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To Evaluate the Role of Doppler Ultrasonography of Ductus Venosus in Pregnant Women

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ABSTRACT

Background: An abnormal flow pattern of ductus venosus helps in screening fetal cardiac defects and chromosomal abnormalities like Down syndrome. Therefore knowledge of normal ductus venosus Doppler flow pattern parameters is essential. Present study was undertaken to establish normal Doppler flow parameters of ductus venosus. AIM: Ultrasonographic Doppler examination of Ductus venosus and establishing quantitative parameters for ductus venosus doppler assessment in normal fetuses of pregnant women in an Indian population. Study Design: Cross sectional study. **Methods:** A total of 551 patients were examined, out of which 431 were completely normal and were included in the study. The ductus venosus was visualized either in a midsagittal longitudinal plane of the fetal trunk or in an oblique transverse plane through the upper abdomen. Insonation angle was taken as less than 60o and various velocities were measured after observing at least three consecutive waves. Velocity of S wave, D wave and a wave , S/D ratio, Resistivity index and Pulstality Index of ductus venosus were noted. Results were tabulated, subjected to statistical analysis and valid conclusions were drawn. **Results:** There is increase in S-wave velocity with increase in gestational age upto 21-24 weeks, followed by decrease in subsequent two gestational age groups and relative increase in 33-36 weeks of gestational age. There is increase in D-wave velocity with increase in gestational age upto group of 21-24 weeks, followed by decrease in next two gestational age groups. There is slight increase in D wave value in 33-36 weeks gestational age group. There is increase in a-wave velocity with increase in gestational age upto group of 25-28 weeks, followed by decrease in next subsequent gestational age groups. Mean S/D ratio, Resistivity index and Pulstality Index of ductus venosus show ranges of 1.25 to 1.77, 0.16±0.09 to 0.24±0.26 and 0.78±0.46 to 1.34±0.58 respectively across various gestational age groups in our study. **Conclusions:** Ductus venosus is an important fetal channel which needs proper assessment. Recent advancement in ultrasonography has helped us to measure various doppler parameters of ductus venosus accurately to establish normal quantitative parameters. Any significant variations from these can effectively help the clinicians to manage pregnancies and predict the outcome.

Keywords: Ultrasonography, Doppler, ductus venosus, velocities, pregnancies.

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INTRODUCTION

Blood flow coming from the placenta returns to the fetal heart via the umbilical vein, ductus venosus, and inferior vena cava. The ductus venosus plays a major role in regulating the circulation of oxygenated blood from the placenta. 70% to 80% of blood flows through the liver, mainly into the right heart and via the ductus arteriosus and the descending aorta back to the placenta.[1] 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.[2] The blood from the ductus venosus is directed towards the left atrium as a consequence of the anatomical position of the fetal atrial septum, which is located further to the right than in post natal life.[3] In normal fetuses the DV waveform shows a peak velocity during ventricular systole (S wave), another peak during ventricular diastole (D wave) and a nadir during atrial contraction (a wave). The DV pulsatility index for veins (PIV) is independent of the insonation angle and has proved to be the most reproducible.[2]

Doppler recording requires some training and patience to reach a reliable level of skill. Only recordings during fetal quiescence are valid for comparison with currently available reference ranges. When the fetus is lying on its back, mid-sagittal insonation through the fetal abdomen permits visualization of the DV connecting the umbilical vein to the IVC. Color Doppler confirms correct identification. Alternatively, an oblique transverse plane of the abdomen can be used to

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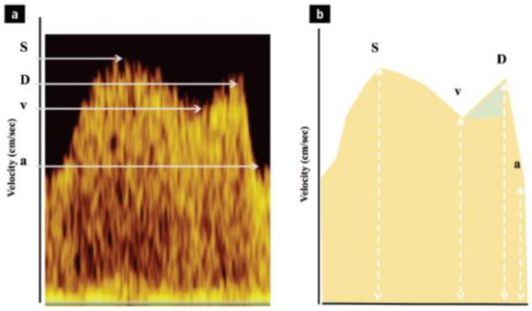
visualize the DV. The DV should not be assessed by scanning through the fetal side, because it will be impossible to obtain an appropriate angle of insonation. Color Doppler settings are adjusted to identify the high velocity of the DV with aliasing (pulse repetition frequency of 2–3 KHz and velocity limit of 30–40 cm/s). The area of interest should be magnified. Pulsed-wave Doppler settings should be adjusted to encompass the DV waveform unbroken, without aliasing. The sample volume should be positioned over the isthmus and adjacent proximal section of the DV, typically measuring 2–5 mm. A wide sample volume ensures recording of the highest velocity during the heart cycle but increases the risk of interference from the umbilical and hepatic veins and IVC.[6]



Ductus Venosus Doppler Indices.[4,5]

