



Sudan University of Science and Technology

College of Graduate Studies



Estimation Of Gestational Age By Umbilical Cord Width Using Ultrasoundography

**تقدير عمر الجنين بقياس عرض الحبل السرى باستخدام الموجات فوق
الصوتية**

*A thesis Submitted for partial fulfillment of requirements
of MSC degree in medical diagnostic ultrasound*

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2016

بِسْمِ اللَّهِ الرَّحْمَنِ الرَّحِيمِ

الآية

قال تعالى:

الرَّحْمَنُ ﴿١﴾ عَلَّمَ الْقُرْآنَ ﴿٢﴾ خَلَقَ الْإِنْسَانَ ﴿٣﴾ عَلَّمَهُ الْبَيَانَ ﴿٤﴾

صدق الله العظيم

سورة الرحمن الآية (1-4)

Dedication

I dedicate this work to my family:

Mama, sisters, son, brothers, to my friends

&

To whom I love so much, I convey this work.

Acknowledgement

I would like to thank **Dr.AfraSiddig Hassan Omer** for her help, supervising and encouragement during my research.

Special thanks to staff in altamiozhospitalCenter for their help in completing this work in success.

ABSTRACT

This is descriptive cross sectional study using statistical Package for Social Science was conducted at Altamuz teaching hospital and obstetric and gynecological hospital. Elhasahisa city. The main objective of this study is to determine the gestational age by ultrasound measurement of umbilical cord width in the second and third trimester of pregnancy .

A total of 50 pregnant ladies in their second and third trimester were enrolled to ultrasound measurement of umbilical cord width , also bipariatal diameter and femur length, during period from July-August 2016, it was possible to obtain certain last menstrual period for all participants to assess the gestational age. Written informed consent was taken for all participants. In assessing the gestational age by umbilical cord width by ultrasound , from one to three days were omitted and from four to six days were considered a week.

The umbilical cord width were measured in millimeters and the width were compared to standard difference values .The study show strong correlation between umbilical cord width and average GA(60%) and with the last menstrual period(57%) ,also study show strong relation of BPD &FL in relation with average GA by 83% & 91% respectively.

ملخص الدراسة

هذه دراسة عرضية وصفية باستخدام برنامج الحزم الإحصائية للعلوم الاجتماعية (SPSS). أجريت الدراسة في مستشفى التميز التعليمي ومستشفى الحصاحيصا للنساء والتوليد

الهدف الرئيس من هذه الدراسة هو تحديد عمر الجنين عن طريق قياس الموجات فوق الصوتية لعرض الحبل السري في الثلث الثاني والثالث من الحمل الدراسة اجريت عن طريق اخذ مقطع عرضي وصفى للحبل السري اجريت الدراسة على 50 سيدة في الثلث الثاني والثالث بقياس الموجات فوق الصوتية لعرض الحبل السري وأيضا قطر راس الجنين وطول عظم الفخذ، في الفترة من يوليو حتى اغسطس للعام 2016 تم تسجيل تاريخ آخر دورة شهرية لجميع المشاركات للتقييم تم اخذ الموافقة المسبقة من جميع السيدات لتقييم عمر الحمل عن طريق عرض الحبل السري بواسطة الموجات فوق الصوتية ، من يوم إلى ثلاث أيام حذفت ومن اربعة الى ستة يام تعتبر كاسبوع .تمت مقارنة الزيادة في عرض الحبل السري مع زيادة العمر عن طريق تاريخ اخر دورة شهرية وكانت النسبة 57% وقورن ايضا عرض الحبل السري مع متوسط العمر لقطر راس الجنين وطول عظم الفخذ وكانت النسبة 60% ووجدت ايضا علاقة خطية قوية بين زيادة قطر راس الجنين وطول عظم الفخذ مع زيادة العمر بنسب 91% و 83% على التوالي.

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List Abbreviation

AC	Abdominal circumference
AVG	Average
BPD	By parietal diameter
FL	Femoral length
GA	Gestational Age
HC	Head circumference
LMP	Last menstrual period
MM	Millimeters
SPSS	Statistical package for social sciences
UCA	Umbilical cord area
UCD	Umbilical cord diameter
UCW	Umbilical cord width
US	Ultra sound
WKS	Weeks

Chapter One

1.1 Introduction:

The umbilical cord is an intra-amniotic structure, is fixed between the placenta on one side and the fetus umbilicus on the other side. Usually consists of two arteries and a single vein contained within a meshwork of connective tissue bundles, elastic fibers, mesenchymal cells mast cells and glycol saminoglycans (wartons jelly). (foxH1978)

The length of umbilical cord varies from no cord (achordia) to as long as 300 cm, with diameter up to 3 cm. Umbilical cords are helical in nature, an average umbilical cord is 55 cm long, with diameter of 1-2 cm and 11 helices. About 5% of cords are shorter than 35 cm and another 5% are longer than 80cm (StefosT.et al2003)

Causes of differences in cord lengths are unknown; however the length of the cord is thought to reflect movement of the fetus in utero. Short cords are associated with fetal movement disorders and intrauterine constraint, as well as placenta abruption, oligohydranniosand cord rupture. Excessively long cords are associated with fetal entanglement, true knots, prolapsed and thrombi. (Heifetz SA1996)

Straight cords with few or absent helices have been associated with adverse fetal outcomes like increased rate of fetal mortality, preterm delivery and fetal heart deceleration on cardio-topography.(Heifetz SA1996)

In this study the researcher will focus in the width of the umbilical cord in free loops, cross section, by medical ultrasound in second and third trimester in

normal pregnancy to estimate the age of the fetus related to several methods of estimating the age e.g. LMP, BPD and FL.

1.2 Problem of the study:

LMP is ideal way to calculate the age. But sometimes cycle irregularity and unknown exactly date of LMP. So it is better to use more parameters to confirm the fetal age.

1.3 Objectives of the study

1.3.1 General objectives:

To estimate the fetal age using umbilical cord width (UCW).

1.3.2 Specific objectives:

- To determine the age of the fetus by measuring the umbilical cord width (UCW).
- To find the effect of maternal age and number of gravity on umbilical cord width(UCW).
- To test the significance of using umbilical cord width in determining the gestational age.
- To correlate the result of GA estimated by UCW with the average age estimated by BPD and FL.
- To correlate GA by LMP and umbilical cord width

1.4 Thesis outline:

This study is consists of five chapters chapter one which an introduction,ideal with problem and objectives of the study and this outline, chapter two presents literature review which include (anatomy, physiology, pathology and previous studies), chapter three deal with materials and methods .While chapter four deals with result and finally chapter five include discussion, conclusion and recommendation.

Chapter two

2.1 Anatomy and physiology:

In placental mammals, the umbilical cord (also called the navel string, birth cord or funiculus umbilicalis) is a conduit between the developing embryo or fetus and the placenta. During prenatal development, the umbilical cord is physiologically and genetically part of the fetus and, (in humans), normally contains two arteries (the umbilical arteries) and one vein (the umbilical vein), buried within Wharton's jelly. The umbilical vein supplies the fetus with oxygenated, nutrient -rich blood from the placenta. Conversely, the fetal heart pumps deoxygenated, nutrient-depleted blood through the umbilical arteries back to the placenta.(WhiteRP1989)

The umbilical cord develops from and contains remnants of the yolk sac and allantois (and is therefore derived from the zygote). It forms by the fifth week of fetal development, replacing the yolk sac as the source of nutrients for the fetus. The cord is not directly connected to the mother's circulatory system, but instead joins the placenta, which transfers materials to and from the mother's blood without allowing direct mixing. The length of the umbilical cord is approximately equal to the crown-rump length of the fetus throughout pregnancy. The umbilical cord in a full term neonate is usually about 50 centimeters (20 in) long and about 2 centimeters (0.75 in) in diameter. This diameter decreases rapidly within the placenta. The fully patent umbilical artery has two main layers: an outer layer consisting of circularly arranged smooth muscle cells and an inner layer which shows rather irregularly and loosely arranged cells embedded in abundant ground substance staining metachromatic. The smooth muscle cells of the layer are rather poorly

differentiated, contain only a few tiny myofilaments and are thereby unlikely to contribute actively to the process of postnatal closure.(White RP1989)

The umbilical cord contains Wharton's jelly, a gelatinous substance made largely from mucopolysaccharides which protect the blood vessels inside. It contains one vein, which carries oxygenated, nutrient-rich blood to the fetus, and two arteries that carry deoxygenated, nutrient-depleted blood away. Occasionally, only two vessels (one vein and one artery) are present in the umbilical cord. This is sometimes related to fetal abnormalities, but it may also occur without accompanying problems.

