.e. less than 0.1), while hyper-coiling as UCI above 90th percentile (i.e. more than 0.3).[24] (As shown in figure 4).

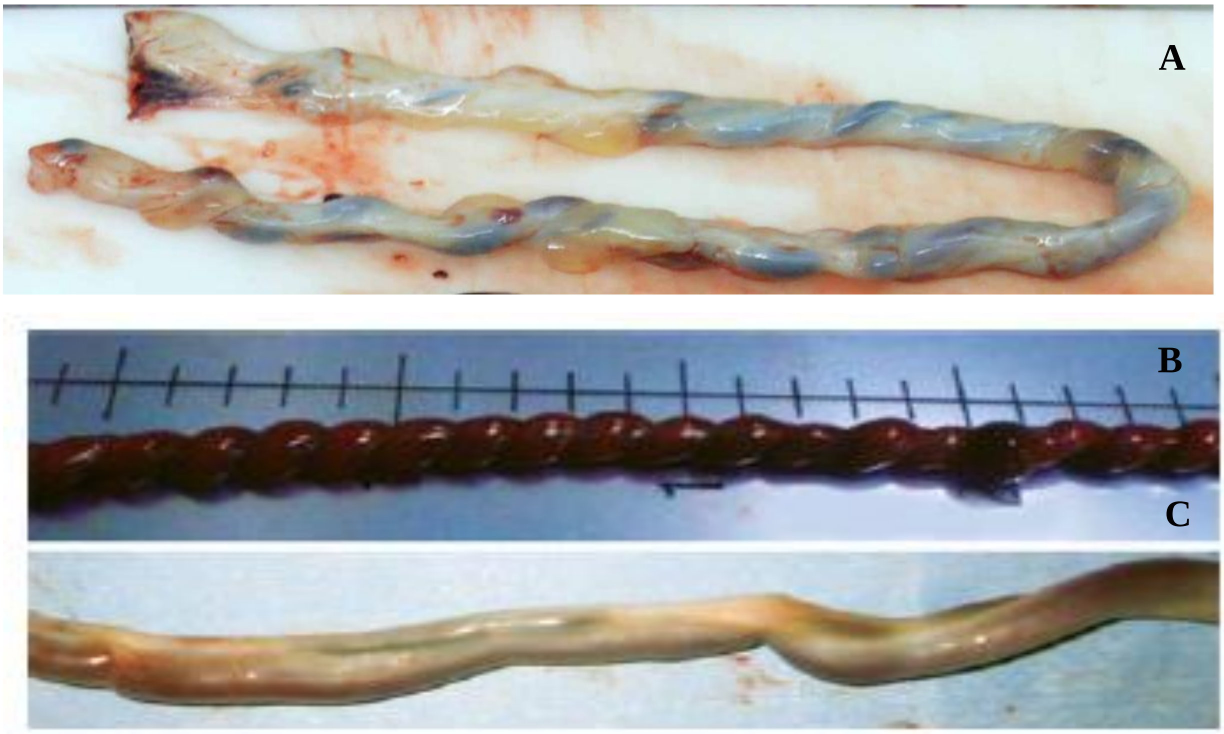


Figure 5: Coiling of the umbilical cord (a) Normal coiling (b) Hyper-coiling (c) Hypo-coiling.[25]

Coiling is also described as either anti-clockwise (left) or clockwise (right) & a mixed pattern of coiling may also be seen. The helices or frequently termed "spirals" of the UC are (anticlockwise) dextral in approximately 90% of cases & sinistral in the remaining.[19] To define the direction of coils, the umbilical cord is placed vertically and vessels on the anterior surface of the cord are noted; if the direction is towards the left hand of the observer, it is noted as left-sided coiling and right-sided if it directed towards observer's right hand.[20]

In 2%-5% of the UC, there is no coiling at all, & this seems to put the fetus at increased risk of adverse outcomes such as stillbirth, fetal growth retardation, oligohydramnios, meconium-stained amniotic fluid, low Apgar scors & intrapartum fetal distress.[21]

Antenatal Assessment of Cord Coiling Index

The umbilical cord can be studied sonographically for various prenatal abnormalities or possible pathologies. Apart from traditional antenatal assessment of the umbilical cord, which includes only the number of blood vessels in the umbilical cord and Doppler assessment of the umbilical arteries, further detailed assessment can be done prenatally, such as the amount of Wharton's jelly, diameter of umbilical vessels, coiling pattern and coiling index.[14,27]

UCI can be calculated for the cord either at the fetal end, placental end or the central part. There is more coiling towards the fetal end as compared to the placental end[29], therefore UCI will be increasing as we move from the placental end to the fetal end. In studies, the UCI has been measured at the placental end at the umbilical cord insertion, or the fetal end near the umbilical cord entrance into the fetal abdomen and in the middle of these two to obtain the true UCI.[14]

To assess the UCI prenatally, in a longitudinal image of the umbilical cord, a pair of coils is identified and the distance between the coils is measured and UCI is calculated. The sonographic UCI is defined as the reciprocal of the distance between two coiles & it represents the number of vascular coils in a given cord.[16] (As shown in fig. 7).