Resistive index	Systolic – Diastolic peak velocity ——————————— Systolic peak velocity
DV Pulsatility index for veins (PIV)	Systolic – End Diastolic Velocity (a) ——————————— Time Average Maximum Velocity

Assessment of the blood flow pattern across the DV at 11–13 weeks gestation is useful in screening for major cardiac defects.[7,8] Assessment of the peak velocity index for veins (PVIV) has been demonstrated as a reliable and useful venous Doppler index.[9] Fetal venous Doppler studies represent valuable diagnostic technique that can influence the management of intrauterine growth retardation of fetus as it helps in identification of the fetus at risk for perinatal complications and help in prediction of neonatal complications.[10] In a fetus with Down's syndrome, flow of blood in the ductus venosus (DV) can be abnormal.[11] These changes in DV blood flow velocity represent changes in diastolic function and risk of acidosis. Signs such as negative flow during atrial contraction or abnormally increased pulsatility of the DV have been suggested to determine optimal delivery time in growth restricted foetuses.[12]

Aims and Objectives

The objectives of the present study were :

- To evaluate the role of Doppler assessment of ductus venosus in normal pregnant women.
- To establish the quantitative parameters for ductus venosus Doppler assessment in normal fetuses of pregnant women in an Indian population.

MATERIALS & METHODS

The study was conducted after approval from the institutional thesis and ethical committee. The main source of data for the study was patients from Guru Nanak Dev Hospital attached to Government Medical College, Amritsar from December 2017 to May 2019.

441 normal patients were randomly selected from the referred patients. Imaging was done after PNDT documentations, using low frequency sectoral ultrasound transducer with a range of 3.5-5 Mhz on Color Doppler ultrasound units (Esoate Mylab25Gold, PHILIPS HD11XE, MINDRAY DC 8 and Samsung RS80A) in the Department of Radiodiagnosis and Imaging of Guru Nanak Dev Hospital, Amritsar. Informed consent was taken after explaining the procedure to the patient in her vernacular language. The data obtained was tabulated and subjected to statistical analysis and valid conclusions were drawn.

Inclusion criteria

- All the pregnant patients who came for PNDT examination at PNDT centre Guru Nanak Dev Hospital, Amritsar.

Exclusion criteria

- Critically ill and unstable patients were not included in the study.
- Patients with pregnancy induced hypertension, thyroid disorders, diabetes, anaemia, hepatitis, polyhydraminos, oligohydraminos, labour pains and IUGR.

RESULTS

There is increase in S wave velocity with increase in gestational age upto 21-24 weeks, followed by relative decrease in subsequent two gestational age groups.

There is increase in D wave velocity with increase in gestational age upto 21-24 weeks, followed by decrease in subsequent two gestational age groups. There is relative increase in D wave velocity in 33-36 gestational age group.

The a-wave velocity shows increase from 8.72±5.13 cm/sec (upto 12 weeks of gestational age) to 18.45±15.51 cm/sec (at 25-28 weeks)and then it decrease to 12.59±8.28 cm/sec in later period of gestation.

Table 1: Showing Distribution Of Maternal Age (In Years) And Weight(In Kg) In Gestational Age Groups In Our Study

Gestational age groups (in weeks)	Number of patients	Maternal age (in years) (Mean±S.D.)	Maternal weight (Kg) (Mean±S.D.)
Upto 12	50	24.50±3.43	53.72±3.41
13-16	51	24.61±3.72	54.78±4.25
17-20	53	23.25±3.49	55.43±4.33
21-24	57	23.89±3.49	55.60±4.30
25-28	40	23.25±3.01	55.30±4.33
29-32	69	24.29±3.21	54.28±3.26
33-36	102	24.59±3.51	54.85±3.99
37 and above	9	22.11±2.85	56.78±4.79
Total	431	24.10±3.44	54.87±4.01

Mean±S.D. of maternal age in our study is 24.10±3.44 years.
Mean±S.D. of maternal weight in our study is 54.87±4.01 kgs.

Table 2: Showing Velocity Of S Wave, D Wave, a Wave of Ductus Venosus In Various Gestational Age Groups In Our Study

Gestational age groups (in weeks)	Number of patients	DV S Wave Velocity (cm/s) (Mean± S.D.)	DV D Wave Velocity (cm/s) (Mean± S.D.)	DV a Wave velocity (cm/s) (Mean± S.D.)
Upto 12	50	25.79±11.56	20.36±10.10	8.72±5.13
13-16	51	30.50±12.59	25.63±11.23	10.89±7.03
17-20	53	35.13±13.18	30.18±11.89	13.75±7.33
21-24	57	36.74±15.10	30.56±11.96	15.07±7.70
25-28	40	35.39±17.06	29.64±16.01	18.45±15.51
29-32	69	35.38±16.18	28.54±13.53	15.65±10.26
33-36	102	36.75±14.47	29.63±12.59	15.80±9.70
37 and above	9	32.11±16.54	25.85±13.54	12.59±8.28
Total	431	34.10±14.81	28.02±12.84	14.20±9.61

