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Fetal Doppler ultrasound assessment of ductus venosus in a 20 – 40 weeks gestation normal fetus in the Pakistani population

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Abstract

Objective: To evaluate the ductus venosus hemodynamic parameters in 31 – 40 weeks gestation normal fetus in the Pakistani population using Doppler ultrasonography. **Material and methods:** In a standardized protocol 106 pregnant women (31 to 40 gestation weeks) were scanned. The peak systolic velocity (maximum velocity during S wave) (PSV), peak velocity index (peak velocity S wave minus peak velocity A wave/peak velocity D wave) (PVI), and S/A ratio (peak velocity S wave/peak velocity A wave) were measured. **Results:** Out of 106 patients, 100 patients were successfully scanned (94% success rate). In the 31-35 weeks gestational age group the mean PSV was 59.7 cm/s, PI 0.7, and S/A 2.16. In the 36-40 weeks gestational age group the mean PSV was 72.9 cm/s, PI 0.42, and S/A 2.46. **Conclusions:** As the normal pregnancy advances the PSV, the flow resistance and S/A ratio in ductus venosus increase.

Keywords: ultrasonography, ductus venosus, spectral analysis, normal pregnancy

Rezumat

Obiectiv: Evaluarea prin ecografie Doppler a parametrilor hemodinamici de la nivelul ductului venos la feti pakistanezi normali cu vârsta gestațională cuprinsă între 31-40 săptămâni. **Material şi metodă:** In cursul unui protocol standardizat 106 de gravide (31-40 săptămâni) au fost scanate. S-a măsurat viteza sistolică de vârf (viteza maximă în timpul undei S) (PSV), indexul velocitar de vârf (viteza de vârf a undei S minus viteza de vârf a undei A/viteza de vârf a undei D) (PVI) şi raportul S/A (viteza de vârf a undei S/viteza de vârf a undei S). **Rezultate:** Din cele 106 paciente măsurătorile s-au făcut cu succes la 100 dintre acestea (rată de succes 94%). In grupul cu vârstă gestațională de 31-35 săpțămâni media PSV a fost 59,7 cm/s, PI 0,7 iar S/A 2.16. In grupul cu vârstă gestațională 36-40 săptămâni media PSV a fost 72,9 cm/s, PI 0,42, and S/A 2,46. **Concluzii:** Pe măsură ce sarcina normal avansează cresc PSV, rezistența la flux şi S/A din ductul venos

Cuvinte cheie: ecografie, ducul venos, analiza spectrală, sarcina normală

Introduction

The ductus venosus Arantii (DV) is a small funnel shaped vessel that is found in the fetal liver, connecting the umbilical vein and the inferior vena cava. Anatomically, DV and the affluent hepatic veins – the intrahepatic branches of the portal vein – are arranged in parallel. This is important because the ratio of flow through the DV and the liver will be inversely related to the ratio of flow resistances, regardless of whether the resistance values actually decrease or increase [1]. The maximum length of the DV is 3 mm in the first trimester of pregnancy and the diameter at isthmus (narrowest portion of inlet) is 2 mm throughout pregnancy. This focal narrowing creates a„jet effect" - at least 50% of umbilical venous blood is shunted towards the foramen ovale which ensures that blood with higher oxygen saturation goes to the ascending aorta [2].

The DV is one of the three physiological shunts responsible for circulating adaptation to intrauterine life. It directs half of the oxygenated blood from the umbilical vein into the left atrium through the foramen ovale and from here to the fetal coronary arteries and brain, without mixing with poorly oxygenated blood [2].

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Studies on fetal sheep, under normal conditions, reveal that two-thirds of the umbilical vein blood flow supplies the liver (equivalent to about 70% of total hepatic blood flow), with about one-third passing through the DV [3,4]. In the presence of hypoxia a significant increase in the DV shunting rate results, most probably in order to ensure an adequate supply of oxygen and glucose to vital organs such as the brain and heart [5]. It is assumed that an increase in the DV shunting rate is important for fetal survival during stress situations and an increase in DV flow is an indicator that the fetus is compromised. The early recognition of distressed fetuses is important in obstetrics [1].

Doppler ultrasonography is increasingly being used for the estimation of the blood flow volume rate in prenatal examination [6]. The precision of the method is still a matter of debate; flow measurement and calculation of the DV shunt rate should be regarded with caution, especially in small fetuses [1].

