

The relationship between umbilical venous blood flow & fetal weight in the last trimester

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Abstract

Background: Doppler applications in pregnancy are expanding exponentially. Flow velocity waveforms provide important information from 12 weeks to term, from maternal vessels, placental circulation and fetal systemic vessels. An important application is the quantitative calculation of umbilical blood flow volume.

Objective: to assess the relation between the umbilical blood flow at one hand & fetal body weight & placenta weight on the other hand in the last trimester in both term & preterm labor groups

Study design: A prospective study

Setting: department of Gynecology & Obstetrics & Department of Radiology at Al-Kadhimiya Teaching Hospital

Patients & methods: This study included 50 pregnant women at first stage of labor. The patients were classified into two groups; group A: Infants born at < 37 weeks of gestation and group B: those infants born at ≥ 37 weeks of gestation. The diameter of the umbilical vein was determined by ultrasound & spectral Doppler was used to assess velocity of blood in the umbilical vein & the umbilical blood flow

(UBF) per unit fetal body weight & placental weight estimated in both groups. **Results :** A statistically significant difference was found in the diameter of the umbilical vein (7.84 mm vs. 8.62 mm , p=0.0001) , the volume of umbilical blood flow (410.22 mL/min vs. 523.20 mL/min, p=0.0001), UBF/Fetal weight (230.68 mL/min/kg vs. 166.79 mL/min/kg , p=0.0001) & UBF/Placental weight (102.65 mL/min/100gm vs. 87.23 mL/min/100gm , p=0.01) of group A & group B respectively while the mean velocity of blood flow in the umbilical vein showed no statistically significant difference in both groups (14.11 cm/s vs. 14.93 cm/s , P=0.8).

Conclusion: The increase in umbilical blood flow is exceeded by the fetal growth and to a lesser degree by placenta growth. A significant reduction in the umbilical blood flow per unit fetal weight & placental weight take place with increasing gestational age.

Keywords: umbilical venous blood flow, fetal body weight, placental weight

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Introduction

Doppler applications in pregnancy are expanding exponentially. Flow velocity waveforms provide important information from 12 weeks to term, from maternal vessels, placental circulation and fetal systemic vessels, with implications for both mother and fetus. Reports of blood flow measurement in pregnancy mostly refer to physiological reduction of placental

vascular resistance⁽¹⁾ or to the redistribution of the cardiac output under hypoxic distress⁽²⁾. Another important application is the quantitative calculation of umbilical blood flow⁽³⁻⁵⁾. During the course of pregnancy, there is a dramatic increase in uterine blood flow from <100 ml / min at 10th week of gestation to 700 – 800 ml / min at term⁽⁶⁾. Umbilical blood flow increases as well from 100 ml / min at 22nd week of gestation to 300 ml / min at the 38th week of pregnancy⁽⁷⁾. Relative to the fetal weight, a constant umbilical blood flow of 120 ml / min per unit fetal weight has been reported up to 35th week of gestation. After that time, it is assumed to decrease slightly⁽³⁻⁵⁾. However other studies have indicated

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that the increment in fetal body weight exceeds the increment in the umbilical blood flow in the last trimester⁽⁸⁾. Normal placental and fetal growth across pregnancy is characterized by sequential cellular hyperplasia, hyperplasia and hypertrophy, and finally, hypertrophy alone⁽⁹⁾. Placental growth follows a sigmoid curve, with plateau occurring earlier in gestation than fetal curve. Between 16th week and term, human fetal weight increase 20 fold⁽¹⁰⁾. Fetal growth is dependent on adequate transfer of nutrients and oxygen across placenta. Thus it is dependent on appropriate maternal nutrition and placental perfusion. We aimed at this study to assess the relation between the umbilical blood flow at one hand & fetal body weight & placental weight on the other hand in the last trimester in both term & preterm labor groups.