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(WhiteRP1989).

The blood flow through the umbilical cord is approximately 35 ml / min at 20 weeks, and 240 ml /min at 40 weeks of gestation. 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.(WhiteRP1989)

2.2Connection to fetal circulatory system:

The umbilical cord enters the fetus via the abdomen, at the point which (after separation) will become the umbilicus (or navel). Within the fetus, the umbilical vein continues towards the transverse fissure of the liver, where it splits into two. One of these branches joins with the hepatic portal vein (connecting to its left branch), which carries blood into the liver. The second branch (known as the ductusvenosus) bypasses the liver and flows into the inferior vena cava, which

carries blood towards the heart. The two umbilical arteries branch from the internal iliac arteries, and pass on either side of the urinary bladder into the umbilical cord, completing the circuit back to the placenta.(WhiteRP1989)

2.3Physiological postnatal occlusion:

In absence of external interventions, the umbilical cord occludes physiologically shortly after birth, explained both by a swelling and collapse of Wharton's jelly in response to a reduction in temperature and by vasoconstriction of the blood vessels by smooth muscle contraction. In effect, a natural clamp is created, halting the flow of blood. In air at 18 °C, this physiological clamping will take three minutes or less. In water birth, where the water temperature is close to body temperature, normal pulsation can be 5 minutes and longer.(WhiteRP1989).

Closure of the umbilical artery by vasoconstriction consists of multiple constrictions which increase in number and degree with time. There are segments of dilatations with trapped uncoagulated blood between the constrictions before complete occlusion. Both the partial constrictions and the ultimate closure are mainly produced by muscle cells of the outer circular layer. In contrast, the inner layer seems to serve. Mainly as a plastic tissue which can easily be shifted in an axial direction and then folded into the narrowing lumen to complete the closure. The vasoconstrictive occlusion appears to be mainly mediated by 5 hydroxytry- ptamine and thromboxane A₂. The artery in cords of preterm infants contracts more to angiotensin II and arachidonic acid and is more sensitive to oxytocin than in term ones. In contrast to the contribution of Wharton's jelly, cooling causes only temporary vasoconstriction.

Within the child, the umbilical vein and ductus venosus close up, and degenerate into fibrous remnants known as the round ligament of the liver and the ligamentum venosum respectively. Part of each umbilical artery closes up (degenerating into what are known as the medial umbilical ligaments), while the remaining sections are retained as part of the circulatory system

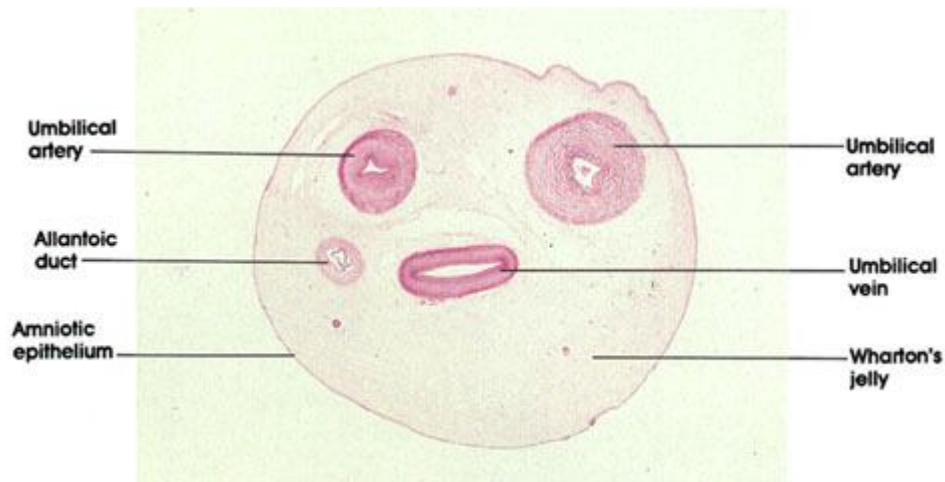


Figure (2.1) umbilical cord of three-minute-old child .A medical clamp was applied.

[Http://en.wikipedia.org/wiki/umbilical-cord#/media/File:umbilical_cord.jpg](http://en.wikipedia.org/wiki/umbilical-cord#/media/File:umbilical_cord.jpg)



Figure(2-2) Vaginal us show the embryo is surrounded by the thin membranes of the amniotic sac, the umbilical cord is seen in the center, attaching the embryo to the placenta.(https://en.mWikipedia.org/wiki/umbilical_cord8/7/2009)



Figure(2-3)Cross section of umbilical cord top right and left umbilical arteries, bottom: umbilical vein, middle allantoic duct..

(<https://en.m.wikipedia.org/wiki/umb>)

2.4 Pathology:

A number of abnormalities can affect the umbilical cord, which can cause problems that affect both mother and child:

2.4.1 Umbilical cord compression:

can result from, for example, entanglement of the cord, a knot in the cord, or a nuchal cord, (which is the wrapping of the umbilical cord around the fetal neck) but these conditions do not always cause obstruction of fetal circulation (predicet al 2005)

2.4.2 Nuchal cord:

A nuchal cord occurs when the umbilical cord becomes wrapped around the fetal neck 360 degrees. Nuchal cords are not very common, with prevalence rates of 6% to 37%. Up to half of nuchal cords resolve before delivery.

"Type A" nuchal cord is wrapped around the neck 360 degrees.

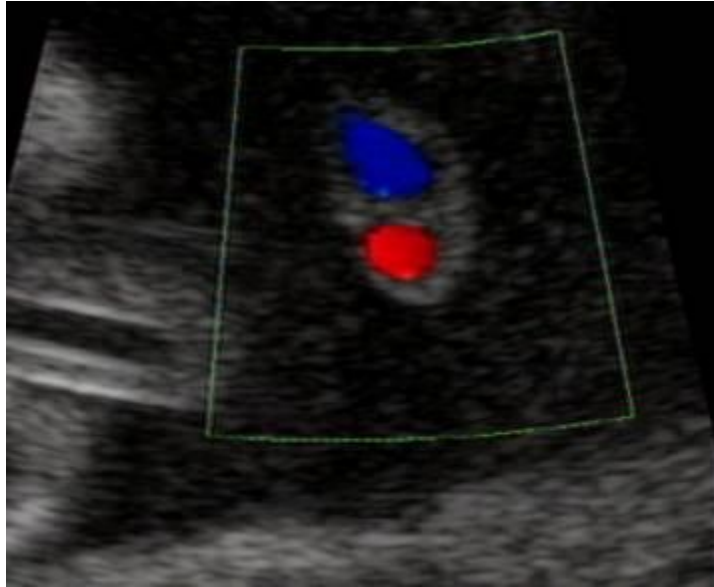
"Type B" pattern is described as a hitch which cannot be undone and ends up as a true knot.

2.4.3 Velamentous cord insertion:

is an abnormal condition during pregnancy . Normally, the umbilical cord inserts into the middle of the placenta as it develops. In velamentous cord insertion, the umbilical cord inserts into the fetal membranes (choriamniotic membranes), then travels within the membranes to the placenta (between the amnion and the chorion). The exposed vessels are not protected by Wharton's jelly and hence are vulnerable to rupture. Rupture is especially likely if the vessels are near the cervix, in which case they may rupture in early labor, likely resulting in a stillbirth . This is a serious condition called vasa previa . Not every pregnancy with a velamentous cord insertion results in vasa previa, only those in which the blood vessels are near the cervix. When a velamentous cord insertion is discovered, the obstetrician will monitor the pregnancy closely for the presence of vasa previa. If the blood vessels are near the cervix, the baby will be delivered via cesarean section as early as 35 weeks to prevent the mother from going into labor, which is associated with a high infant mortality. Early detection can reduce the need for emergency cesarean sections. (Hasegawa, j. et al 2006)

2.4.4 Single umbilical artery:

Occasionally, there is only the one single umbilical artery (SUA) present in the umbilical cord. Approximately this affects between 1 in 100 and 1 in 500 pregnancies, making it the most common umbilical abnormality. It is more common in multiple births. Its cause is not known.