According to the umbilical coiling pattern the UC can be classified as:

1. Normal.
2. Uncoiled (two straight umbilical arteries with an umbilical coiling angle equal to zero).
3. Hypocoiled, if the UCI is below the 10th percentile for gestational age.
4. Hypercoiled, if the UCI is above the 90th percentile for gestational age.
5. Atypical coiling: a) Uncoordinated coiling or bizarre, or a periodic coiling pattern, in which the absence of a repetitive pattern does not allow the measurement of the UCI. b) Supercoiling, in the presence of a spring spatial configuration of the UC.

Reynolds' hypothesis, according to which the umbilical coils serve as a peristaltic pump mechanism enhancing the venous return to the fetus, has been advocated by several authors to explain how abnormal coiling could influence the perinatal outcome.[17]

In particular, a high frequency of uncoiled & hypocoiled cords has been reported in IUGR & maternal hypertensive disorders.[29]

The alterations of venous blood flow can be detected earlier than arteries. The umbilical vein area & the umbilical vein blood flow are significantly reduced in IUGR compared to normally grown fetuses.[31] The discrepancy in the umbilical vein size might represent an adaptive response to venous overload on the one hand & chronic hypovolemia on the other hand.[32]

Supercoiling can be associated with pathologic fetal intra-abdominal process & may be explained by a relative increase in resistance at the level of the umbilical ring, which in turn induces venous congestion of the extra-abdominal umbilical vein.[31]

Coiling of the umbilical cord is fully developed by the end of the first trimester and it does not change after this except that the length of the cord keeps getting bigger in between the coils.[30]

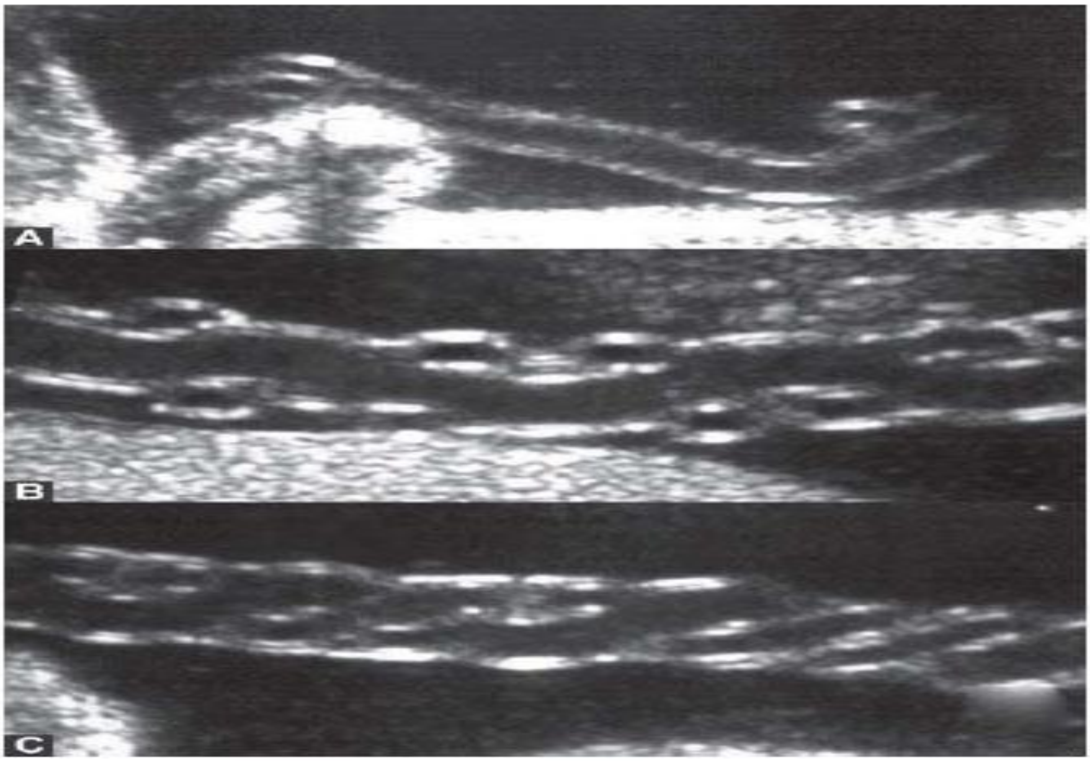


Fig. 6: An ultrasound demonstration of umbilical cord coiling patterns. The umbilical cord has different coiling patterns based on the frequency of the umbilical twists; from hypo-coiled or under-coiled (A) normal-coiled (B) to hyper-coiled or over-coiled umbilical cords (C).[36]

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 10th percentile or called as lean in 14% of them, and the other has a normal cross section.

