



Early Detection of Fetal Minor Cardiac Anomalies in High-Risk Pregnant Women Using Doppler Measurements of Ductus Venosus

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Article Info

Abstract:

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Background: Ductus venosus (DV) is a very essential regulator of oxygenated blood in fetal life, an essential component of assessing prenatal fetal cardiac activity is DV evaluation. It is a useful technique for prenatal congenital heart disease (CHD) screening and diagnosis. **Objective:** To evaluate the DV abnormal measurements by Doppler ultrasonography and their value to improve the prediction of fetal CHD in pregnant women. **Methods:** study Was carried out on 142 fetuses from 114 cases of pregnant women (28 of them had twin) with a risk factor for fetal congenital heart diseases were subjected to 1st trimester scan for detection of ductus venosus abnormality, this was followed by 2nd trimester fetal echocardiography to detect minor CHD, by using 2D ultrasound for anomaly scan and complementary by 3D. **Results:** our study revealed that 97.2% of the study population had (Normal A wave) normal ductus venosus, and 2.8% had

abnormal A wave. Regarding the heart anomalies; (97.9%) of the study population had a normal heart scan, and 2.1% had abnormal heart scan in the form of atrioventricular septal defect (AVSD-VSD). There was a substantial correlation between prenatal echocardiography-detected heart abnormalities and ductus venosus waveforms. The cardiac defect was observed in 3 fetuses (2.1%) and 2 of these had abnormal Doppler waveforms in the ductus venosus.

Conclusion: Our study concluded that there was a substantial correlation between prenatal echocardiography-detected heart abnormalities and ductus venosus waveforms.

1. Introduction:

The inferior vena cava and the intra-abdominal umbilical vein are connected by the fetal ductus venosus. The ductus venosus directs the blood from the placenta via the umbilical vein to the inferior vena cava, where it empties into the right atrium before traveling via the foramen ovale (FO) to the left side of the heart. (1).

20% to 30% of the placenta's oxygenated blood passes through the ductus venosus and into the inferior vena cava. (2) With a frequency of up to 8 per 1000 live births, cardiac problems are the most prevalent birth defects, with serious cardiac anomalies accounting for half of these cases. (3).

Numerous genetic and environmental factors have been linked to the development of congenital heart disease (CHD), according to a number of studies. Moreover, a few risk factors have been found, including retinoic acid consumption, rubella, phenylketonuria, and the use of particular medications. (4). CHD is associated with the highest rates of death and morbidity in prenatal and newborns. (5).

An essential part of right ventricular hemodynamics and preload is DV blood flow. An essential component of assessing prenatal fetal cardiac activity is ductus venosus evaluation. It is an important first diagnostic and screening tool for chromosomal abnormalities linked to

prenatal congenital heart disease (CHD). (6).

One method that has been utilized to evaluate fetal hemodynamics is Doppler ultrasonography. Both qualitative results and quantitative metrics are used to represent ultrasonography. The qualitative results of DV characterize the blood flow pattern, whether it is reversed, absent, or present. The quantitative measures, such as the pulsatility index (PI) and systolic-to-diastolic ratio (S/D), are regarded as Doppler indices. (7).

Although fetal echocardiography guidelines that evaluate the atria, ventricles, pulmonary venous return, and the ductal and aortic arches have been developed. Fetal echocardiography is a very sophisticated and time-consuming examination that takes much skill to perform. DV Doppler is a straightforward screening tool that could increase the rate of CHD identification.

2. Patients and methods:

This study Was carried out on 142 fetuses from 114 cases of pregnant women (28 of them had twin). All the patients were enrolled from Beni-Suef University Hospital and other specialized centers in the period from 2020 to 2022. Ethical approval was sought from Bani-Suef University Ethical committee with Approval

No:

FMBSUREC/03052020/Hussein. This study is a cross sectional Comparative one.

Inclusion criteria:

- Pregnant women between 11 weeks - 13weeks +6 days gestation (1st trimester) and between 18-24weeks (2nd trimester).
- women with factors for fetal CHD.

Exclusion criteria:

- Uncertain gestational age (GA).
- Women who were absent during the patient follow-up process.
- Women who underwent elective termination.
- Women who did not have risk factor.

Risk factors for fetal congenital heart disease included:

- Maternal teratogen exposure (drug-related) like anticonvulsants, lithium, ACE inhibitors and exposure to prostaglandin synthetase inhibitors (ibuprofen and salicylic acid).
- Autoimmune disorder like systemic lupus erythematosus and rheumatoid.
- Assisted conception or In vitro fertilization.
- Obesity defined as a body mass index (BMI) greater than or equal to 30 kg/m².

After taking detailed history from pregnant women, all selected women were subjected to:

<https://ejmr.journals.ekb.eg/>

- First trimester scan (at 11weeks-13weeks+6days): using trans-abdominal Doppler ultrasound Voluson P8, where several ductus venosus hemodynamic parameters were assessed.
- Second trimester scan (at18-24 weeks): using the same machine, 2D ultrasound for cardiac anomaly scan and complementary 3D.