Figure(2,4)Cross-section of umbilical cord with single artery

www.ultrasound-imag.com24/6/2001

Most cords have one vein and two arteries. The vein carries oxygenated blood from the placenta to the baby and the arteries carry deoxygenated blood from the baby to the placenta. In approximately 1% of pregnancies there are only two vessels usually a single vein and single artery. In about 75% of those cases, the baby is entirely normal and healthy and the missing artery isn't missed at all. One artery can support a pregnancy and does not necessarily indicate problems. For the other 25%, a 2-vessel cord is a sign that the baby has other abnormalities sometimes life-threatening and sometimes not. SUA does increase the risk of the baby having cardiac, skeletal, intestinal or renal problems. Babies with SUA may have a higher likelihood of having other congenital abnormalities, especially of the heart. However, additional testing (high level ultrasound scans) can rule out many of these abnormalities prior to birth and alleviate parental anxiety. Echocardiograms of the fetus may be advised to ensure the heart is functioning properly. Genetic counseling may be useful, too,

especially when weighing the pros and cons of more invasive procedures such as chorionic villus sampling and amniocentesis.(GeipeLA,et al 2000)

Although the presence of an SUA is a risk factor for additional complications, most fetuses with the condition will not experience other problems, either in utero or after birth. Especially encouraging are cases in which no other soft markers for congenital abnormalities are visible via ultrasound. Prior to ultrasound technology, the only method for determining the presence of a SUA was at birth, following an examination of the placenta. Given that the vast majority of expectant mothers do not receive the kind of advanced ultrasound scanning required to confirm SUA in utero, most cases may never be detected antenatally even today.(Geipe LA ,et al 2000)

Doctors and midwives often suggest parents take the added precaution of having regular growth scans near term to rule out intrauterine growth restriction, which can happen on occasion and warrant intervention. Yet the majority of growth restricted infants with the abnormality also have other defects. Finally, neonates with the finding may also have a higher occurrence of renal problems, therefore close examination of the infant may be warranted shortly after birth. Among SUA infants, there is a slightly elevated risk for post-natal urinary infections.It may be associated with Edwards's syndrome.

2.4.5 Umbilical cord prolapse :

occurs when the umbilical cord comes out of the uterus with or before the presenting part of the fetus . It is a relatively rare condition and occurs in fewer than 1% of pregnancies. Cord prolapse is more common in women who have had rupture of their amniotic sac. Other risk factors include maternal or fetal factors that prevent the fetus from occupying a normal position in the maternal

pelvis, such as abnormal fetal lie, too much amniotic fluid, or a premature or small fetus. The concern with cord prolapse is that pressure on the cord from the fetus will cause cord compression that compromises blood flow to the fetus. Whenever there is a sudden decrease in fetal heart rate or abnormal fetal heart tracing, umbilical(Lin M G 2006)

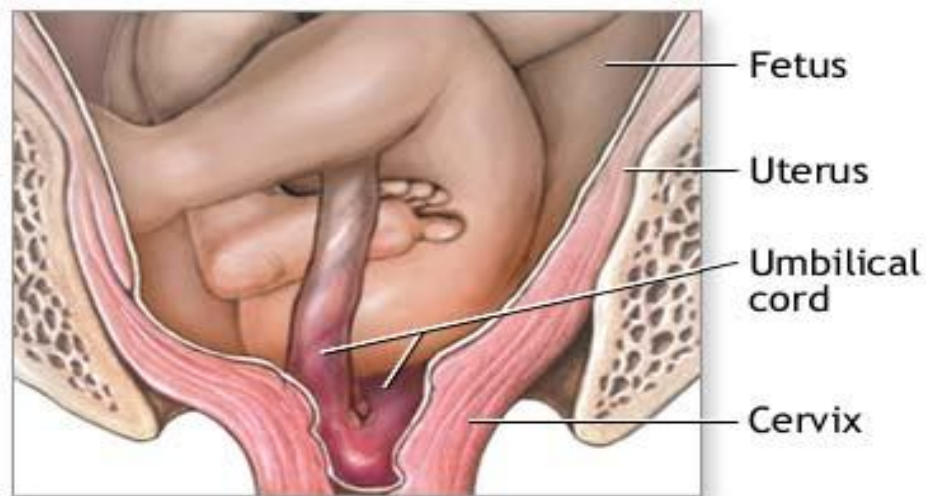


Figure (2.5) umbilical cord prolapse

WWW//nursincrib.com/wp-contact/uploads/prolapse

cord prolapse should be considered. Due to the possibility for fetal death and other complications, umbilical cord prolapse is considered an obstetric emergency during pregnancy or labor. Current management guidelines focus on quick delivery, which usually entails a cesarean section. With appropriate management, the majority of cases have good neonatal outcomes.(LinM G2006)

Classification: There are three types of umbilical prolapse that can occur:

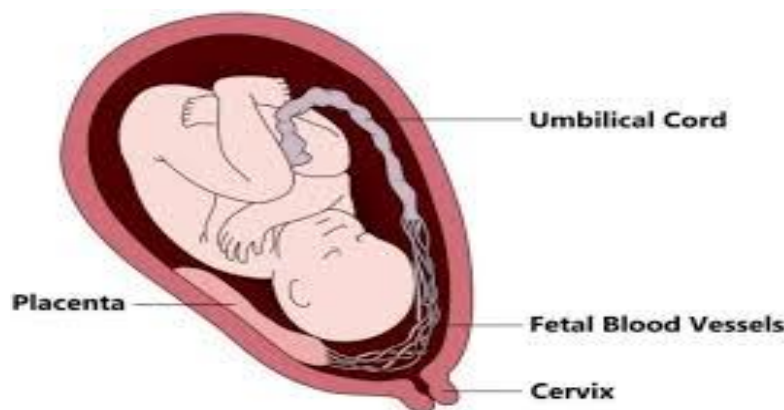
Overt umbilical cord prolapse: descent of the umbilical cord past the presenting fetal part. In this case, the cord is through the cervix and into or beyond the vagina overt umbilical cord prolapse requires rupture of membranes. This is the most common type of cord prolapse.(Lin M G 2006)

Occult umbilical prolapse: descent of the umbilical cord alongside the presenting fetal part, but has not advanced past the presenting fetal part. Occult umbilical prolapse can occur with both intact or ruptured membranes.(LinM G 2006)

funic (cord) presentation : presence of the umbilical cord between the presenting fetal part and fetal membranes. In this case, the cord has not passed the opening of the cervix. In funic presentation, the membranes are not yet ruptured.(LinM G 2006)

2.4.6 Vasa previa(vasapreviaAE) :

Is an obstetric complication in which fetal blood vessels cross or run near the internal orifice of the uterus . These vessels are at risk of rupture when the supporting membranes rupture, as they are unsupported by the umbilical cord or



Figure(2.6)Anatomical diagram of vasa Previa

[HttS://www.google.com/search g=vasa+previa](https://www.google.com/search?q=vasa+previa)

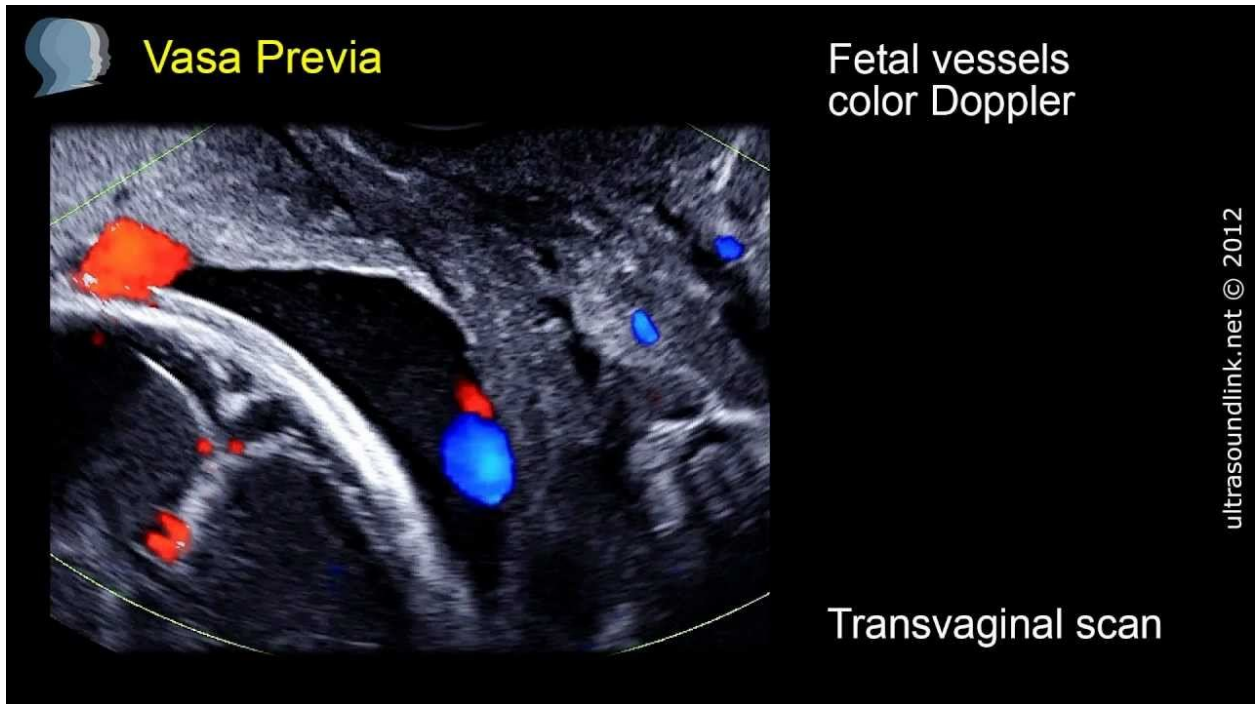


Figure (2.7) Show Ultrasound image of vasa previa

[HttS://www.google.com/search g=vasa+previa](https://www.google.com/search?q=vasa+previa)

