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Original Research Article

The Role of Fetal Ductus Venosus Doppler in Anticipating Pregnancy Outcomes

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Abstract:

Background and Aim: The identification of an abnormal flow pattern in the ductus venosus serves as a valuable tool in the screening process for foetal cardiac defects and chromosomal abnormalities, including Down syndrome. Understanding the parameters of a normal ductus venosus Doppler flow pattern is crucial. This study aimed to assess the significance of the ductus venosus pulsatility index in early pregnancy as a predictor of adverse pregnancy outcomes.

Material and Methods: A total of eighty pregnant women, each carrying a single viable foetus between 13 and 24 weeks of gestation, took part in this prospective cross-sectional study conducted over the course of one year at a Tertiary Care Teaching Institute in Gujarat, India. Routine ultrasound examination encompasses the assessment of the placental site and the measurement of the crown-rump length (CRL). Assess the biparietal diameter, femur length, and abdominal circumference to confirm gestational dating during the first trimester and in specific cases during the second trimester.

Results: The findings indicate that in the normal group, there were 3 cases (4.41%) with non-regular cycles, contrasted with 65 cases (95.65%) exhibiting regular cycles. In the abnormal group, the figures were 2 cases (16.6%) for non-regular cycles and 10 cases (83.3%) for regular cycles. In the normal group, there were 32 cases without placenta previa, accounting for 74.4%, compared to 15 cases with placenta previa, which represented 22.05%. In the abnormal group, 10 cases were without placenta previa, making up 83.3%, while 2 cases had placenta previa, corresponding to 16.6%. The analysis revealed no statistically significant difference in pregnancy outcomes, with a p-value greater than 0.05.

Conclusion: Various foetal disorders that could lead to cardiovascular complications and other atypical outcomes in newborns can be effectively managed and anticipated through the use of the DV Doppler examination during the perinatal period.

Keywords: Fetal ductus venosus Doppler**,** First Trimester, Placenta Previa, Pregnancy.

Introduction

The journey of blood flow from the placenta to the foetal heart involves several critical pathways, including the umbilical vein, ductus venosus, and inferior vena cava. The ductus venosus is crucial in managing the flow of oxygen-rich blood from the placenta, highlighting its significance in foetal circulation. Approximately 70% to 80% of blood circulates through the liver, primarily directed into the right heart and returning to the placenta via the ductus arteriosus and the descending aorta. [1] The assessment of blood flow velocity waveforms in the ductus venosus serves as an indirect indicator of foetal cardiac health and functionality. Additionally, the anatomical positioning of the ductus venosus provides insights into the pressure gradient existing between the right atrium and the umbilical vein. The foetal cardiovascular system depends on the ductus venosus to effectively manage the transfer of cardiac output as required. In a limited number of countries, first-trimester screening is mandated as part of prenatal care, highlighting its essential function in detecting

foetal chromosomal and anatomical abnormalities. The measurement of DV blood flow is an optional aspect of first-trimester screening. [2] Doppler ultrasound has emerged as an essential instrument for assessing the blood flow in the foetus and placenta, predicting adverse pregnancy outcomes, and reducing the necessity for emergency interventions, hospitalisations, and extended stays for both mother and child, especially in cases where intrauterine growth restriction (IUGR) may be a concern. [3,4] When the foetus is positioned supine, midsagittal insonation via the foetal abdomen allows for the observation of the ductus venosus linking the umbilical vein to the inferior vena cava. The Colour Doppler technique has successfully verified the accurate identification. Alternatively, an oblique transverse plane of the abdomen serves as a valuable method for visualising the DV. The assessment of the DV should avoid scanning through the foetal side, as achieving an appropriate angle of insonation will be challenging.

The Colour Doppler settings are fine-tuned to detect the elevated velocity of the DV, utilising aliasing with a pulse repetition frequency ranging from 2 to 3 KHz and a velocity limit set between 30 and 40 cm/s. The focus of attention should be expanded. The settings for pulsed-wave Doppler must be fine-tuned to ensure that the DV waveform is captured in its entirety, free from any aliasing effects. The sample volume must be strategically placed over the isthmus and the nearby proximal section of the DV, generally ranging from 2 to 5 mm in measurement.