The first trimester scanning include:

- The crown-rump length of fetuses (CRL).
- Nuchal translucency (NT) thickness.
- Fetal heart rate (FHR).
- DV assessment.

The second trimester scanning include:

- Early fetal echocardiography performed (Four, five chamber and three vessel views).

3. Result:

This study Was carried out on 142 fetuses from 114 cases of pregnant women (28 of them had twin), Final number of examined fetuses were 142. To evaluate the ductus venosus abnormal measurements by Doppler ultrasonography and their value to improve the prediction of fetal CHD in high-risk pregnant women.

Table (1) maternal risk factors among the studied participants:

Items	Total (no=142)
Age	29.2 ±5.1
<35	116 (81.7%)
≥35	26 (18.3%)
Twin	28 (19.7%)
Metabolic disorder	6 (4.3%)
History of CHD in 1st degree	5 (3.5%)
Taking drugs	12 (8.5%)
Maternal infection	12 (8.5%)
Positive consanguinity	12 (8.5%)
Obesity	11 (7.7%)
Autoimmune disorder	3 (2.1%)
Assisted conception	73 (51.4%)

Table (2) Parameters of fetal Doppler US in the first trimester:

Items	Total (no=142)	
	No	%
Crown rump length	70.6 ± 8.52	
Normal	142	100
Abnormal	0	0
Fetal heart rate	159.3 ± 6.7	
Normal	142	100
Abnormal	0	0
Nuchal translucency	1.8 ± 0.4	
Normal	141	100
Abnormal	1	0.7
Peak systolic velocity	33.2 ± 8.7	
Normal	142	100
Abnormal	0	0
Peak diastolic velocity	30.6 ± 7.9	
Normal	142	100
Abnormal	0	0
Shape of a wave		
Normal	138	97.2
Abnormal	4	2.8
Maximum Velocity during atrial contraction	8.2 ± 3.6	
Time Avg. velocity	27.1 ± 7.3	
Pulsatility index of Vein	0.9 ± 0.1	
Peak Velocity Index of vein	0.82 ± 0.17	

This table showed that the A wave was abnormal in 4 cases; 3 of them was reversed and 1 with absent a wave.

Table (3) Parameters of fetal echo in the second trimester:

Items	Total (no=142)	
Gestational age	21.1±1.4	
Echo		
Normal	139	97.9
CHD(AVSD-VSD)	3	2.1

Table (4) Comparison between normal and abnormal ECHO in 2nd trimester regarding 1st trimester parameters:

1st trimester		Mean	Std. Deviation	P-value
FHR	Normal (no=139)	159.2662	6.80534	.438
	Abnormal (CHD) (no=3)	162.3333	2.51661	
NT	Normal (no=139)	1.8029	.35893	.645
	Abnormal (CHD) (no=3)	1.9700	.53589	
MAV	Normal (no=139)	8.3099	3.53646	.004*
	Abnormal (CHD) (no=3)	2.2100	4.45687	
TAV	Normal (no=139)	27.2124	7.26701	.245
	Abnormal (CHD) (no=3)	22.2400	8.86785	
PIV	Normal (no=139)	.9286	.13211	.100
	Abnormal (CHD) (no=3)	1.0567	.15044	
PVIV	Normal (no=139)	.8195	.11338	.007*
	Abnormal (CHD) (no=3)	1.0000	.14177	
	Abnormal (CHD) (no=3)	21.3333	.57735	

This table showed that there was a significant lower mean MAV, and higher PVIV in patients with VSD than normal cases in the echo of 2nd trimester. *P-value is significant in these items.

Table (5) Sensitivity, specificity, PPV, NPV of a wave in the prediction of CHD in the echo of 2nd trimester:

a- wave		Fetal echo 2 nd		Total
		Normal	Abnormal (CHD)	
Normal	Count	137	1	138
	% within a-wave	99.3%	0.7%	100.0%
	% within fetal echo	98.6%	33.3%	97.2%
Abnormal (absent or reversed)	Count	2	2	4
	% within a-wave	50.0%	50.0%	100.0%
	% within fetal echo	1.4%	66.7%	2.8%
Total	Count	139	3	142
	% within a-wave	97.9%	2.1%	100.0%
	% within fetal echo	100.0%	100.0%	100.0%

This table showed that the sensitivity, specificity, PPV & NPV of a wave in prediction of CHD in the echo of 2nd trimester were 66.7%, 98.6%, 50%, and 33.3%.

Table (6) Risk factors associated with CHD.

Items	Normal (no=139)	CHD (no=3)	P-value
Age	29.2±5.1	25±3	0.148
<35	113(81.3%)	3(100.0%)	0.543
≥35	26(18.7%)	0(0.0%)	
Assisted pregnancy	73(52.5%)	0(0.0%)	0.112
Metabolic disorder	6(4.4%)	0(0.0%)	0.710
history of CHD in 1st degree	5(3.6%)	0(0.0%)	0.738
taking drugs	12(8.6%)	0(0.0%)	0.595
Maternal infection	10(7.2%)	2(66.7%)	0.019*
Positive consanguinity	10(7.2%)	1(33.3%)	0.216
Obesity	11(7.9%)	0(0.0%)	0.784
autoimmune disorder	3(2.2%)	0(0.0%)	0.797

*P-value is significant, this table showed that There was also a significant relation between maternal infection and CHD.