Placental tissue. The term comes from "pre" meaning "before" and "via" meaning "way". In other words, vessels lie before the baby in the birth canal and in the way. (Lijio et-al 2003)

2.4.7 Cord knots :

True knots and false knots can form in the umbilical cord. True knots occur in approximately 1% of pregnancies with the highest rate occurring in monozygotic twins. False knots are more common. True knots arise from fetal movement and are more likely to develop during early pregnancy, when relatively more amniotic fluid is present and greater fetal movement occurs. True knots are

also associated with advanced maternal age, multiparty and long umbilical cords. True knots have been reported to lead to increase in fetal loss, presumably because of compression of the cord vessels when the knot tightens.

False knots have no known clinical significance. Detection of umbilical cord knots has been reported with ultrasonography image.(RamoY et al 2006)



Figure (2-8) Cord knots



Figure (2.9)Ultra sound appearance of cord knot

www ultrasound image .com 24/6/2014

2.4.8 Cord cyst:

Cord cysts can be defined as true or false cysts, and they can occur at any location along the cord. They are irregular in shape and are located between the vessels. Cysts are formed in 0.4% of pregnancies.



Figure (2.10) Ultrasound appearance of cord cyst

WWW ultra sound image .com 24/6/2001

True cysts are small remnants of the allantois or the umbilical vesical. Cysts have an epithelial lining, occur at the fetal end of the cord, and usually resolve during the first trimester. True cysts can be associated with hydronephrosis, patent urachus, omphalocele.

False cysts can be as large as 6cm and represent liquefaction of Wharton jelly.

They do not have an epithelial lining and are most commonly found at the end of the cord. Pseudocysts are associated with chromosomal anomalies, omphalocele and patent 20% cord cysts of any type, are associated with structural or chromosomal anomalies during fetal anatomy scans. The abdominal wall near the cord insertions the most likely location to detect a cysts. Cysts can be

visualized most easily with color Doppler studies during when the umbilical vessels are small.(Gehzzi et-al 200

2.4.9Cord varix:

Cord varix is cystic dilation that can occur in any portion of the umbilical vein. Cord varix occurs rarely, and its cause is unknown. Color Doppler flow studies shows very turbulent flow through the cyst which is continuous with the umbilical vein.

Reports have documented poor fetal outcomes in the presence of varices and associated with fetal anomalies. Once detected, regular fetal testing, third trimester interval growth studies(Rahemtulla et al 2001)



Figure(2-11)show ultra sound appearanceforCordvarix:

WWWultra sound image .com 24/6/2001.

2.5 Previous study:

Caroline Edwardl et al. 2014 evaluated the gestational age (GA) by measuring the Umbilical Cord Diameter (UCD) in the second and third trimester of pregnancy, and to compare the findings with the Femur Length (FL), Bi- parietal Diameter (BPD) and Last Menstrual Period (LMP). Fifty Sudanese Pregnant women underwent routine sonographic examination using 3.5MHz curve liner transducer; the sonographic cross-sectional area of the umbilical cord was measured in a plane adjacent to the insertion of the cord into the fetal abdomen. Maternal age and number of parity have been evaluated. The relation was statistically significant between UCD depth, width and GA. Gestational age can be predicted and can be depicted by the following equations: $GA = (1.380 \times \text{UCD length} + 8.160)$ and $GA = (1.545 \times \text{UCD width} + 5.943)$. There was unsubstantial relation between UCD and maternal age. A linear relationship was found between parity and the UCD depth and width. Using paired T-test indicates that the GAs calculated from FL was accurate, there was no significant difference detected between the LMP age and the estimated one and UCD depth, width, but BPD showed significant difference at $p = 0.005$. Measuring UCD is useful for the assessment of gestational age. It has a role in obstetric care in the second and third trimester of pregnancy, and these equations can be used to estimate the gestational age instead of BPD and FL.

Eze et al 2014 noted that common fetal parameters for gestational age (GA) estimation have pitfalls especially in advanced pregnancy and pregnancy complicated by fetal structural anomaly. Objective: To assess the relationship between umbilical cord size and GA of the fetus. Subjects and Methods: A sonographic cross sectional study involving 300 pregnant women with GA between 14 weeks to 40 weeks was done in Enugu, Nigeria. Gestational ages

were first estimated by use of Naegele's formula for GA estimation based on the date of onset of each subject's last menstrual period. Fetal parameters such as biparietal diameter, femur length, head circumference and abdominal circumference were measured and also used to estimate GA. Umbilical cord diameters were measured and used to compute the umbilical cord cross-sectional area.

Their results: showed the mean umbilical cord diameter and cross-sectional area were $14.5\text{mm} \pm 7.2\text{mm}$ and $201.6\text{mm} \pm 139.5\text{mm}^2$ respectively. Umbilical cord growth rate of 1.0mm/week was noted between the 14th and 35th week of pregnancy. There were significant correlations ($p < 0.001$) between umbilical cord size and other fetal parameters for GA estimation. Conclusion: Umbilical cord size had strong linear relationship with common fetal GA estimation parameters and could be used to complement these parameters for GA estimation.

Key words: Sonography, umbilical cord size, gestational age, Nigeria

John et al 2007 determined whether a large cross-sectional area of the umbilical cord is a predictor of fetal macrosomia. Methods Consecutive patients of >34 weeks' gestation, who presented for sonographic examination and who delivered within 4 weeks of the examination, were included in the study. The sonographic cross-sectional areas of the umbilical cord, the umbilical vessels and the Wharton's jelly were measured in a free loop of the umbilical cord. Logistic regression analysis was used to determine significant predictors of macrosomia (actual birth weight >4000 g and >4500 g). Fetal biometric parameters (biparietal diameter, abdominal circumference and femur length), sonographic estimated fetal weight and umbilical cord area >95 th centile for gestational age were used as covariates. Results during the study period, 1026 patients were enrolled. Fifty-three (5.2%) newborns had a birth weight >4000 g, and 22 (2.1%) weighed >4500

g. The proportion of cases with a large umbilical cord was significantly higher in the group of macrosomic compared with non-macrosomic infants (54.7% vs. 8.7%, $P < 0.0001$). Multiple regression models demonstrated an independent contribution of the large cord in the prediction of birth weight > 4000 g and > 4500 g (odds ratio (95% CI), 20.6 (9.2 – 45.9) and 4.2 (1.2 – 17.7), respectively). The sensitivity, specificity and positive and negative predictive values of a sonographic large umbilical cord were 54.7%, 91.3%, 25.4%, and 97.4%, respectively. The combination of abdominal circumference > 95 th centile and large cord predicted 100% of macrosomic infants. The proportion of umbilical cords with a Wharton's jelly area > 95 th centile for gestation was significantly higher in macrosomic fetuses of diabetic compared with non-diabetic mothers. **Conclusions** Sonographic assessment of umbilical cord area may improve the prediction of fetal macrosomia.

Jose et al. 2005 determined the cross-sectional area of the umbilical cord, its diameter and the diameter of its vessels to establish a reference curve for these parameters during pregnancy, through a prospective cross-sectional study, including 2,310 low-risk pregnancies between 12 and 40 weeks' gestation. Means and standard deviations (SDs), plus the 10th, 50th and 90th percentiles for each measurement were calculated using polynomial regression analysis. Mann-Whitney, Kruskal-Wallis and Wilcoxon tests were used for statistical analysis. These parameters increased significantly with gestational age. The area of the cord also varied significantly with parity. Their new reference curves for low risk pregnancies were calculated using polynomial regression, and an almost linear increase in values was found up to 32 weeks of pregnancy, tending to stabilise from then onwards. The regression equation of the umbilical cord area

according to gestational age (GA) was: $-1.417 + 0.3026*GA - 0.008*GA(2) + 0.000007*GA(3)$ and the degree of adjustment (R(2)) was 0.89.