Patients and methods

This was a prospective study that included 50 pregnant women at the Department of Obstetrics and Gynecology in cooperation with Ultrasound (U/S) unit at Al-kadhimyia Teaching Hospital from July 2007 through August 2008. Informed consent was obtained from all participants. All the participants were at first stage of labor. The patients were classified into 2 study groups based on gestational age at delivery; group A: Infants born at < 37 weeks of gestation were classified as preterm (n = 15), and group B: those infants born at ≥ 37 weeks of gestation (n = 35). The inclusion criteria were singleton pregnancy, term or preterm pregnancy, first stage of labor (infrequent uterine contraction) & intact membrane. Those pregnant women with pre-eclampsia, diabetes mellitus, multiple pregnancy, ultrasound evidence of congenital abnormalities, polyhydramnios or oligohydramnios or those infants with features of intrauterine growth restriction or

macrosomia (according to standard growth charts) were excluded. The demographic criteria for each patient was obtained (age, weight, parity & gestational age determined by reliable last menstrual period or early U/S and confirmed by neonatal examination). The blood flow in the umbilical vein was determined by pulsed doppler sonography using Siemens sonoline versa pro machine with 3.5 – 5 MHz convex transducer. The Doppler ultrasound was performed in the first stage of the labor for all patients. Umbilical venous frequency shift was recorded at the placental origin of the umbilical vein, with insonation angle of 30-60°. The diameter of umbilical vein (U.V.) determined & the volume of umbilical blood flow (UBF) was estimated as $Q = V \times d^2 \times \pi \times 0.15$ where (Q) is the volume of umbilical blood flow (ml / min), (V) is the mean velocity (cm / s), and (d) is the diameter of the umbilical vein (mm). To avoid inter-observer variation, all measurements of mean velocity of blood flow and diameter of umbilical vein were performed by the same radiologist. To reduce error due to a solitary measurement, each Doppler shift signal of the umbilical vein and each vessel diameter were measured twice. Thus, both mean flow velocity and the umbilical diameter for the calculation of the volume of umbilical venous blood flow were determined from the means of two consecutive measurements.

After birth, assessment of the neonatal birth weight, placental weight and ABGAR score were performed by the obstetrician and the neonatologist.

Statistical analysis

Data were collected and described by using number, percentage, mean ± SD & correlation. The association was considered to be statistically significant when P value is < 0.05.

Results

Figure 1 represents the distribution of the study groups according to the gestational age

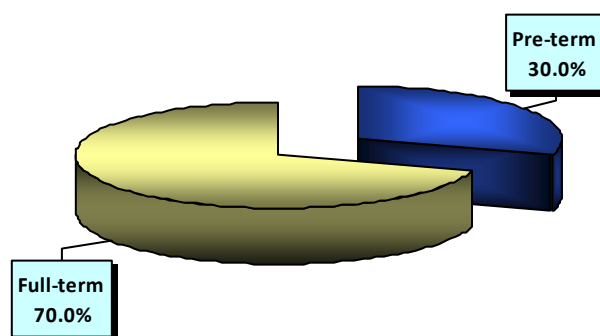


Figure 1: Pie chart represents the distribution of the study groups according to the gestational age

Table 1 shows the demographic characteristics of group A and B are, the mean gestational age at group A was 33.47 ± 1.88 while in group B was 38.86 ± 1.33

Table 1: the demographic characteristics of the study groups.

Variables	Pre-term (n=15)	Term (n=35)
	Range (Mean $\pm$ SD)	Range (Mean $\pm$ SD)
Age in years	17-38 (27.13 $\pm$ 4.07)	22-42(28.31 $\pm$ 3.52)
Gestational age (weeks)	29-36(33.47 $\pm$ 1.88)	37-42(38.86 $\pm$ 1.33)
Parity	1-4(0.80 $\pm$ 0.77)	1-5(1.71 $\pm$ 1.23)

Table 2 shows the different Doppler parameters that are assessed in both groups & their relation with newborn body weight & placenta weight.

A statistically significant difference was found in the diameter of the umbilical vein , the volume of

umbilical blood flow, UBF/Fetal weight & UBF/Placental weight of both groups while the mean velocity of blood flow in the umbilical vein showed no statistically significant difference in both groups ($P=0.8$).

