Research Article

Cross sectional area of umbilical cord as a predictor for neonatal birth weight

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Abstract

Background: In an effort to ameliorate the adverse outcomes associated with traumatic delivery, maternity care professionals continue to search for methods of predicting fetal weight accurately.

Aim: This study was designed to clarify the relation between cross sectional area of umbilical cord measured by ultrasound and actual birth weight and compare it with that of hadlock's formula.

Patients and method This ; prospective cohort study included 113 pregnant women with uncomplicated, singleton pregnancy and gestational age of 37-42 weeks, admitted with early labor or prepared for elective cesarean section. All were examined by ultra sound, during which fetal anthropometric parameters (BPD, FL, and AC) and cross sectional area of umbilical cord were measured. The estimated fetal weight calculated by Hadlock's formula and by cross sectional area of umbilical cord was correlated with actual birth weight.

Results: There was a significant moderate correlation between umbilical cross sectional area with, maternal BMI and neonatal gender, gestational age, but there was no correlation with maternal age, height and parity p.(<0,001) . The umbilical cord cross sectional area and Wharton's jelly area were found to be moderately correlated with neonatal actual birth-weight, and no significant correlation with umbilical vessels area P (<0.001)

The correlation strength of the umbilical cord cross sectional with the estimated birth weight was higher than that by Hadlock's formula with the value of Coefficient of determinant (R2= 0.3828) for umbilical cord area versus (R20.194) for Hadlock's.

Conclusion: The cross sectional area of umbilical cord was more accurate in predicting birth weight than fetal anthropometric parameters Bi parietal diameter, femur length and abdominal circumference, (BPD, FL,AC)by Hadlock's formula.

Key words: umbilical cord , predictor, neonatal birth weight

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INTRODUCTION

In an effort to ameliorate the adverse outcomes associated with traumatic delivery, maternity care professionals continue to search for methods of predicting fetal weight accurately. The diagnosis of macrosomia still problematic despite advances in ultrasound technology and our longstanding experience in obtaining fetal biometric measurements and research efforts to date. Investigators have attempted to improve ultrasound based prediction of fetal weight by various methods, like assessment of fat deposition at different locations(1–4), the use of three-dimensional ultrasound technology(5, 6) and more advance bioinformatics processing systems that incorporate parental and pregnancy-specific information(7). None of these has gained popularity and ultrasound methods that account for subcutaneous fat thickness have not been shown consistently to improve our ability to estimate fetal weight accurately using formulae derived from conventional biometric parameters (4, 8). Umbilical cord is a vital structure of maternal-fetal life that can be used to evaluate pregnancy outcomes. In the past, sonographic investigations of the umbilical cord were limited to identification of the number of vessels and Doppler evaluation of the blood flow (9, 10). The morphology of the Umbilical cord has been usually studied by pathologists (11, 12). During the past decade, improved ultrasound techniques in measuring the diameter of the umbilical cord and its components resulted in a more advanced perinatal diagnosis (13-15). It has been reported that heavier neonates have a larger umbilical cord circumference at birth (16). The purpose of this study was to determine whether sonographic measurements of cross-sectional area of the umbilical cord is a predictor of fetal weight and to assess whether inclusion of umbilical cord area measurement in conventional biometry may improve prenatal detection of fetal birth weight.

PATIENTS AND METHODS

This cross sectional study was conducted in Obstetrics and Gynecology Department at Al_Yarmouk teaching hospital in the period from March 2015 to January 2016.

A total of 113 women with uncomplicated, term (37_42) weeks, singleton pregnancies admitted to labor room with early labor or for elective cesarean section were enrolled .Pregnant women who had been excluded were those with dead fetus, multiple pregnancies, preterm labor,ruputred membrane, amniotic fluid index <5cm or>25cm,Structural fetal anomaly or any abnormality detected during our sonographic study(two vessels umbilical cord ,uterine fibroid ,abnormal Doppler flowmetry of umbilical artery),maternal diseases(Diabetes mellitus ,Hypertensive disorders ,renal diseases ,Ischemic heart diseases), history of drug intake (Antihypertensive, antiepileptic, oral hypoglycemic drugs) and patient with unknown pre-pregnancy weight.