Chapter three

3.1 Study design

This was descriptive analytic study. It was achieved at Al Tamioz teaching hospital and Elhasahesa hospital for obstetric and gynecology during the period from July to August 2016

3.2 sample

3.2 .1 Inclusion criteria :

A total of 50 pregnant Sudanese women in their age between (18_42) years in their second and third trimester were selected trans abdominal ultra sound for the fetus to estimate the gestational age using BPD, FL and UCW LMP also was recorded .

3.3 Exclusion criteria:

- Maternal with fetal anomaly.
- chronic maternal disease.
- Multiple pregnancy.
- Unknown date of LMP
- Poly hydromnious and olygohydromious

3.4 Material:

The equipment include (ALPINION) ultra sound machine with 3.5MHZ curve linear transducer.

3.5 Methods:

3.5.1 Scanning protocol

50 pregnant ladies were selected for trans abdominal ultra sound were included in second and third trimester firstly measured by parietal diameter of a transverse section of the fetal skull at the level of the parietal eminences.

Measuring FL: Is ideally undertaken after the AC has been measured. Slide the probe caudally from the AC section until the iliac bones are visualized. At this point, a cross-section of the one or both femurs is usually seen, the upper femur should be selected for measurement

Keeping the echo from anterior femur in view, rotate the probe slowly until the full length of the femur is obtained. To ensure that you have the full length of the femur and that your section is not oblique, soft tissue should be visible beyond both end of the femur and the bone should not appear to merge with the skin of thigh at any point. The measurement of the femur is made from the center of the U shape at each end of the bone. This represents the length of the metaphysis.

3.5.2 Method of ACW measurement:

Trans abdominal scan ,patient supine, the UC width was measured cross section in free lobe with the calipers placed outer to-outer so that the Wharton jelly was also included in the measurement. Two measurements were taken in two different images, tow sonogrpheers obtained the measurements of the umbilical cord width to ensure an accurate measurement



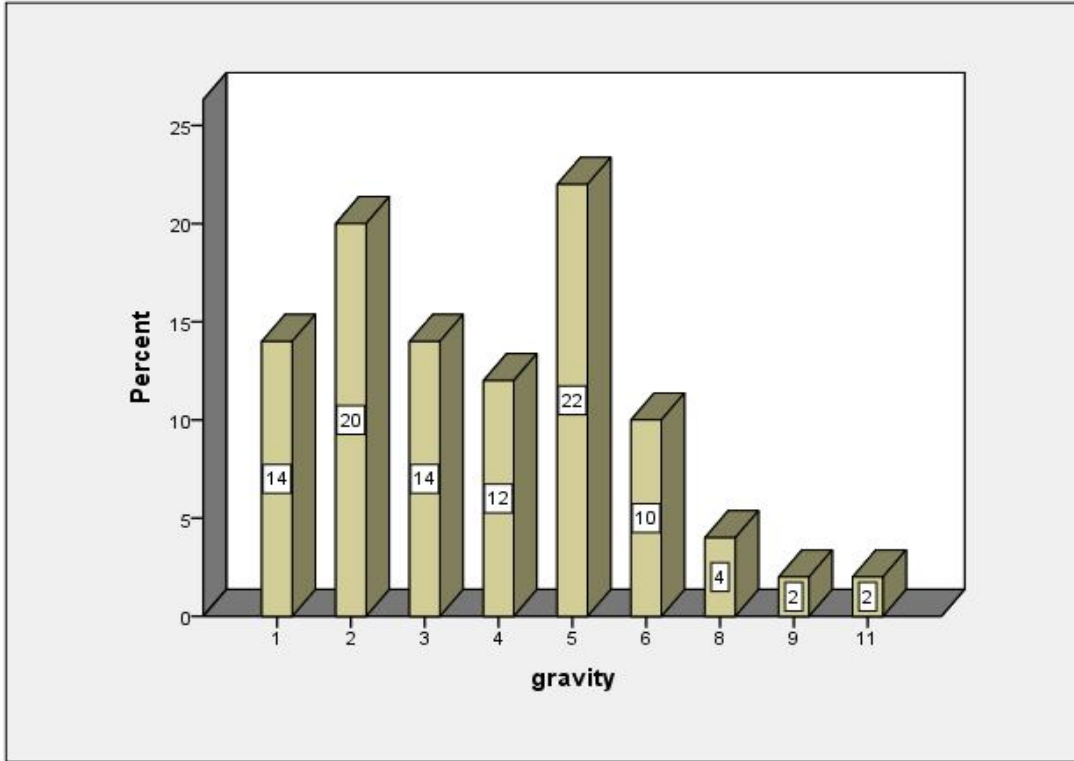
Figure (3.1) Measurement of umbilical cord width from outer to outer (warton^s Jelly is included) cross section image.

Chapter Four

4. Results

Table(4.1)show statistical parameters for all patients

	Min	Max	Mean	STD
Age	18	42	28.84	6.14
Gravity	1	11	3.86	2.24
LMP	13	38	28.18	7.12
BPD mm	23	92	70.6	17.76
FL mm	19	74	54.58	15.48
GA	15	38	28.66	6.87
UCw	6	23	14.52	3.63



