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EVALUATION OF PREDICTIVE ABILITY FOR THE INDICATOR OF NATAL CORD COILS OF THE PREGNANT WOMEN

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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. **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: The cross-sectional area of the umbilical cord was below the 10th 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.

KEYWORDS: Evaluation, of predictive ability, natal cord coils, pregnant women.

INTRODUCTION

The umbilical cord also referred to as Funiculus umbilicalisor 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]

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]

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 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]

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]

Umbilical cord anatomy

In a cross-section of the umbilical cord (Figure No. 1), which showed a white colored surface and two umbilical arteries and one vein attached to the vascular architecture of the placenta.[3]

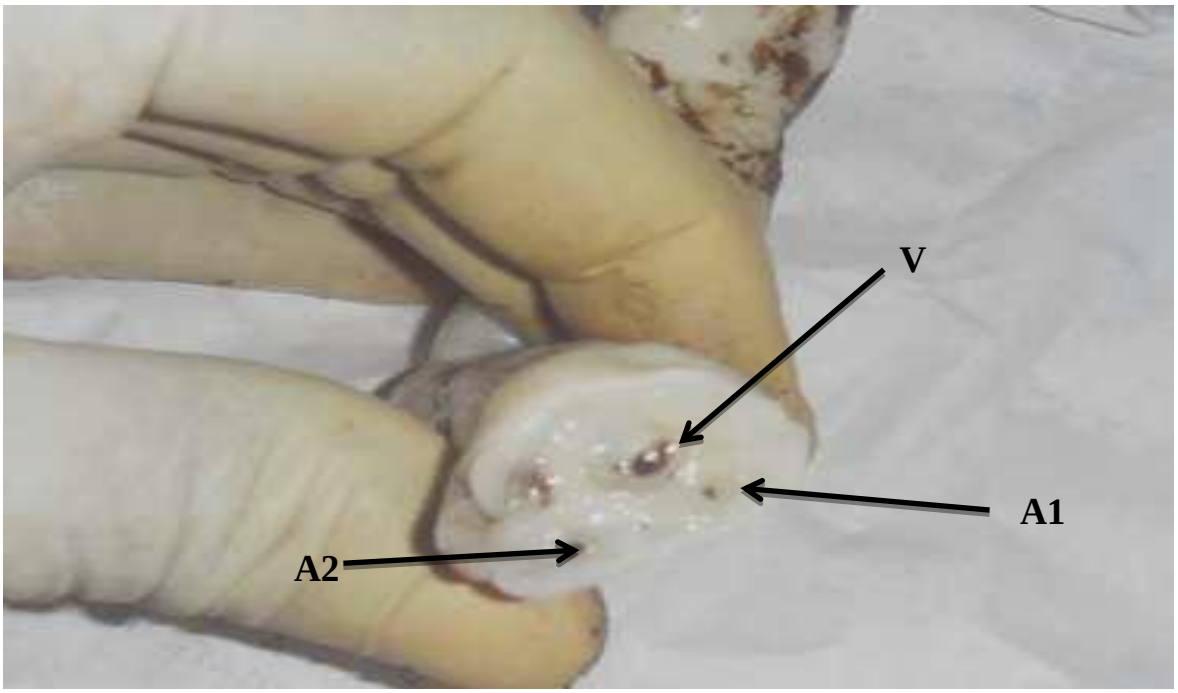

Figure 1: Cross-section of the umbilical cord showing its three vessels. (V=umbilical vein, A1=umbilical artery and A2=second umbilical artery), (3)

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] (As shown in figure 2).