Table 3: Showing S/D Ratio, Resistivity Index And Pulstality Index Of Ductus Venosus In Various Gestational Age Groups In Our Study

Gestational age groups (in weeks)	Number of Patients	DV S/D Ratio (Mean± S.D.)	DV RI (Mean± S.D.)	DV PIV (Mean± S.D.)
Upto 12	50	1.46±1.29	0.24±0.18	1.34±0.58
13-16	51	1.48±1.47	0.18±0.16	0.95±0.39
17-20	53	1.27±0.32	0.18±0.17	0.79±0.38
21-24	57	1.41±1.54	0.16±0.09	0.85±0.55
25-28	40	1.25±.26	0.16±0.11	0.78±0.46
29-32	69	1.77±2.84	0.23±0.32	0.83±0.49
33-36	102	1.26±0.28	0.24±0.26	0.92±1.12
37 and above	9	1.26±0.21	0.19±0.11	1.05±0.86
Total	431	1.69±6.03	0.21±0.21	0.92±0.71

Mean S/D ratio range from 1.25±0.26 to 1.77±2.84 in our study across different gestational age groups.

Mean±S.D. of resistivity index (RI) of ductus venosus in our study groups range from 0.16±0.09 to 0.24±0.26.

Mean±S.D. of pulsatility index of ductus venosus (PIV) ranges from 0.78±0.46 to 1.34±0.58 in our study groups.

DISCUSSION

S-WAVE VELOCITY

We found the mean of S-wave velocity in upto 12 weeks pregnancies to be 25.79±11.56 cm/sec. Our study is comparable to study conducted by Prefumo F et al,[13] (27-33.6cm/sec).

In pregnancies of 13-16 weeks, mean S-wave velocity in our study is 30.5±12.59 cm/sec. In a study performed by Tseng CC et al,[14] the result for S-wave velocity in 12-16 weeks of pregnancies was 25-50 cm/sec.

In our study, mean S-wave velocity in 17-20 weeks of gestational age group is 35.13±13.18cm/sec, in 21-24 weeks is 36.74±15.10 cm/sec, in 25-28 weeks is 35.39±17.06cm/sec, in 29-32 weeks is 35.38±16.18 cm/sec and in 33-36 weeks is 36.75±14.47 cm/sec. In a similar study conducted by Gilani SA et al,[2] S-wave velocity in 20-25 weeks was 33.5 (24.6-42.5)cm/sec, in 26-30 weeks was 42.3 (27.1-57.5) cm/sec and in 31-35 weeks was 59.6 (44.2-75.1) cm/sec.

Mean S-wave velocity in pregnancies of gestational age 37 and above weeks is 32.11±16.54 cm/sec in our study.

There is increase in S-wave velocity with increase in gestational age upto 21-24 weeks, followed by relative decrease in subsequent two gestational age groups.

D-WAVE VELOCITY:

In pregnancies upto 12 weeks of gestational age, the mean value of D-wave velocity in our study (20.36±10.10 cm/sec) is comparable to study conducted by Prefumo F et al,[13] (D-wave velocity was 15.40 cm/sec).

In 13-16 weeks of pregnancies mean D-wave velocity is 25.63±11.23 cm/sec, in 17-20 weeks D-wave velocity is 30.18±11.89 cm/sec, in 21-24 weeks D-wave velocity is 30.56±11.96cm/sec, in 25-28 weeks D-wave velocity is 29.64±16.01 cm/sec, in 29-32 weeks D-wave velocity is 28.54±13.53 cm/sec, in 33-36 weeks D-wave velocity is 29.63±12.59 cm/sec and for pregnancies 37 and more weeks of gestational age D-wave velocity is 28.85±13.54 cm/sec.

There is increase in D-wave velocity with increase in gestational age upto 21-24 weeks, followed by decrease in subsequent two gestational age groups. Relative increase is present in D wave velocity in 33-36 gestational age group.

a-WAVE VELOCITY:

In our study, for pregnancies upto 12 weeks, mean a-wave velocity is 8.72±5.13 cm/sec. Our results is comparable to study conducted by Teixeira LS et al,[16] (a-wave velocity is 3-10 cm/sec) and by Prefumo F et al,[13] (a-wave velocity is 5.9-7.8 cm/sec).