Figure(4.1)show distribution of number of Gravity for all patients

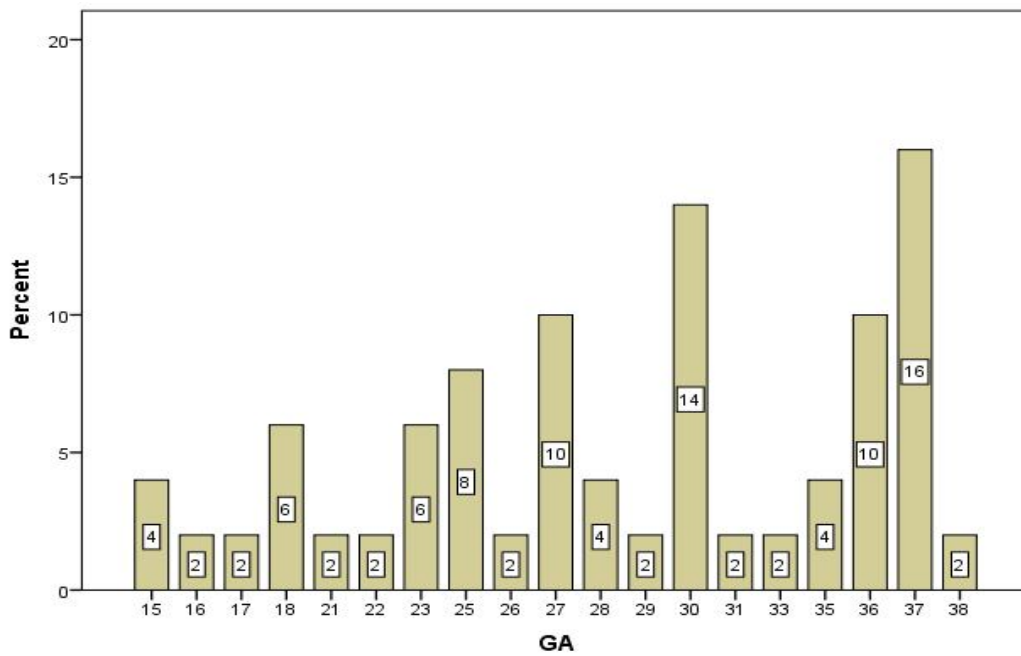


Figure (4.2)show distribution of GA for all patients

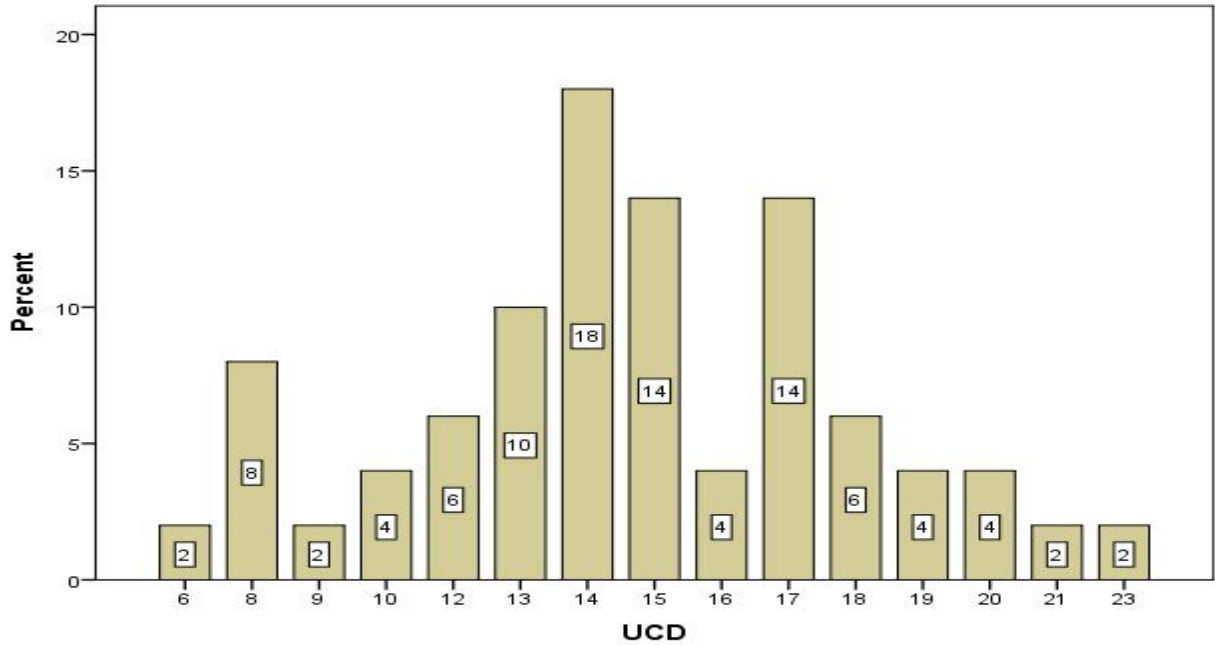


Figure (4.3) show distribution of UCW for all patients

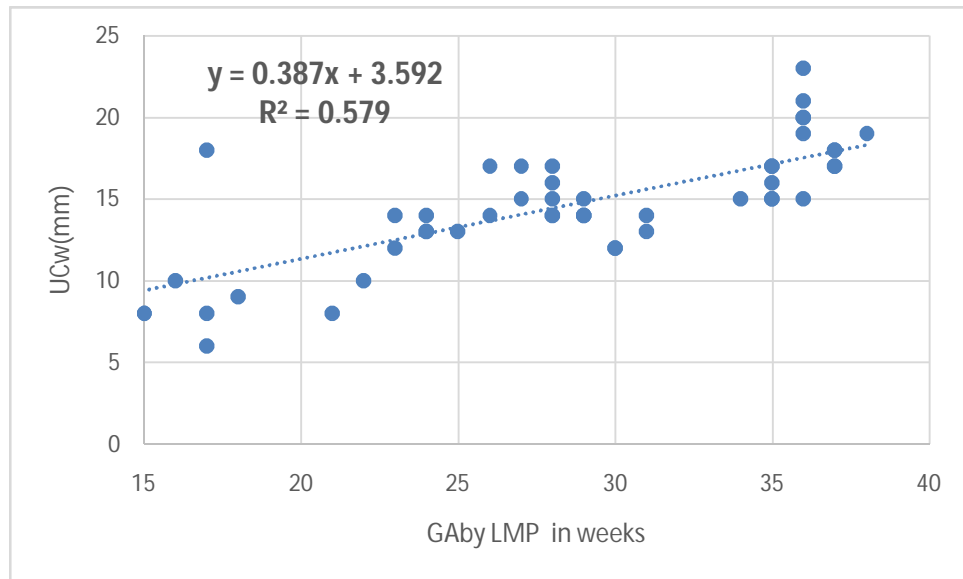


Figure (4.4) Scatter plot diagram shows linear relation between UCW with GA by LMP

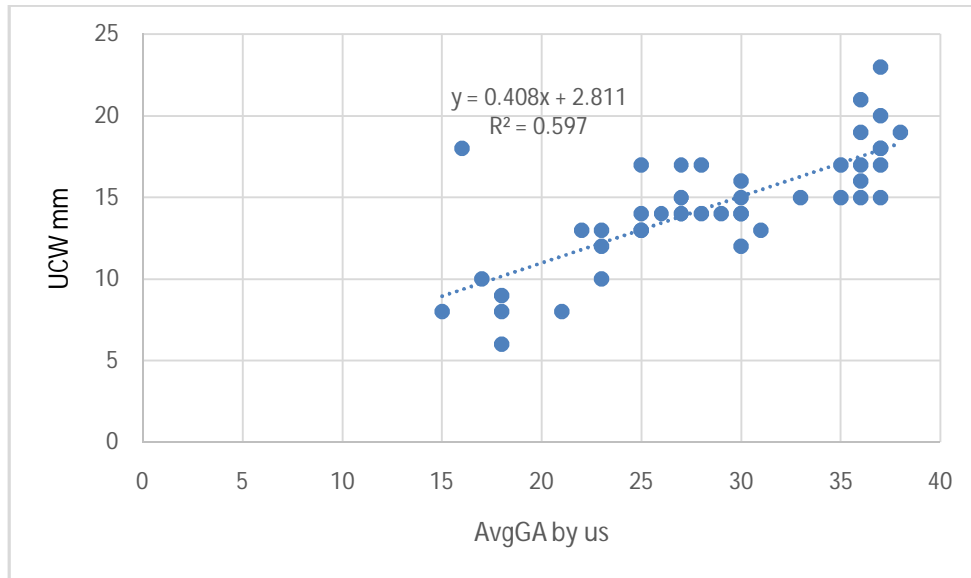


Figure (4.5) Ascatter plot diagram shows linear relationship between UCW and average GA age