A broad sample volume guarantees the capture of peak velocities throughout the cardiac cycle; however, it also heightens the potential for interference from the umbilical and hepatic veins, as well as the inferior vena cava (IVC). [5,6] The incorporation of abnormal DV blood flow patterns, specifically an increased pulsatility index for veins, enhances the ability to predict chromosomal abnormalities, major congenital heart defects (CHD), and adverse pregnancy outcomes. These outcomes include miscarriage, stillbirth, small for gestational age, low birth weight, and foetal growth restriction, particularly when integrated into first-trimester screening protocols. [7]

This study aimed to assess the significance of the ductus venosus pulsatility index of veins during early pregnancy as a predictor of adverse pregnancy outcomes.

Materia and Methods

A total of eighty pregnant women, each carrying a single viable foetus between 13 and 24 weeks of gestation, took part in this prospective cross-sectional study conducted over the course of one year at a Tertiary Care Teaching Institute in Gujarat, India.

Inclusion Criteria

- The study included uncomplicated singleton pregnancies with a gestational age ranging from 13 to 24 weeks.

Exclusion Criteria

- Several pregnancies occurring simultaneously.
- Preterm pregnancies.
- Abnormalities in foetal development or the presence of aneuploidy.
- Pregnant women with additional medical conditions such as Diabetes Mellitus or a history of cardiac, liver, or renal disease.

The assessment included a comprehensive collection of personal details such as age, duration of marriage, and any unique habits. It also encompassed menstrual history, including the date of the last menstrual period (LMP), cycle regularity, cycle length, and the flow amount during the last period. Additionally, obstetric history was documented, noting the number of C-sections, any abortions, instances of placenta previa in previous pregnancies, history of ectopic pregnancies, medical disorders associated with pregnancy, and the number of living children. Current medical or obstetric issues were also recorded, alongside any past experiences related to postpartum conditions.

Ultrasound examination

Foetal biometric measurements play a crucial role in the detection of congenital deformities, including assessments of the ductus. Venosus Doppler assessments were conducted between 13 and 24 weeks, with serial follow-ups. The outcomes were confirmed at the time of delivery. Monitoring cases exhibiting abnormal ductus venosus Doppler findings.

Transabdominal ultrasound is a diagnostic imaging technique that utilises sound waves to create images of the organs and structures within the abdomen. This non-invasive procedure is commonly employed to assess various conditions and monitor the health of patients.

Routine ultrasound examination encompasses an assessment of the placental site and the measurement of the crown-rump length (CRL). Assess the biparietal diameter, femur length, and abdominal circumference to confirm gestational dating during the first trimester and in certain cases during the second trimester. To mitigate the risk of contamination from adjacent veins, it is essential that the pulse wave of the Doppler sample volume remains modest, ideally between 0.5 and 1.0 mm, and is positioned within the region exhibiting yellowish aliasing.

The insonation angle should be maintained at less than 30 degrees. Filtering at low frequencies, specifically within the range of 50 to 70 Hz, is employed to mask the a-wave. For optimal evaluation of the waveforms, it is crucial to maintain a high speed of 2-3 cm per second, which facilitates a more effective dispersion of the waveforms.

Statistical Analysis

The collected data was systematically organised and input into a spreadsheet application (Microsoft Excel 2019) before being transferred to the data editor interface of SPSS version 19 (SPSS Inc., Chicago, Illinois, USA). Quantitative variables were characterised by their means and standard deviations or by their median and interquartile range, depending on the distribution observed. Qualitative variables were reported using counts and percentages. The confidence level for all tests was established at 95%, while the level of significance was set at 5%.

Results

This research involved 80 pregnant women carrying a single viable foetus, all within the gestational age of 13 to 24 weeks, and was carried out at the Department of Obstetrics and Gynaecology at a Tertiary Care Teaching Institute in Gujarat.