The diameter of the umbilical vein was greater in term than in pre term

infants ($P = 0.0001$) as a result there was a significant increase in the

umbilical blood flow in term group than in pre term group ($P = 0.0001$).

Table 2: The relation of different measurements of umbilical vein parameters with gestational age.

Measurement	Pre-term (n=15)	Full-term(n=35)	P value
	Mean±SD	Mean±SD	
Mean velocity of blood flow (cm/s)	14.11±1.22	14.93±0.57	0.8NS
Umbilical vein diameter (mm)	7.84±0.21	8.62±0.23	0.0001*
Volume of umbilical blood flow (mL/min)	410.22±53.94	523.20±31.84	0.0001*
UBF/Fetal weight (mL/min/Kg)	230.68±38.32	166.79±17.04	0.0001*
UBF/Placental weight (mL/min/100 gram)	102.65±8.42	87.23±6.56	0.01*

Figure 2 shows that a positive correlation ($r=0.8$) exists between the umbilical blood flow & fetal weight with a significant reduction in umbilical

blood flow per unit of fetal weight noted with increasing gestational age (P value = 0.0001).

NS: not significant, *Significant

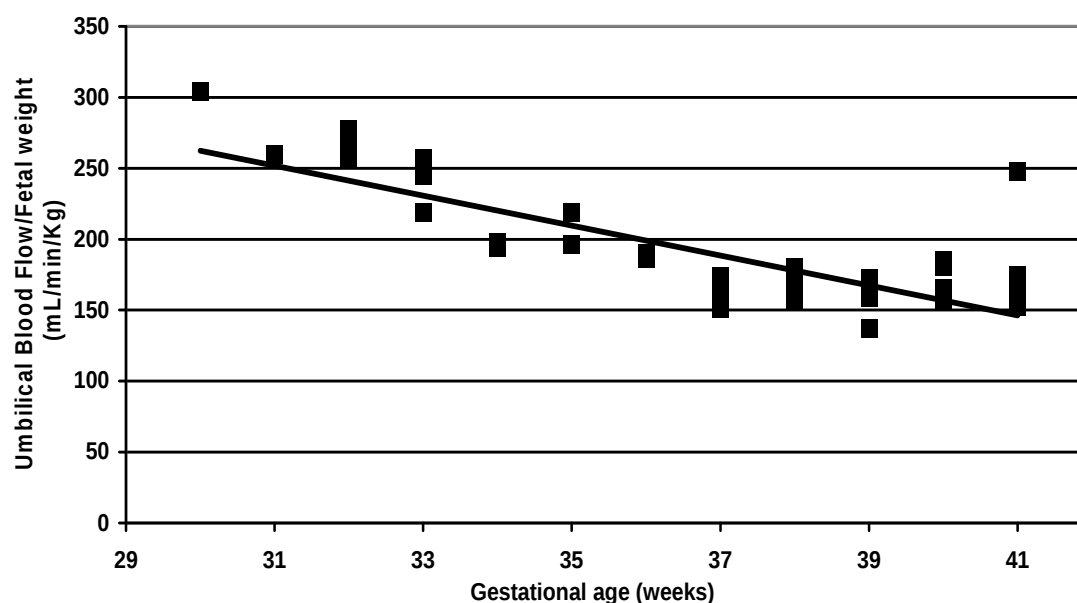


Figure 2: The correlation between gestational age (weeks) and umbilical blood flow per unit fetal weight (ml/min/kg). $r = -0.8$

Figure (3) shows that a slight but statistically significant reduction in umbilical blood flow per unit

placental weight was found in group B in comparison with group A ($r=0.5$, $P = 0.01$).