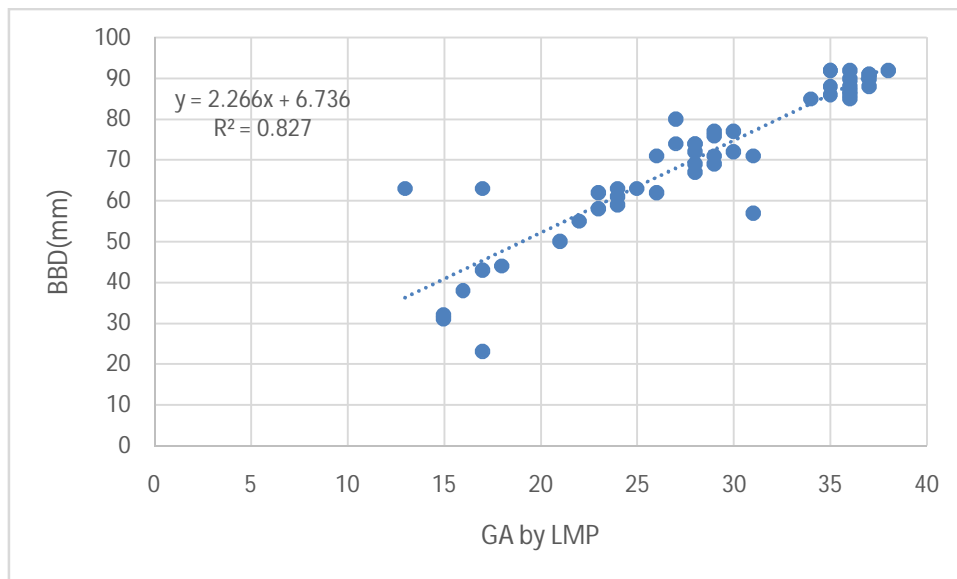


Figure (4.6) show correlation between BPD with GA by LMP

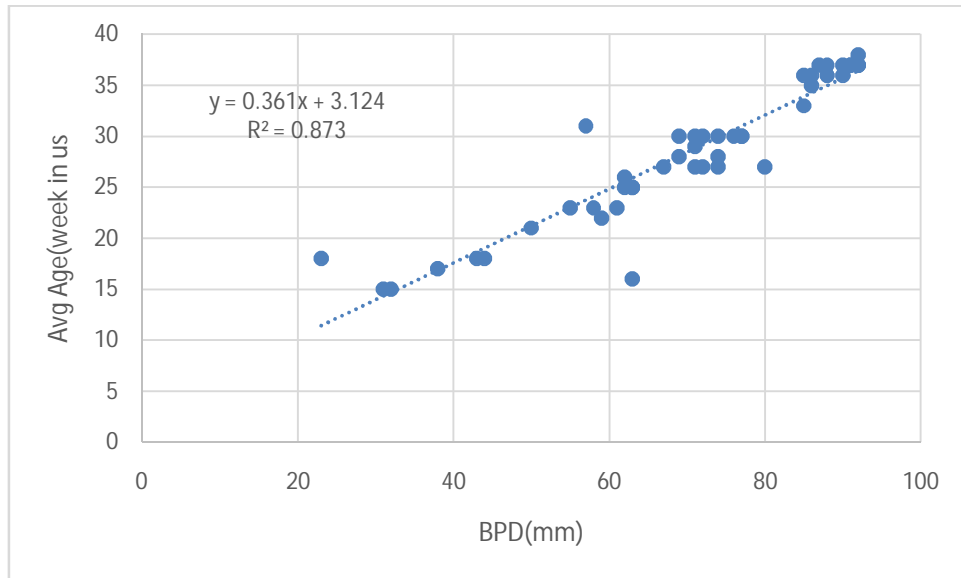


Figure (4.7) Ascatter plot diagram showsrelation between BPD with average GA

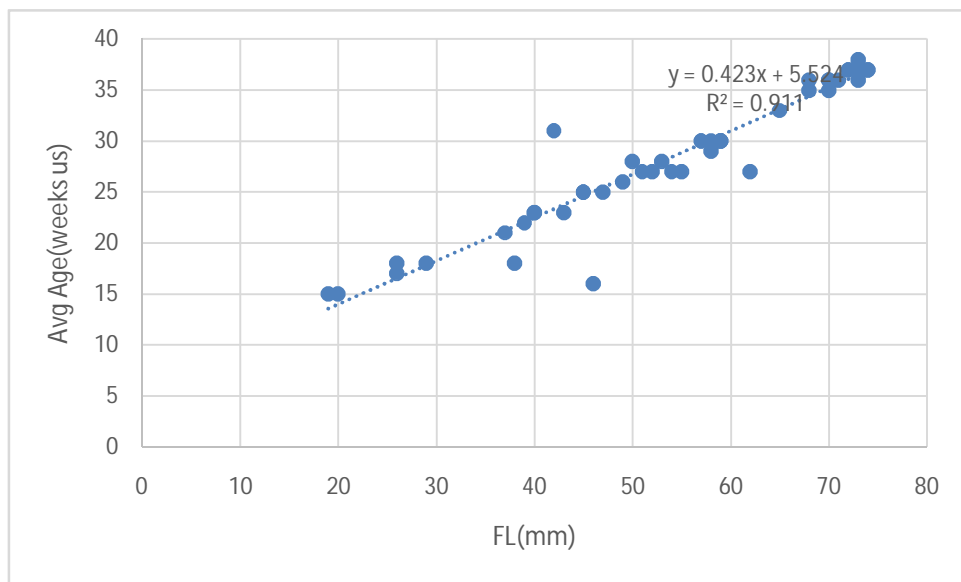
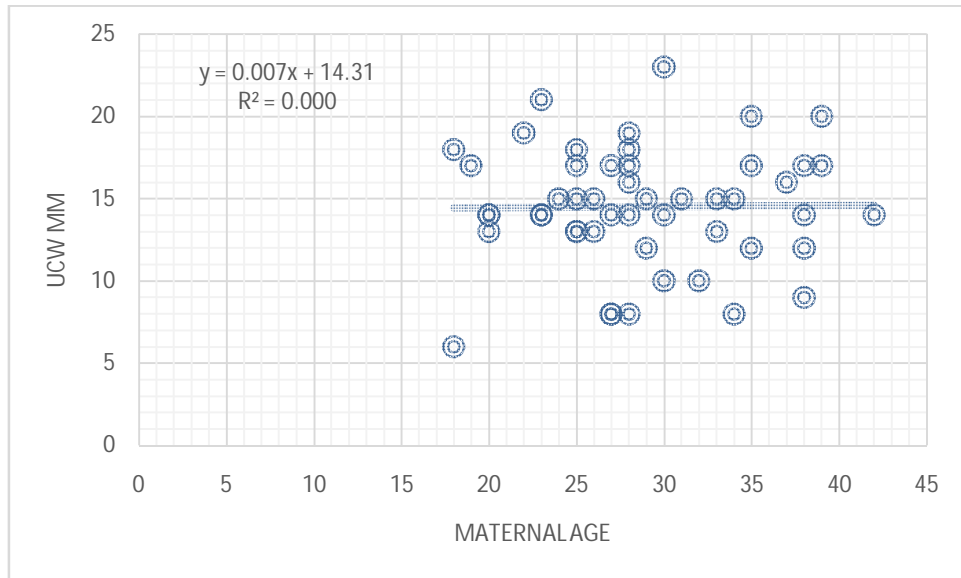
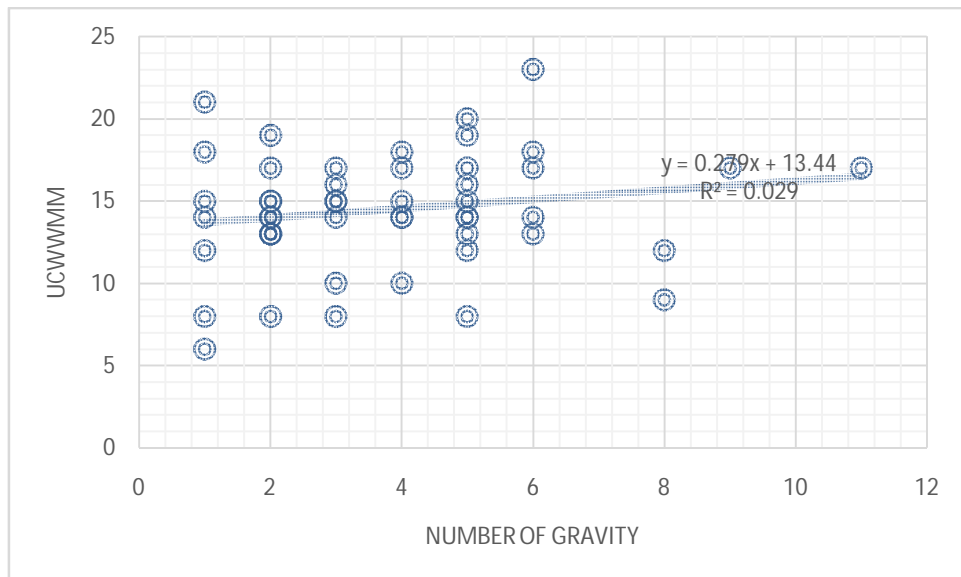


Figure (4.8) Ascatter plot diagram showsrelation between FLwith average gestational age.



Figure(4.9)Ascatter plot diagram show correlation between UCW with maternal age



Figure(4.10)showScatter plot diagram of UCW with number of gravity

Chapter five

5 .1Discussion

This study was conducted to assess gestational age using UCw using diagnostic US which performed to assess the women with mean LMP time equal to 28.18 ± 7.12 the other statistical parameter for all patients were have mean \pm sd, for maternal age 28.84 ± 6.14 , for number of gravity 3.86 ± 2.24 ,for LMP,for BPD mm 70.6 ± 17.76 for FL mm 54.58 ± 15.48 for GA 28.66 ± 6.87 and for UCw 14.52 ± 3.63 .

Figure 4.1: show distribution of number of gravity for all patients as frequency , first frequency was 14, for patient with second pregnancy 20, third pregnancy 14, fourth pregnancy 12, fifth pregnancy 22, sixth pregnancy 10, seventh 4,eighth 2, and ninth 2.

Figure 4.2: show distribution of GA perweeks as frequency for 15 weeks 4, for 16 weeks 2, for 17 weeks 2, for 18 weeks 6, for 21 weeks 2, for 22 weeks 2, for 23 weeks 6, for 25 weeks 8, for 26 weeks 2, for 27 weeks 10, for 28 weeks 4, for 29 weeks 2, for 30 weeks 14, for 31 weeks 2, for 33 weeks 2, for 35 weeks 4 ,for 36 weeks 10, for 37 weeks 16, for 38 weeks 2 .

Figure 4.3: show distribution of UCW as frequency. For 6 weeks the frequency is 2, for 8 weeks 8, for 9 weeks 2, for 10 weeks 4, for 12 weeks 6, for 13 weeks 10, for 14 weeks 18, for 15 weeks 14, for 16 weeks 4, for 17 weeks 14, for 18 weeks 6, for 19 weeks 4, for 20 weeks 4, for 21 weeks 2, for 23 weeks 2 .

The study show linear correlation between UCW with (LMP -avg GA by us) and no significant difference between UCD with maternal age and number of gravity .

Figure 4.4: show a linear correlation between umbilical cord width and age by last menstrual period . it was found that the UCW is increased by 0.38 mm/every week of GA by LMP .were the relation value ($R^2= 0.579$).

$$UCW=.38788*GAbyLMP+$$

Figure 4.5: show a linear correlation between umbilical cord width and average gestational age by us :it was found that the UCW is increased by 0.40 mm/every week of average GA . were the relation value ($R^2 = 0.597$).and this agree with previous study of Caroline et al 2014.

$$UCW=0.4085*Avg\ age+2.58,$$

$$R^2 = 0.597$$

Figure 4.5: show a strong linear correlation between BPD and average gestational age:it was found that the BPD is increased by 0.262 mm/every week of average GA. were the relation value ($R^2 = 0.87$).