Verbal consents from the patients obtained before enrolment in the study and the ethical approval from the scientific council of Iraqi board obtained before the beginning of the study. Full history obtained from each patient and general physical examination, vital signs (blood pressure, body temperature, and pulse rate), calculation of body mass index, abdominal and pelvic examinations have been performed. Calculation of gestational age was based on reliable recollection of the last menstrual period and confirmed or modified by early dating ultrasound (<20 weeks).

The presence of fetal anomalies would result in exclusion of the patient. Liquor amount, fetal anthropometric parameters, biparietal diameter, abdominal circumference and femoral length were measured for all fetuses. Estimated fetal weight (EBW) was calculated automatically by software in the ultrasound scanner using the formula proposed by hadlock's et al [17].

Additionally ,the monographic cross-sectional area of the umbilical cord ,the umbilical arteries and the umbilical vein were measured in a plane adjacent to the insertion into the fetal abdomen (fig 1) ,placing the markers at its outer borders, with maximum magnification of the image these values were computed using the software of the ultrasound machine ,as previously mentioned .The surface cross sectional area of the Wharton’s jelly was computed by subtracting the cross-sectional area of the vessels from that of the umbilical cord. All ultrasound scans performed by a single operator using medical system (GE healthcare , Austaria GMBH & CoOG, Voluson E6) equipped with convex probe 3.5 MHz transducer

Figure (1): Measurement of umbilical cross sectional area .department of radiology Al-Yarmouk teaching hospital

Then patients were directed to the labor ward or to the operating theatre according to the mode of delivery planned. After delivery we collected information about fetal gender, Apgar score and mode of delivery .The neonatal birth weight measured by digital baby weighing scale (niklee co.china) calibrated in kilograms.

The umbilical cord cross sectional area, cord vessels, WJ area were measured and the relation with the birth weight studied.

Statistical analysis

Each patient assigned a serial identification number. The data were analysed using the Statistical Package for Social Sciences (SPSS) version 20.

The categorical data presented as frequency and percentage tables. The continuous variables were presented as averages, standard deviations, median and range. Pearson’s correlation test was used to assess the correlation of fetal birth-weight with Estimated fetal weight by Hadlock's formula and the umbilical cord area with other parameters, the correlation was considered weak when the coefficient of correlation (r) (0 - 0.3), moderate if (r= 0.3 – 0.7) and strong when (r>0.7).Regression formulas and coefficient of determinant (R^2) were calculated via simple linear regression.

RESULT

The current study had included 113 pregnant women presented to the gynaecology and obstetrics department in their late pregnancy, the mean age of the participants was 31.5 (± 9) years and ranged from 16 to 47 years; the mean gestational age at delivery was 38.9 (± 1.4) weeks and ranged from 37 to 42 weeks. The mean weight before pregnancy was 67.5 (±9.1) Kg, while the mean height was 160.5 (± 6.5) cm; thus, the average calculated body mass index was 26.3 (± 4.1) kg/m^2, more than half of them (51.3%) were in normal range (<25 kg/m^2), 37 (32.7%) were overweight and 18 (15.9%) were obese. Table (1)

Table 1: Main maternal parameters, N=113.

Parameters	Mean ± SD	Range
Age (year)	31.5±9	16-47
Weight (kg),	67.5±9.1	54-93
Height (cm)	160.5±6.5	147-174
Body mass index		
Normal (<25) kg/m2	58	51.3%
Overweight (25-30) kg/m2	37	32.7%
Obese (≥30) kg/m2	18	15.9%
BMI (kg/m2)	26.3±4.1	22-37.3
Gestational age at delivery (weeks)	38.9±1.4	37-42

Regarding the ultrasound parameters that had been used as indicators for birth weight estimation, the estimated fetal weight (EFW) was calculated according to Hadlock's formula with average 3095 (±605) grams, through the measuring of Bi-parietal diameter (BPD), Femoral length (FL) and Abdominal circumference (AC) with mean values of 92.9 (± 9), 69.9 (± 5.9) and 328.5 (± 28.3) mm respectively. The other estimators were the measurements of umbilical cord parameters and especially the cross sectional area, the average cross sectional area of fetal UC that had been measured by U/S in the current study was 220.4 (± 61.6) mm^2 and ranged from 122 to 356 mm^2, while the average of Wharton's jelly area was 153.4 (± 61.5) mm^2, and that for umbilical vessels was 67.1 (± 18.3) mm^2. Table (2).