The demographic data of the studied group is presented in Table 1. The age group of 24-30 years was predominant, comprising 22 individuals (37.5%), with a mean age of 28.5±5.30. Additionally, the duration of marriage between 3-5 years was the most common, represented by 45 individuals (56.25%), with a mean duration of 3.50±1.20. The distribution of the studied groups concerning pregnancy outcomes is illustrated in Table 2. In the analysis, 68 cases were classified as normal, accounting for 85% of the total, whereas 12 cases were deemed abnormal, representing 15%.

The age of participants in the normal group varied from 20 to 35 years, with an average of 28.50±4.20. In contrast, the abnormal group had ages ranging from 20 to 32 years, with a mean of 26.34±3.89. The analysis revealed no statistically significant difference in pregnancy outcomes when considering basic demographic and maternal data ($p>0.05$). The analysis revealed no statistically significant difference in pregnancy outcomes when considering basic demographic and maternal data ($p>0.05$).

Table 3 illustrates the distribution of menstrual cycle regularity among the study groups. In the normal group, there were 3 cases (4.41%) classified as non-regular cycles, contrasted with 65 cases (95.65%) identified as regular cycles. Conversely, the abnormal group presented 2 cases (16.6%) of non-regular cycles and 10 cases (83.3%) of regular cycles.

In the normal group, there were 32 cases without placenta previa, accounting for 74.4%, while 15 cases, or 22.05%, had placenta previa. In the abnormal group, 10 cases, representing 83.3%, were without placenta previa, and 2 cases, or 16.6%, had the condition. The analysis revealed no statistically significant difference in pregnancy outcomes, with a p-value greater than 0.05.

Table 1: Demographic data of the study group

Age (Years)	Number	Percentage (%)
Less than 24	22	27.5
24-30	30	37.5
More than 30	28	35
Duration of marriage (years)		
< 2	21	26.25
3-5	45	56.25
<5	14	17.5

Table 2: Distribution of the studied groups regarding the outcome of pregnancy

Variable	Number	Percentage
Normal	68	85
Abnormal	12	15
Congenital heart defects	4	33.3
Congenital malformation (trisomy 21)	2	16.6
Low birth weight	5	41.6
Stillbirth	1	8.33
Total	80	100

Table 3: Comparison between outcomes of pregnancy

Variable	Pregnancy Out come				P value
	Normal (n=68)		Abnormal (n=12)		
	Number	Percentage	Number	Percentage	
Regularity of the cycle					
Non regular	3	4.41	2	16.6	0.52
Regular	65	95.65	10	83.3	
Placenta previa in previous pregnancy					
No	53	77.9	10	83.3	0.09
yes	15	22.05	2	16.6	
History of ectopic					
No	64	94.11	12	100	0.22
yes	4	5.88	0	0	
Present history of obstetric problems					
No	48	70.58	7	58.33	0.42
yes	20	29.41	5	41.66	
Past history of obstetric problems					
No	54	79.41	9	75	0.11
yes	14	20.58	3	25	
Contraceptive history					
No	51	75	7	58.33	0.29
yes	17	25	5	41.66	
Family history					
No	55	80.88	9	75	0.09
yes	13	19.11	3	25	

Discussion

Preeclampsia is a condition characterised by acute hypertension that arises specifically during pregnancy, affecting only human females. This condition is marked by high blood pressure accompanied by protein in the urine and/or swelling during the latter part of pregnancy or shortly after childbirth, with associated risks to maternal mortality linked to pregnancy. [8] Severe placental insufficiency is associated with significant early and extreme growth restriction. Regular Doppler assessments of the umbilical artery, middle cerebral artery, and ductus venosus play a crucial role in the surveillance of at-risk pregnancies. A significant number of severely compromised foetuses exhibit pathological venous velocimetry, particularly characterised by heightened pulsatility in the ductus venosus, indicating potential myocardial dysfunction.