Figure 4.5: show a strong linear correlation between FL and average gestational age :it was found that the FL is increased by 0.42 mm/every week of average GA . were the relation value ($R^2 = 0.9$).

Contribution of A FL in assess the gestational age is an accurate parameter $R^2=0.9117$ also BPD was accurate more than UCW $R^2=0.873$ and UCW $R^2=0.5977$ Respectively.

This variation from previous study of Caroline 2014 and this may be due to difference in the site and the way of measurement.

5.2 Conclusion:

umbilical cord is a fetal life line has one vein and two arteries. Umbilical cord abnormalities may lead to fetal anomalies. Umbilical cord diameter increase with increase age of fetus. There is no significant difference between UCW and number of gravity and maternal age. We may use UCW as complementary parameter for assessing GA with $R^2=0.597$. LMP for all pregnant ladies were give positive correlation to increasing of umbilical cord width, $R^2=0.579$

FL still an accurate parameter for assessing Gaby ultra sonography $R^2=0.9117$

5.3 Recommendations:

- umbilical cord diameter should be used to calculate the fetal age
- the umbilical cord to every pregnant should be checked because cord abnormality may lead to fetal morbidity and mortality.
- in the future for using this topic the researcher must take the maternal length and weight, fetal weight, and placental thickness.

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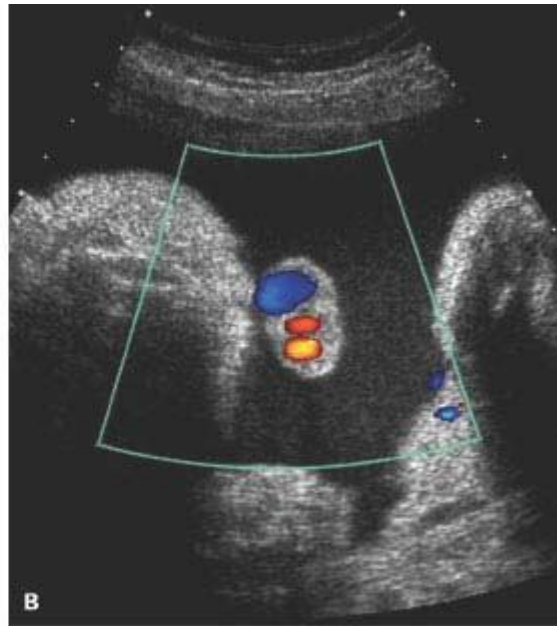
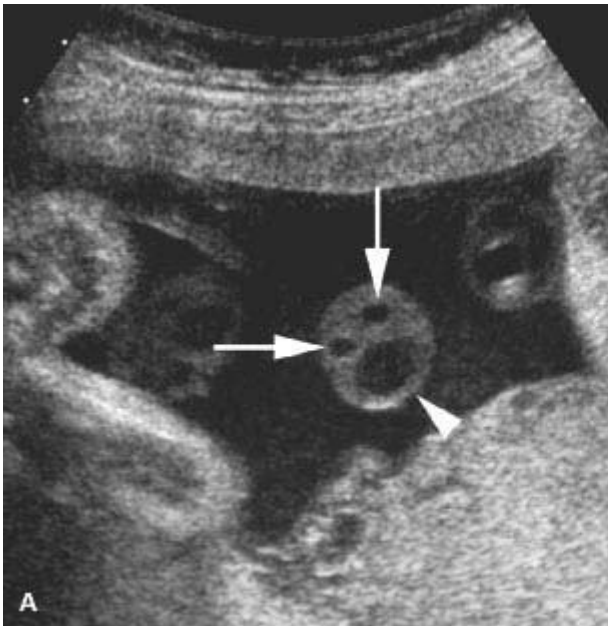
Ultrasound image show BPD measurement



Ultra sound image show FL measurement



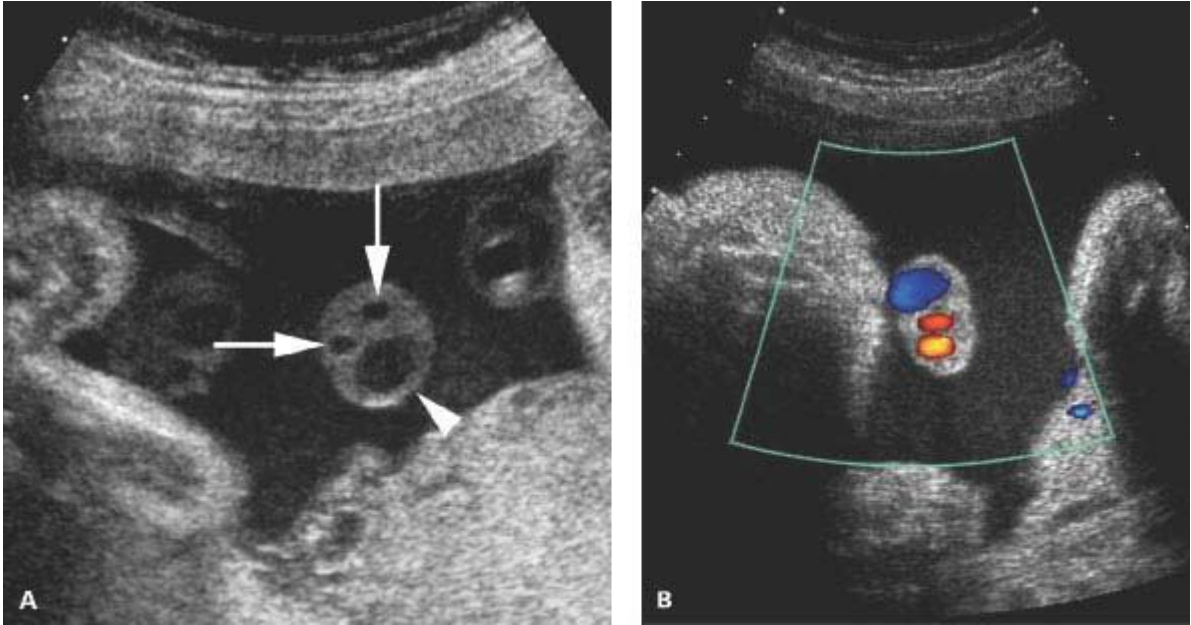
Cross section Ultrasound image for umbilical cord with caliber outer to outer



Cross section us image of umbilical cord A and B Doppler us image tow and one vein

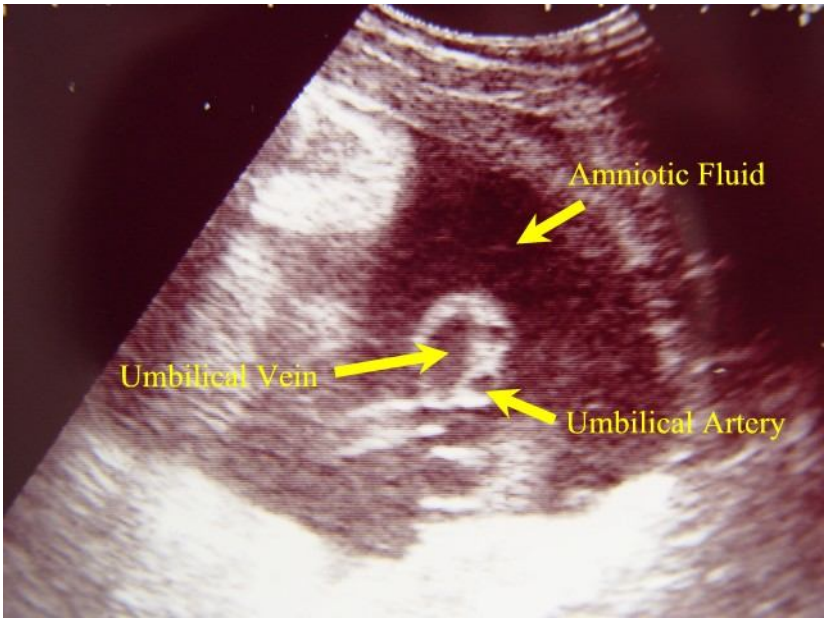


2D ultra sound image show cross section umbilical cord



A- Show cross section umbilical cord tow arteriestop right and top left and one vein

B- Doppler ultrasound for umbilical cord



Labled ultrasound image of cross sectional umbilical cord.



ALPINION 2D ultra sound machine with curvilinear and linear transducers
3.5 and 10 MHZ