Concerning the characteristics of newborns, 63 (55.2%) of them had been delivered by caesarean section, and out of the total newborns 65 (57.5%) were boys. The average birth-weight of the newborns was 3390 (±724) grams and more than two thirds (68.1%) of the was in the range between 2500 and 3500, and only 2 (1.8%) were less than 2500 grams; while 24 (21.2%) were in the range between 3500 and 4500, and 10 (8.8%) were over 4500 grams. After birth, 2 (1.8%) of the newborns were showing neonatal anomalies (Cleft lip), on the other hand, the first minute Apgar score was less than 7 in 15 (13.3%). Table(3)

Table 2: Main fetal parameters and sonographic indicators of fetal birth-weight, N=113.

Parameters	Mean±SD	Range
Bi-parietal diameter (BPD)(mm)	92.9±9	75-111
Femoral length (FL)(mm)	69.9±5.9	59-82
Abdominal circumference (AC)(mm)	328.5±28.3	273-402
Estimated fetal weight (g)	3095±605	1906-4786
Umbilical cord area (mm^2)	220.4±61.6	122-356
Umbilical vessels area (mm^2)	67.1±18.3	39-103
Wharton's jelly area (mm^2)	153.4±61.5	61-291

Table 3: Number and percentage of newborn babies, according to their Characteristics, N=113.

Variables	Number	%
Gender		
Male	65	57.5%
Female	48	42.5%
Mode of delivery		
Caesarean section	63	55.2%
Normal vaginal delivery	50	44.8%
Birth-weight		
<2500g	2	1.8%
2500-3500g	77	68.1%
3500-4500g	24	21.2%
≥4500g	10	8.8%
Mean±SD (Range)	3390±724 g	2100 – 5000 g
Neonatal Anomalies	2	1.8%
Apgar scores <7	15	13.3%

In correlation between the birth-weight of the neonates and prenatal U/S measured parameters as best estimation of fetal body weight, the results showed significant moderate correlations with Femoral length (FL) and Abdominal circumference (AC) (r= 0.411, p<0.001) and (r= 0.35, p<0.001) respectively, but there was no correlation with Bi-parietal diameter (BPD); subsequently and after calculating the Estimated fetal weight from the above three parameters, it also showed a significant moderate correlation with the birth-weight (r= 0.441, p<0.001).

In the same line, both umbilical cord and Wharton's jelly were found to be moderately correlated with neonatal birth-weight (r= 0.619, p<0.001) and (r= 0.614, p<0.001) respectively, with no significant correlation with umbilical vessels area. Table(4)

It is so clear that even if they were moderately correlated with birth-weight, but the correlation strength with the umbilical cord area was higher than that of the Estimated fetal weight by Hadlock's formula.

Table 4: Correlation between fetal birth-weight and U/S parameters for its estimation.

Parameters	Birth weight (g)	
	Correlation coefficient (r)	p-value
Bi-parietal diameter (BPD)(mm)	0.156	0.098
Femoral length (FL)(mm)	0.411	<0.001 **
Abdominal circumference (AC)(mm)	0.35	<0.001 **
Estimated fetal weight (g)	0.441	<0.001 **
Umbilical cord area (mm2)	0.619	<0.001 **
Umbilical vessels area (mm2)	0.019	0.845
Wharton's jelly area (mm2)	0.614	<0.001 **
** Correlation is significant at the 0.01 level (2-tailed).		

Figures 2 & 3 below illustrates the correlation of neonatal birth-weights with their prenatal estimated body weight by Hadlok's formula as well as that with umbilical cord, with the value of Coefficient of determinant (R^2) for EFW of 0.195 which means that 19.5% of the change in birth-weight can be predicted using EFW, while it was (R^2= 0.383) for umbilical cord area, thus 38.3% of birth-weight changes can be predicted using UC area, with regression formulas for each predictor .