Table 1: 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 2).

Table 2: 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 α ≥ 0.05.

Figure 7; 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**).

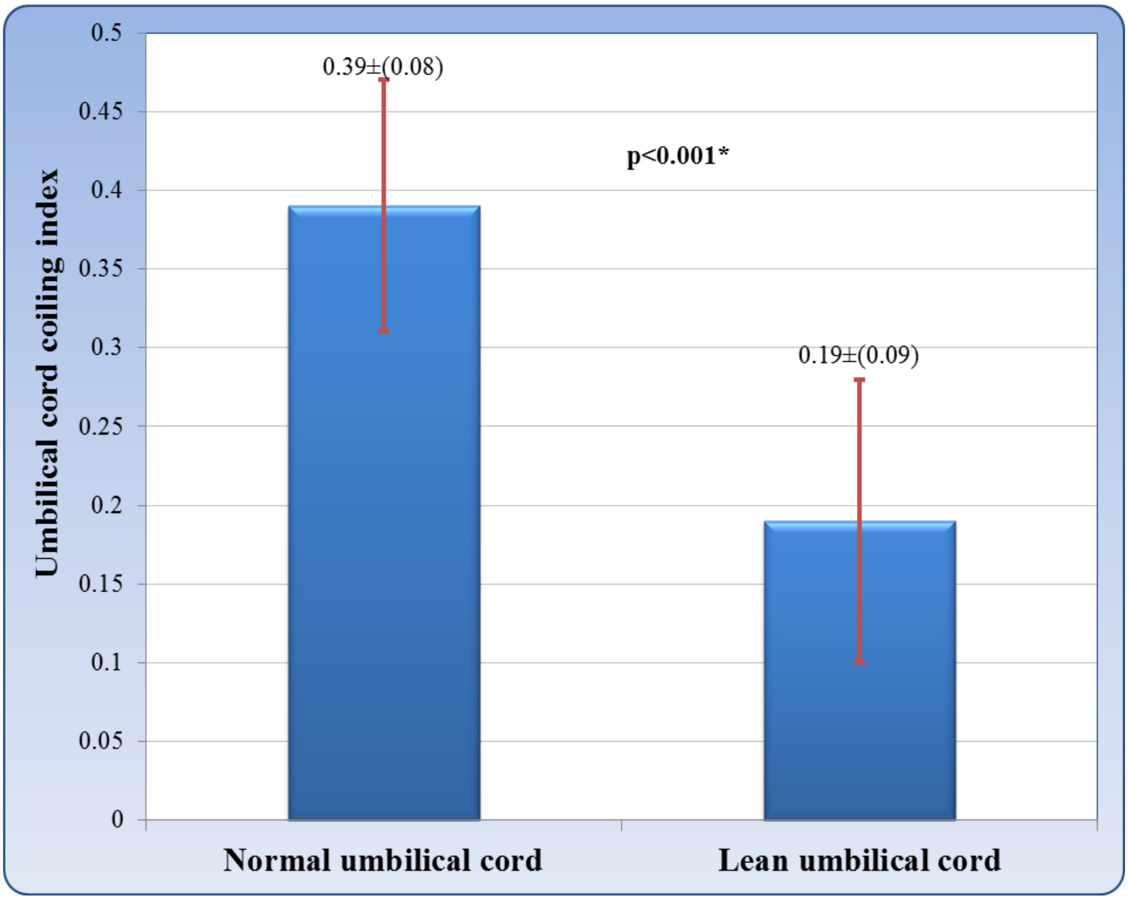


Figure 7: Comparison of Umbilical cord coiling index according to UC cross-sectional area, n=100.

DISCUSSION

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]

The results of our study revealed that thinner or leaner UC was significantly associated with decreased UC coiling, UC cross-sectional area, amount of Wharton's Jelly & UV blood flow volume, which was in concordance with studies from Italy[28], Switzerland[37] and Egypt.[41], while in another study that carried out in Ghana 2012 by Doctor Samuel Bimpong among 266 pregnant women where the results showed that all the parameters of the umbilical cord were not significantly different between the normal and lean umbilical cord[44], this might be resulted from differences in the race, genetics, sample size, ultrasound equipment sensitivity or the setting of the studies.

The incidence of hypocoiled UC is usually higher in fetuses with a lean cord suggesting that the high proportion of vascular hypocoiling in lean UC is not an occasional finding but could be the consequences of an altered expression of genes responsible for the production of the structural constituent of the UC vessel walls & of the Wharton's Jelly (e.g., Elstin, collagen & hyaluronic acid).[41]

Otsubo et al[51], noted that hypocoiled cord was highly associated with abnormal cord insertion. Predanic et al[43], stated that increased UC coiling could have a protective effect on blood flow in term of decreased arterial resistance & higher blood flow velocities as well as increased venous blood flow.

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