In normal fetuses the DV waveform shows a peak velocity during ventricular systole, another peak during ventricular diastole and a nadir during atrial contraction. The DV pulsatility index for veins is independent of the insonation angle and has proved to be the most reproducible parameter [7].

Modifications of the DV flow have been demonstrated in the presence of chromosomal abnormalities [7], fetal cardiac defects [8], severe oligohydramnios [9] fetal growth restriction, twin-twin transfusion, invasive diagnostic procedures (chorionic villus sampling and fetal blood sampling), fetal anemia and transfusion [10].

Due to the importance of the DV for normal growth of the fetus, the purpose of the study was to evaluate the hemodynamic parameters by Doppler ultrasound in healthy pregnant Pakistani women of 31 to 40 weeks gestation.

The study was approved by our institutional review board, and written consent papers were obtained from all participants.

Material and methods

This study was performed at Afro-Asian Institute of Medical Sciences, Lahore, Pakistan, from July 2008 to July 2009, 100 female patients being enrolled. The mean age was 32 years (between 20-48 years). The gestational age was 31-35 in 47 women, and 36-40 weeks in 53 women. The study was performed transabdominally using Toshiba-Xario & GE-Logic-5P machine, with convex 3.5 MHz transducer. The DV velocity was measured in a sagital sonogram of the fetus by placing the sample volume at the initial or middle portion of the vessel. Cases with reversed flow of the ‘‘A’’ wave of the DV were excluded from the study.

During Doppler studies, the patients lay in a semi recumbent position with a slight lateral tilt. This minimized the risk for developing supine hypotension syndrome due to caval compression. Because during fetal breathing movements there are variations in the shape of the flow velocity waveforms from fetal vessels, Doppler examinations was conducted only during fetal apnea and in the absence of fetal hiccup or excessive movement. Limit exposure was 5 minutes.

For the Doppler study the angle of insonation was beneath 60º; peak systolic velocity (maximum velocity during S wave), peak velocity index (peak velocity S wave minus peak velocity A wave/peak velocity D wave), and S/A ratio (peak velocity S wave/peak velocity A wave) were measured [11].

Data were analyzed using SPSS statistical software package.

Results

All 100 patients were successfully scanned. The peak systolic velocity (PSV), pulsatility index (PI), and S/A ratio were calculated (table I). Fig 1-6 show normal fetus Pulsed Doppler US of the DV and at different gestational ages.

Table I. The means, lower and upper limits of the peak systolic velocity (PSV), pulsatility index (PI), and S/A ratio in the study

Gestational age (weeks)	Mean PSV (cm/s)	Mean PI	Mean S/A
31-35	59.7 (44.3-75.2)	0.7 (0.5-0.9)	2.16 (2.0-2.4)
36-40	72.9 (58.2-93.0)	0.42 (0.25-0.6)	2.46 (2.4-2.7)