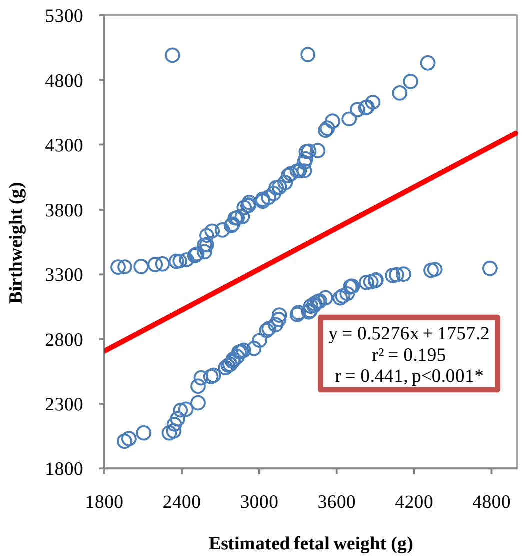

Figure 2: Correlation between Estimated fetal weight by Hadlock's formula and Fetal birth-weight, N=113. (Scatter-plot graph

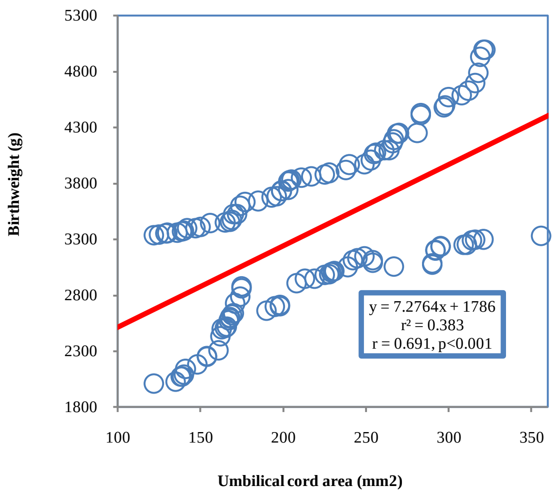

Figure 3: Correlation between Umbilical cord area and Fetal birth-weight, N=113. (Scatter-plot graph

DISCUSSION

The effect of fetal actual birth weight on obstetrical decision making can't be overestimated, still no clinical or ultrasonic measures reaches satisfactory agreement.

In this study, we used the ultrasound to look for a relation between the umbilical cord cross sectional area and estimated birth weight, as it's easy to use and readily available, although the measurement of umbilical cord cross sectional area and vessels area requires training. We compared the estimated birth weight obtained by this method with that of Hadlock's formula which depend on fetal anthropometric measures like femoral length ,bi parietal diameter and abdominal circumference(FL,BPD,AC).In comparing these two methods, we found that the correlation of neonatal actual birth-weights with their prenatal estimated birth weight by Headlock's formula with the value of Coefficient of determinant (R^2) for EFW of 0.194 which means that 19.4% of the change in birth weight can be predicted using estimated fetal weight EFW by Headlock's, while the value of Coefficient of determinant for umbilical cord cross sectional area umbilical cord (R^2= 0.3828), thus 38.3% of birth-weight changes can be predicted using umbilical cord cross sectional area , which means that the prediction of birth weight is more accurate than that by Hadlock's formula (R^2 0.38 vs. 0.194).There is linear increment of the actual birth weight according to umbilical cord area with a regression equation:

(Actual birth weight=7.276 x cross sectional area of umbilical cord+1785.996)

There was also a significant correlation between the Wharton's jelly (WJ)and actual birth weight (p value < 0.001) but no significant correlation with the umbilical cord vessels (UV) area P value 0.845. This result in agreement with other studies, Raio et al, at 1990 studied 860 fetuses over 20 weeks, they found that fetuses in which the area of the umbilical cord was below the 10th percentile (lean umbilical cord) were found to be at greater risk of low birth weight, thereby confirming the existence of a correlation between the area of the umbilical cord and fetal birth weight [(18)].

Tahmasebi et al, during evaluation of umbilical cord thickness, cross sectional area and coiling index as predictors of pregnancy outcome, they found there

Was a significant relation between the umbilical cord cross sectional area with the actual birth weight [19)]

Goodlin et al and Ghezzi et al found a lean umbilical cord, specially accompanied with reduced Wharton’s jelly in ultrasound to be associated with increased risk of delivery of a fetus with small for gestational age at birth [(20,21).] On the other hand Cromi et al, found a large umbilical cord cross sectional area on ultrasound examination in 11.1% (114/1026) fetuses and the proportion of cases with a large umbilical cord cross sectional area was significantly higher in the population of macrocosmic fetuses than in that of non-macrocosmic ones (29/53 (54.7%) vs. 85/973 (8.7%), P < 0.0001). [(22)] Rakesh et al ,they studied the cross sectional area of umbilical cord with pregnancy outcome, they found therewas a significant relation between the fetus weight and the umbilical cord cross sectional area (p value = < 0.001) [(23)]

Bruch and Weissman et al, found that Umbilical cords with large cross sectional area were strongly associated with the presence of metabolic diseases, such as diabetes and macrocosmic fetuses. On the other hand, thin cords leading to a greater incidence of low birth weight fetuses [(24,25)]. Barbeiri 2008 et al , studied the validity of using the umbilical cord to predict the actual body weight ,they found that the umbilical cord cross sectional area is a weak predictor for the actual body weight .[(26)],this disagreement might be due to difference in gestational age (20-40) weeks and included criteria in this study of low risk pregnancy ,they also classified the umbilical cord according to their percentile curve.