Our results in pregnancies of 13-16 weeks show a-wave velocity to be 10.89±7.03 cm/sec, in 17-20 weeks a-wave velocity is 13.75±7.33 cm/sec, in 21-24 weeks a-wave velocity is 15.07±7.07 cm/sec, in 25-28 weeks a-wave velocity is 18.45±15.51 cm/sec, in 29-32 weeks a-wave velocity is 15.65±10.26 cm/sec and in 33-36 weeks a-wave velocity is 15.80±9.70 cm/sec.

There is increase in a-wave velocity with increase in gestational age groups upto 25-28 weeks followed by decrease in next subsequent gestational age groups.

S/D RATIO

In our study, upto 12 weeks of pregnancies the mean value for S/D ratio is 1.46±1.29 which is comparable to study conducted by Turan OM et al,[17] (the value for S/D ratio was 1.00-1.27).

In pregnancies of gestational age 13-16 weeks S/D ratio is 1.48±1.47, in 17-20 weeks S/D ratio is 1.27±0.32, in 21-24 weeks S/D ratio is 1.41±1.54, in 25-28 weeks S/D ratio is 1.25±0.26, in 29-32 weeks S/D ratio is 1.77±2.84, in 33-36 weeks S/D ratio is 1.26±0.28 and in 37 and above weeks S/D ratio is 1.26±0.21.

S/D show range of 1.25±.26 to 1.77±2.84 across various gestational age groups in our study.

Resistivity Index (RI)

In pregnancies of upto 12 weeks mean RI is 0.24±0.18, in 13-16 weeks is 0.18±0.16, in 17-20 weeks is 0.18±0.17, in 21-24 weeks is 0.16±0.09, in 25-28 weeks is 0.16±0.11, in 29-32 weeks is 0.23±0.32 and in 33-36 weeks is 0.24±0.26. For pregnancies of 37 weeks and above RI is 0.19±0.11.

Pulsatility index of ductus venosus (piv).

We found in our study group the mean value for PIV for pregnancies of upto 12 weeks to be 1.34±0.58, which is comparable to a study done by Teixeria LS et al16 (0.9-1.3) and Turan OM et al,[17] (0.6-1.4).

For pregnancies of gestational age 13-16 weeks, the mean value for PIV in our study is 0.95±0.39, which is comparable to a study done by Turan OM et al,[17] (the value for PIV in pregnancies of 12-16 weeks was 0.8-1.0).

In our study for pregnancies 17-20 weeks the mean value for PIV is 0.79±0.38. In a study done by Turan OM et al,[17] the mean value for PIV in 16-20 weeks of pregnancies was 0.67-0.83. In another study by Pokharel P et al,[18] the range of mean value for PIV in pregnancies of gestational age 16-20 weeks was 0.36- 0.47.

In pregnancies of 21-24 weeks the mean value for PIV is 0.85±0.55, in 25-28 weeks is 0.78±0.46 and in 29-32 weeks pregnancies mean PIV is 0.83±0.49. Our results are comparable to study done by Turan OM et al,[17] (PIV in pregnancies of 20-24 weeks was 0.54-0.69, in 24-28 weeks was 0.54-0.58 and in 28-32 weeks was 0.51-0.57). In another study by Pokharel P et al,[18] the mean value for PIV in pregnancies of 20-24 weeks was 0.40- 0.42, in 24-28 weeks was 0.39- 0.50 and in 28-32 weeks was 0.37-0.49.

In a study performed by Gilani SA et al,[2] the mean value of PIV for pregnancy of 20-25 weeks is 1.05 (0.7-1.4) and in pregnancies of 26-30 weeks is 0.9 (0.6-1.2).

For 33-36 weeks of pregnancies the mean value for PIV is 0.92±1.12. In a study done by Turan et al17 the value for PIV in pregnancies of 32-36 weeks was 0.52-0.55, therefore our results are comparable. Another study by Gilani SA et al,[2] the value for PIV for pregnancies of 31-35 weeks was 0.7 (0.5-0.9).

For pregnancies of 37 weeks and above, the mean value for PIV is 1.05±0.86. In a study done by Turan et al,[17] the value for PIV in pregnancy greater than 36 weeks was 0.47-0.53, therefore our results are comparable. In another study by Borrell et al,[11] the value for PIV for pregnancies of 36-40 weeks geastational age was 0.42 (0.25-0.6).

CONCLUSION

Ductus venosus is an important fetal channel which needs proper assessment. Recent advancements in ultrasonography have helped us to measure various parameters of ductus venosus accurately which can effectively help the clinicians to predict the outcome and management of pregnancies.

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ABBREVIATIONS

DV	=	Ductus Venosus
DVPI	=	Ductus Venosus Pulstality Index
IUGR	=	Intrauterine Growth Retardation
PI	=	Pulstality Index
PIV	=	Pulstality Index of Veins
PRF	=	Pulse Repetition Frequency
PVIV	=	Peak Velocity Index for Veins
RI	=	Resistivity Index
TAMX	=	Time Averaged Velocity