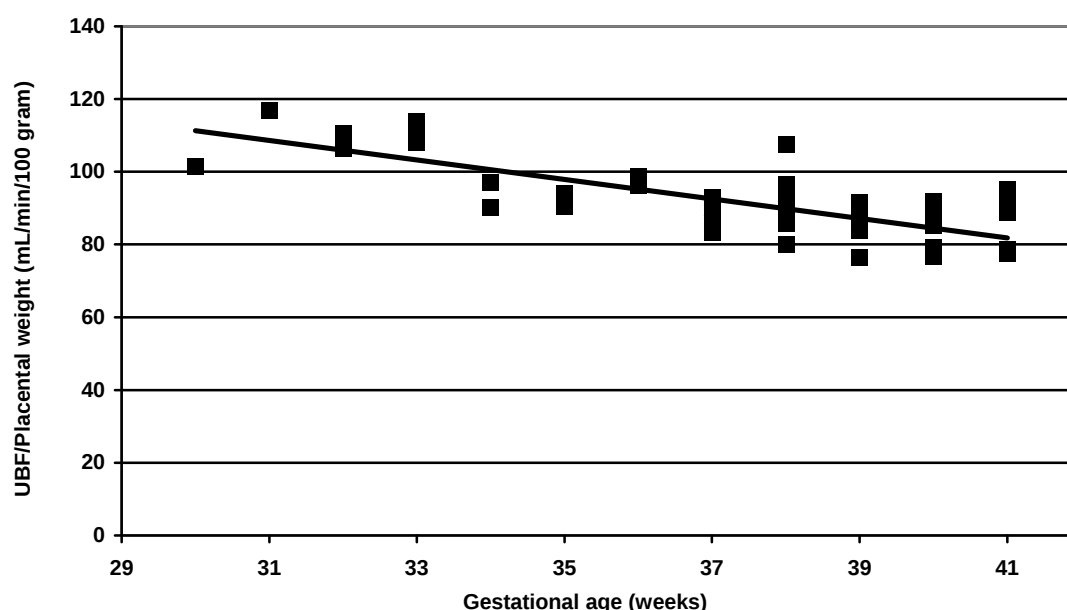


Figure 3: The correlation between gestational age (weeks) and UBF/Placental weight (ml/min/100gr). $r=-0.5$

Discussion

For the fetus, placental blood volume flow rate is as important as cardiac output and lung perfusion in adults. The measurement of fetal blood flow velocity using Doppler U /S was introduced into routine obstetric practice many years ago, both to detect fetal circulation in the context of any gestational disease and to assess fetal well- being.⁽¹¹⁾

Volume flow rate determinations based on the Doppler principle is being one of the rapidly growing application during pregnancy⁽¹²⁻¹⁴⁾. In this study we investigated the relation between umbilical venous blood flow & fetal weight in last trimester. The range of velocity of umbilical venous blood flow in this study was between (11.5 – 15.8)cm/s and the mean velocity was similar in group A and B 14.1 , 14.9 cm/s, respectively which is consistent with result of Link et al⁽⁶⁾ who found that the mean flow velocity was 13.1 cm/s in preterm group and (13.6 cm / s) in term group with no significant correlation with gestational age while Barbera et al⁽¹²⁾ found that the

umbilical vein blood flow velocity increases throughout pregnancy a conclusion that was inconsistent with our results.

The umbilical vein diameter was greater in group B (8.6 mm) than in group A (7.8 mm). This result was consistent with result of link et al⁽⁶⁾ who found that the mean umbilical vein diameter was 8.8 mm in full term group and 8.1 mm in preterm group, and was statistically significant difference .Also this result was consistent with the results of Barbera et al⁽¹²⁾ who found a significant increase in the umbilical vein diameter throughout pregnancy.

The observation of a constant velocity of blood flow and an increasing cross section of the umbilical vein is consistent with result of Erskine et al⁽³⁾ and Kunzel et al⁽⁸⁾, both found that the increase of umbilical venous blood flow throughout gestation was due to and depended on the growth of the umbilical vein in the presence of a rather constant flow velocity.

With respect to the blood flow volume, we found that the blood flow in the umbilical vein increased markedly in group B, the mean UBF was 523.2 ml / min while in group A it was 410.2 ml / min. This result was in agreement with result of Link et al ⁽⁶⁾ and kunzel et al ⁽⁸⁾ who found that the blood flow volume significantly increased with gestation from 432 ml/min in pre term to 515 ml/min in full term. Barbera et al ⁽¹²⁾ found that the absolute umbilical vein flow increases exponentially from 97.3 ml/min at mid-gestation to 529.1 ml/min at 38th week of gestation which was in agreement with our results.