In the current study there was no significant relationship between the maternal ages., height, parity and fetal gender with estimated body weight (EFW) by Hadlock's formula but there was a significant relation between fetal gestational age (r=0.32 p value < 0.001) and maternal BMI (r=0.40 p value < 0.001) with EFW. Which means that the EFW is changing by the change of the BMI of the mother and by gestational age of pregnancy.

Regarding the umbilical cord cross sectional area there was no significant relation with the maternal age, height, parity but a significant relation found with maternal BMI (r=0.61 p value < 0.001) ,fetal gestational age and gender (r=0.27 p = 0.003) (r=0.50 p value < 0.001) respectively . Which means that the umbilical cord cross sectional area is changing by the change of the BMI of the mother, gestational age and the gender of fetus.

In comparing these data with other studies, Raio et al showed no significant relation between the age, parity and the gestational age at time of delivery with umbilical cord parameter in ultrasound study.[(18)]

Rakesh et al found that there’s a significant relation between umbilical cord parameter with maternal age and fetal gestational age with no reference to the BMI or the gender[(23)], Barbeiri 2012 et al also found there’s a significant relationship between umbilical cord parameter in ultrasound study with maternal age, parity and fetal gestational age[(27)], Tahmasebi et al showed no result for relation between maternal age, parity ,fetal gender and gestational age with umbilical cord parameters. [(19)]

Bruch and Weissman et al, found that Umbilical cords with small cross sectional area or those with a sparse amount of WJ may be related to the presence of oligohydramnios and fetal distress during labor, leading to a greater incidence of Cesarean sections and low birth weight fetuses [(24,25)]

Conclusion

It is clear for the present sample that the umbilical cord area is a good indicator for estimation of birth weight, which might gave advocacy for future usage of the umbilical cord formula for birth weight prediction.

REFERENCES

1- Chauhan SP, Grobman WA, Gherman RA, Chauhan VB, Chang G, Magann EF, Hendrix NW. Suspicion and treatment of the macrosomic fetus: a review. Am J Obstet Gynecol 2005; 193: 332–346.

2- Mintz MC, Landon MB, Gabbe SG, Marinelli DL, Ludmir J, Grumbach K, Arger PH, Coleman BG. Shoulder soft tissue width as a predictor of