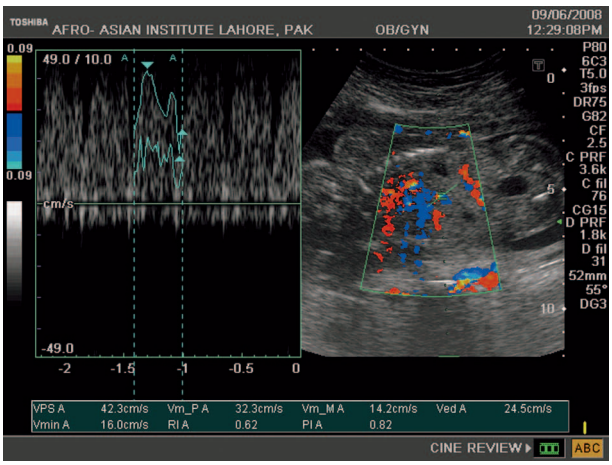


Fig 1. Pulsed Doppler velocity waveform of DV in a 30 weeks fetus

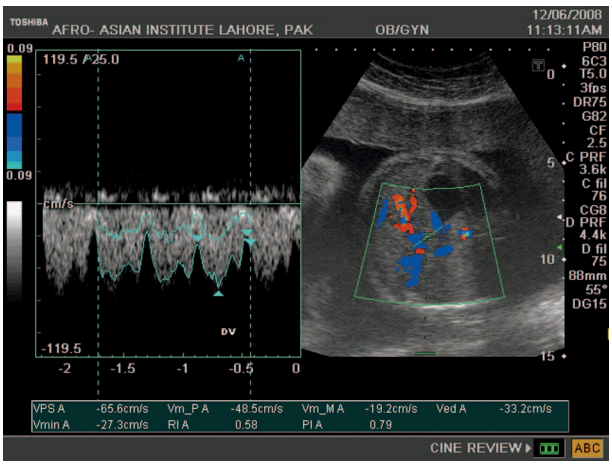


Fig 2. Pulsed Doppler velocity waveform of DV in a 33 weeks fetus

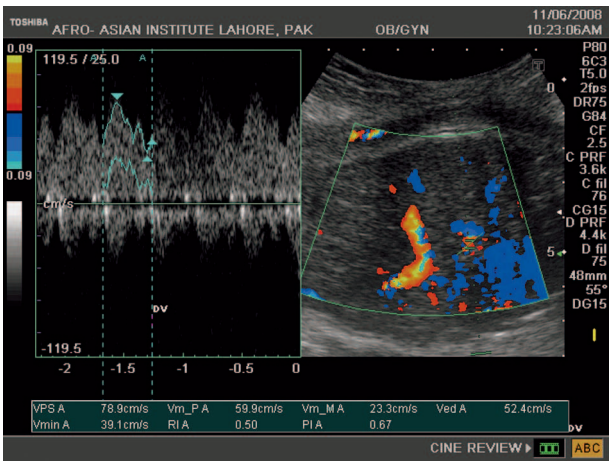


Fig 3. Pulsed Doppler velocity waveform of DV in a 37 weeks fetus

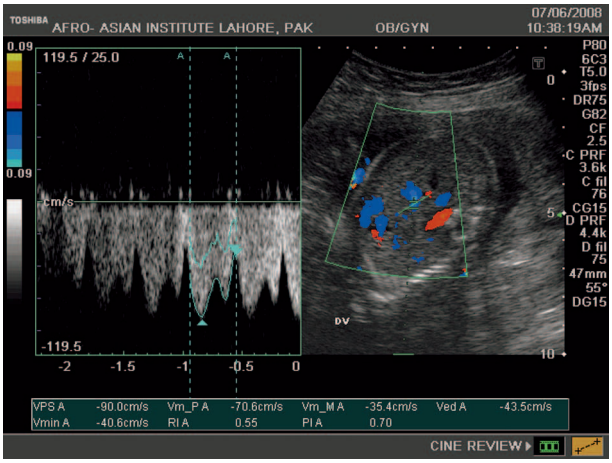


Fig 4. Pulsed Doppler velocity waveform of DV in a 38 weeks fetus

Discussion

In this study we have demonstrated that using the combination of grey scale and color Doppler ultrasound there is a good success rate in identifying the DV at different gestational ages. Umbilical artery Doppler studies are already a routine part of second and third trimester growth and biophysical profile ultrasounds. With a success rate of 94% for sampling the DV it is feasible to incorporate this measurement into routine obstetric ultrasound. For a well trained sonographer this measurement will extend the examination only by 2-3 minutes. In our study the limiting factors for identifying DV were maternal obesity and fetal movements.

The most common misevaluations include incorrect tracing, under- or overestimation of the peak systolic velocity, overestimation of the end-diastolic velocity, and, as a consequence, incorrect calculation of the pulsatility index facilitated either by human or software error [12]. To avoid this kind of difficulty, we selected manual tracing in cases with atypical shape of DV and we marked with attention the end-diastolic velocities.

When comparing the hemodynamic parameters obtained from our normal fetus with data previously published [5,8,9,13] a good agreement between the normal values could be seen: the peak systolic velocities in DV increases while the pulsatility index decreases as pregnancy advances. There is a slight decrease in S/a ratio with advancing pregnancy. These findings are important because this is the first study of the DV in Pakistani healthy pregnant women.

The main limitation of the study is related to the impossibility to monitor the pregnant women until delivery. The comparison of the hemodynamic parameters in different age of the fetus and an unequivocal deliver of a healthy fetus would be of great value. The lack of the appreciation of interobserver variability (the recordings and measurement were done by a single operator) is another limit of the study.

In conclusion evaluation of the DV and measurement the hemodynamic parameters using Doppler ultrasonography should be part from routine obstetric ultrasound examination in the third trimester of pregnancy especially in women having pregnancies with heart abnormalities related with aortic regurgitation.

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