In the analysis, a total of 68 cases, representing 85%, were classified as normal and valid, whereas 12 cases, accounting for 15%, were deemed abnormal. The ultrasound results indicated a notable reduction in the PI and S/A ratio in the abnormal group compared to the normal group, with cutoff values established at less than 0.55 for PI and less than 1.90 for the S/A ratio. Recent research conducted over the past decade utilising cordocentesis has identified a link between abnormal DV Doppler readings and foetal acidity levels. Rizzo and colleagues developed an area under the ROC curve demonstrating a sensitivity of 72% and a specificity of 60% for predicting hypoxaemia, utilising the DV ratio of the S/atrial systole (A) at 0.66.9At the time of delivery, acidosis can be identified with remarkable sensitivity of 100%, though it presents a specificity of 57% and an overall accuracy of 80% when employing a DV RI threshold of 0.29. Furthermore, individuals with a DV RI greater than 0.29 faced a risk of neonatal acidosis that exceeded three times that of those with a level of 0.29. A study conducted by Allam et al. found that the MCA S/D ratio was an effective Doppler parameter for predicting acidosis during delivery. The researchers established a cut-off value of 4.37, which demonstrated a sensitivity of 87.5%, specificity of 64%, and an accuracy of 77%. [9]

Hecher et al. [10] indicate that the Doppler velocimetry (DV) does not consistently change prior to non-stress tests (NST); however, most authors suggest that DV is a reliable indicator of changes that occur before alterations in other biophysical assessments. Currently, the ductus venosus (DV) appears to be one of the most effective indicators for monitoring compromised foetuses, playing a crucial role in determining the appropriate timing for delivery. Numerous studies have shown that venous Doppler, especially the DV, can effectively predict negative perinatal outcomes. Despite the importance of understanding neonatal acidosis, research utilizing DV Doppler for its prediction remains limited, and there is a lack of agreement on the most effective parameters and cut-off values for this purpose. [11,12]

This prediction is crucial as foetal metabolic acidosis represents the final event preceding death in foetuses experiencing growth restriction. Over the past ten years, numerous studies have utilised cordocentesis to establish a connection between abnormal DV Doppler readings and foetal acidosis. Due to the increased likelihood of complications in these already vulnerable foetuses, cordocentesis has not been integrated into standard care protocols for managing these situations. Rizzo et al. [13] calculated an area under the ROC curve for predicting hypoxaemia, revealing a DV ratio of the S/atrial systole (A) at 0.66, accompanied by a sensitivity of 72% and a specificity of 60%. Romero et al. [14] demonstrated that the MCA PI has traditionally been regarded as the benchmark for evaluating foetuses with intrauterine growth restriction (IUGR). The findings indicate that the MCA peak systolic velocity (PSV) not only enhances the insights offered by the MCA pulsatility index (PI) but also delivers more precise information compared to the MCA PI. In foetuses with intrauterine growth restriction (IUGR) exhibiting an abnormal middle cerebral artery pulsatility index (MCA PI) alongside a normal middle cerebral artery peak systolic velocity (MCA PSV), the severity of the IUGR condition is comparatively milder than in instances where both parameters are abnormal. As the condition of intrauterine growth restriction (IUGR) worsens, there is a notable increase in the middle cerebral artery peak systolic velocity, leading to abnormal readings. A 2010 comprehensive evaluation of the relevant literature indicates that when placental insufficiency impacts a pregnancy, an abnormal DV Doppler offers a moderate level of accuracy in predicting compromised foetal and neonatal health, as well as perinatal death. [15] The standard measures of prenatal outcomes, gestational age and foetal weight, emerged as the most reliable predictors of morbidity and mortality. The atypical DV Doppler used for mortality prediction stood out as an exception. This finding aligns with several previous studies. [16] The study faced a notable limitation due to its small sample size. Foetal venous Doppler studies are important diagnostic tools that can significantly impact the management of intrauterine growth-restricted foetuses. These studies assist in identifying foetuses at risk for perinatal complications and aid in predicting potential neonatal issues.

Conclusion

Numerous foetal disorders that might result in cardiovascular deterioration and other aberrant outcomes in newborns can be managed clinically and predicted perinatally using the DV Doppler examination.

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