macrosomia in diabetic pregnancies. Am J Perinatol 1989; 6: 240–243.
3- Sood AK, Yancey M, Richards D. Prediction of fetal macrosomia using humeral soft tissue thickness. Obstet Gynecol 1995; 85: 937–940.
4- Bethune M, Bell R. Evaluation of the measurement of the fetal fat layer, interventricular septum and abdominal circumference percentile in the prediction of macrosomia in pregnancies affected by gestational diabetes. Ultrasound Obstet Gynecol 2003; 22: 586–590.
5- Lee W, Deter RL, McNie B, Goncalves LF, Espinoza J, Chaiworapongsa T, Romero R. Individualized growth assessment of fetal soft tissue using fractional thigh volume. Ultrasound Obstet Gynecol 2004; 24: 766–774.
6- Matsumoto M, Yanagihara T, Hata Three-dimensional qualitative sonographic evaluation of fetal soft tissue. Hum Reprod 2000; 15: 2438–42.
7- Nahum GG, Stanislaw H. Accurate prediction of fetal macrosomia using combination methods. Am J Obstet Gynecol 2006; 195: 879–880.
8- Chauhan SP, West DJ, Scardo JA, Boyd JM, Joiner J, Hendrix NW. Antepartum detection of macrosomic fetus: clinical versus sonographic, including soft-tissue measurements. Obstet Gynecol 2000; 95: 639–642.
9- Wu MH, Chang FM, Shen MR, Yao BL, Chang CH, Yu CH, et al. Prenatal sonographic diagnosis of single umbilical artery. J Clin Ultrasound. 1997; 25(8):425–30. [PubMed]
10- Scorza WE, Nardi D, Vintzileos AM, Fleming AD, Rodis JF, Campbell WA. The relationship between umbilical artery Doppler velocimetry and fetal biometry. Am J Obstet Gynecol. 1991; 165(4 Pt 1):1013–9.[PubMed]
11- Malpas P, Symonds EM. Observations on the structure of the human umbilical cord. Surg Gynecol Obstet.1966; 123(4):746–50. [PubMed]
12- Heifetz SA. Single umbilical artery. A statistical analysis of 237 autopsy cases and review of the literature.Perspect Pediatr Pathol. 1984; 8(4):345–78. [PubMed]
13- Raio L, Ghezzi F, Di Naro E, Franchi M, Maymon E, Mueller MD, et al. Prenatal diagnosis of a lean umbilical cord: a simple marker for the fetus at risk of being small for gestational age at birth. Ultrasound Obstet Gynecol. 1999; 13(3):176–80. doi: 10.1046/j.1469-0705.1999.13030176.x. [PubMed] [Cross Ref]
14- Raio L, Ghezzi F, Di Naro E, Franchi M, Bolla D, Schneider H. Altered sonographic umbilical cord morphometry in early-onset preeclampsia. Obstet Gynecol. 2002; 100(2):311–6. [PubMed]
15- Weissman A, Jakobi P. Sonographic measurements of the umbilical cord in pregnancies complicated by gestational diabetes. J Ultrasound Med. 1997; 16(10):691–4. [PubMed]
16- Patel D, Dawson M, Kalyanam P, Lungus E, Weiss H, Flaherty E, Nora EG Jr. Umbilical cord circumference at birth. Am J Dis Child 1989; 143: 638–639
17- Chithra CH, Kumari L, Sangeereni. Comparative Study of Fetal Weight Estimation Using Hadlock's and Johnson's Formula and its Correlation with Actual Birth Weight. Int J Sci Stud 2014;2(7):163-170.
18- Raio L, Ghezzi F, Di Naro E, Gomez R, Mueller MD, Maymon E, Mazor M. Sonographic measurements of the umbilical cord and fetal anthropometric parameters. Eur J Obstet Gynecol Reprod Biol 1999; 83: 131–5
19- Morteza Tahmasebi, Reza Alighanbari.Evaluation of umbilical cord thickness, cross-sectional area, and coiling index as predictors of pregnancy outcome. Indian Journal of Radiology and Imaging ; August 2011: 21 (3) .195-198
20- Goodlin RC. Fetal dysmaturity, "lean cord and fetal distress. Am J Obstet Gynecol. 1987;156(5):1357.
21- Ghezzi F, Raio L, Gunter Duwe D, Cromi A, Karousou E, Durig P. Sonographic umbilical vessel morphometry and perinatal outcome of fetuses with a lean umbilical cord. J Clin Ultrasound. 2005;33(1):18–23.
22- A. Cromil, F. GHEZZI, E. DI NARO. Large cross-sectional area of the umbilical cord as a predictor of fetal Macrosomia, Ultrasound Obstet Gynecol 2007; 30: 861–866
23- Rakesh K Gupata, Amit Mittal .Prognostic indices for pregnancy outcome on ultrasound ,PJR 2012; 22(3) 78-83
24- Bruch JF, Sibony O, Benali K, Challier JC, Blot P, Nessmann C. Computerized microscope morphometry of umbilicalvessels from pregnancies with intrauterine growth retardationand abnormal umbilical artery Doppler. Hum Pathol. 1997;28:1139 45.
25- Weissman A, Jakobi P, Bronshtein M, Goldstein I. Sonographic measurements of the umbilical cord and vessels during normal pregnancies. J Ultrasound Med. 1994;13(1):11-4.
26- Cristiane Barbieri a; Jose Guilherme Cecatti a; Fabiana Krupa a, Validation study of the capacity of the reference curves of ultrasonographic measurements of the umbilical cord to identify deviations in estimated fetal weight. Scandinavica;2008, 87:3, 286 – 291
27- C. Barbieri , J. G. Cecatti , F. G. Surita, Sonographic measurement of the umbilical cord area and the diametersof its vessels during pregnancy. Journal of Obstet Gynaecol, April 2012; 32: 230–236