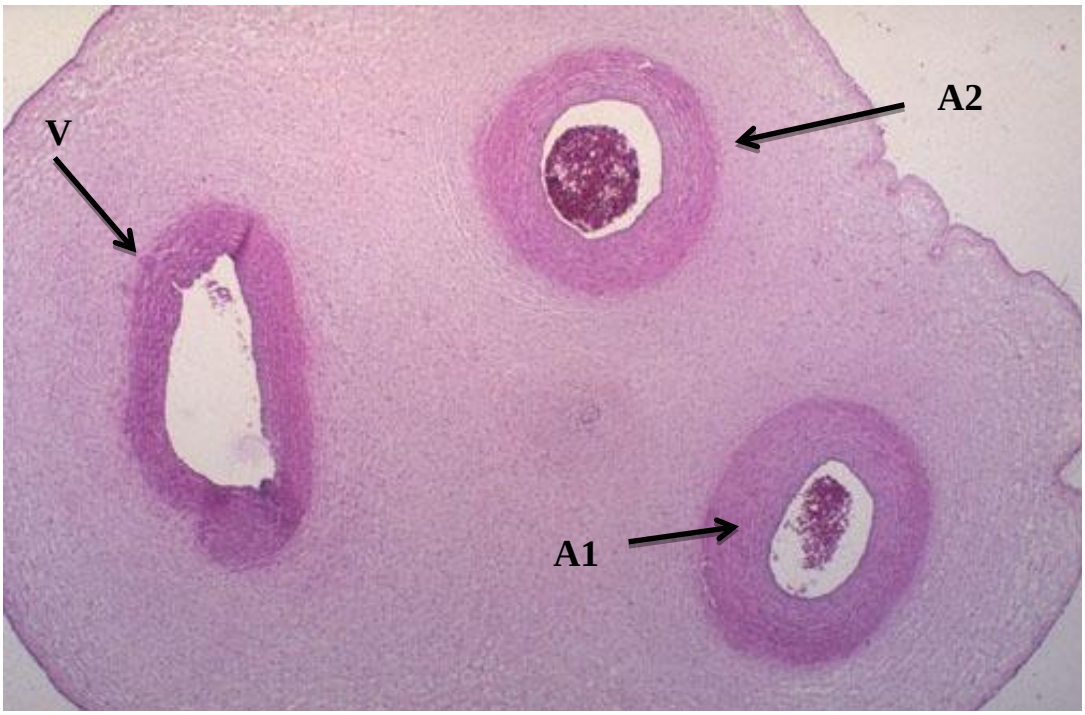

Figure 2: Histological view (H & E stain) of a normal 3 vessel view of the umbilical cord (V=umbilical vein, A1=umbilical artery and A2=second umbilical artery)[11].

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. As shown in figure 3.

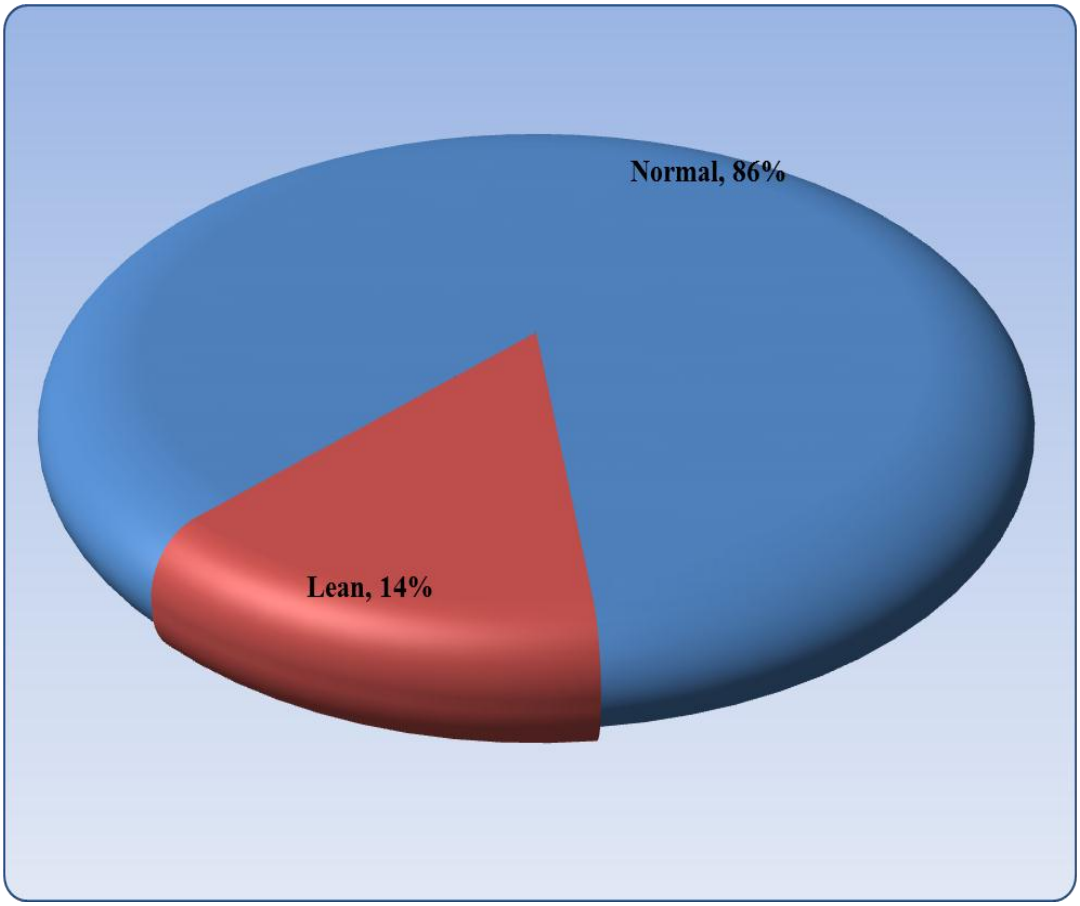

Figure 3: Prevalence of lean umbilical cord (<10th percentile of it cross-section at term) in pregnant women, n=100.

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 $\alpha \geq 0.05$.

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]

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