We found a continuous reduction in the umbilical blood flow per unit of fetal weight with increasing gestation (166.7 ml / min / kg in group B and 230.6 ml /min / kg in group A). This result was in agreement with results of Link et al, ⁽⁶⁾ and of Kunzel et al, ⁽⁸⁾ they found that the blood flow per unit of fetal weight reduced in full term (154 ml / min / kg) compared to (221 ml / min / kg) in preterm group which was a significant difference , whereas Barbera et al, ⁽¹²⁾ found that the umbilical blood flow per kilogram of fetal weight did not change significantly with gestational age, this result disagree with our result.

Regarding the relation between the placental weight & the UBF , we found that the blood flow per unit of placental weight was reduced with increasing gestation, group A showed a mean UBF of 102.6 ml /min per 100 gm and group B 87.2 ml / min per 100 gm of placental weight . This result was in agreement with result of Link et al ⁽⁶⁾ who found that the umbilical blood flow per unit placental weight was slightly but significantly diminished in full term than in preterm group 90 and 100 ml / min / 100gm respectively.

It was concluded that A significant reduction in the umbilical blood flow per unit fetal weight takes place with increasing gestational age & the umbilical blood flow per unit placental weight was reduced with increase gestation.

References

1. Ferrazi E, Gementi P and Bellotti M et al. Doppler velocimetry: critical analysis of umbilical, cerebral and aortic reference values. Eur J Obstet Gynecol Reprod Biol.1991; 38:189-196.
2. Arbeille P, Leguyader P, Fignon A et al. Doppler ultrasonographic investigation of fetal cerebral circulation. In: Maulik D. Editor, Doppler ultrasound in obstetrics and gynecology (1st ed). Springer-Verlag. New York. 1996; 161-180.
3. Erskine RLA and Ritchie JWK. Quantitative measurement of fetal blood flow using Doppler ultrasound. Br J Obstet Gynecol.1985; 92:600-604.
4. Eik-Nes SH, Marsal K, Brubakk A et al. Ultrasonic measurement of human fetal blood flow. J Bio med Eng.1982; 4:28-36.
5. Gill RW, Kossff G, Warren PS and Garrett WJ. Umbilical venous flow in normal and complicated pregnancy. Ultrasound Med Biol.1984; 10:349-363.
6. Link G, Clark KE, Lang U. Umbilical blood flow during pregnancy: evidence for decreasing placental perfusion. Am J Obstet Gynecol. 2007; 196:489-495.
7. Gill RW, Trudinger BJ, Garrett WJ et al. fetal umbilical venous flow measured in utero by pulsed Doppler and B-mode ultrasound. Normal pregnancies. Am J Obstet Gynecol.1981; 139:720-725.
8. Kunzel W, Jovanovic V and Grubner S. Blood flow in the umbilical vein and artery in pregnancy. Geburtshilfe Frauen heilkd.1991; 51:513-522.
9. Baschat A. Fetal growth disorders. In James DK. High risk pregnancy management options.2006; 240-243.
10. Battaglia FC, Rgenault TR. Placental transport and metabolism of amino-acid. Placenta. 2001; 22:145-161.
11. Marsl K, Persson PH, Larsen T et al. Intrauterine growth curves based on ultrasonically estimated fetal weights. Acta Paediatr. 1996; 85:843-848.
12. Barbera A, Galan HL, Ferrazzi E et al. Relation of umbilical vein blood flow to growth parameters in human fetus. Am J Obstet Gynecol. 1999 ; 181: 1 : 174-179.
13. Challis DE, Warren PS, Gill RW. The significance of high umbilical Venous blood

flow measurements in a high-risk population. J Ultrasound Med 1995; 14: 907-912

14. Kohl T, Silverman NH. Evaluation of umbilical venous blood flow by Doppler color flow mapping and conventional ultrasonographic methods. J Ultrasound Med 1996; 15: 465-73)