4. Discussion:

The most frequent congenital anomalies are heart and great artery abnormalities, which cause About 20% of stillbirths and 30% of newborn fatalities are caused by congenital defects. While specialized fetal echocardiography can diagnose the majority of severe heart abnormalities in utero, standard pregnancy ultrasound screening misses most affected fetuses. (8).

The heart receives its supply of highly oxygenated umbilical venous blood from the ductus venosus. Because of its waveform's relationship to

pressure-volume variations in the cardiac atria, it is crucial for tracking any fetal conditions that might have an impact on forward cardiac function. (9).

The early prediction of congenital cardiac disorders is improved by using the DV Doppler into first-trimester nuchal translucency screening. DV A-wave reversal or absence in the first trimester indicates fetal risk for CHD in fetuses with high nuchal translucency that are chromosomally normal. (10).

This study Was carried out on 142 fetuses from 114 cases of pregnant

women. In our study the mean maternal age was 29.2 ± 5.1 (range, 19-40) and the mean crown-rump length was 70.6 ± 8.52 (range, 40-89) mm. The results of the current study are in good agreement with the results of several studies, but differed from the results generated by others. **Chelemen et al., 2011** revealed that the median mother age was 31 (range 14-51) years, and the CRL was between 45 and 84 mm.

Data of the current study show that the mean Nuchal translucency was (1.8 ± 0.4) ranged from 1.0 – 3mm.

Chelemen et al., show that aberrant flow in the ductus venosus is seen in fetuses with significant cardiac abnormalities, both in those with elevated and normal NT (11). As a result, the efficacy of early heart defect screening ascertained using fetal NT measurement enhanced through evaluation of ductus venosus flow. Thirty-five of the euploid fetuses in the research showed major cardiac problems, whereas the remaining forty, 905 did not. In 30 (35.3%) and 18 (21.2%) of the fetuses with cardiac problems and 1,956 (4.8%) and 290 (0.7%) of the fetuses without cardiac disorders, respectively, the fetal NT was above the 95th and 99th centiles. Reversed A-waves were observed in 856 (2.1%) of the fetuses without cardiac

issues and in 24 (28.2%) of the newborns with cardiac problems. Specialized fetal echocardiography would identify 38.8% of severe cardiac anomalies in patients with NT above the 99th centile and those with inverted a-wave, independent of NT, with an overall false positive rate of 2.7%. (11).

The results of the current study revealed that 138(97.2%) of the study population had (Normal A wave) of ductus venosus, and 4 (2.8%) had (abnormal A wave), two of them had cardiac anomalies (VSD, A-VSD)

Regarding our study 139(97.9%) of the study population had normal heart scan, and three (2.1%) had an abnormal heart scan.

Among the three cases with cardiac anomalies, two of them had abnormally ductus venosus a-wave, with one of them had abnormal increasing in NT thickness and two cases with cardiac anomalies had normal NT thickness and normal ductus venosus a-wave.

Our findings are in line with earlier research on the application of the DV waveform in CHD screening. In their meta-analysis, Papatheodorou et al. found a 50% overall detection rate and a 7% false-positive rate. They also noted that the test performance was dependent on NT measurement; in fetuses with a

normal NT, the false-positive rate was 4% in comparison to 20% in fetuses with increased NT. About 41000 normal fetuses and 85 fetuses with heart abnormalities were included in the largest investigation on this topic. According to the authors, 2.1% of the normal population and roughly 30% of the impacted individuals had the DV a-wave reversed. (10).

Increased nuchal translucency (>95th centile for crown-rump length) was linked to 29 of 998 fetuses that were thought to be chromosomally normal, whose flow during atrial contraction was either reversed or absent. Among these 29 fetuses, nine had significant heart abnormalities. No other substantial cardiac abnormalities were seen, even in chromosomally normal fetuses with aberrant ductus venosus velocimetry or increased nuchal translucency alone. Therefore, he concluded that in chromosomally normal fetuses with heightened nuchal translucency, assessment of ductus venosus blood flow velocimetry could improve the prediction ability for an underlying severe cardiac defect. (12) Even when chromosomally normal fetuses had aberrant ductus venosus velocimetry or elevated nuchal translucency alone, no other significant cardiac abnormalities

were discovered. Thus, he came to the conclusion that evaluation of ductus venosus blood flow velocimetry could enhance the prediction ability for an underlying significant cardiac abnormality in chromosomally normal fetuses with enhanced nuchal translucency. (12)

We discovered a strong link between CHD and maternal infection with a **significant P-value (0.019)**. In parallel with our results, *Ye, et al., 2019* A meta-analysis comprising 17 case-control studies revealed that moms who contracted a virus during their early pregnancy had a markedly higher chance of their offspring getting congestive heart failure (CHD) in comparison to mothers who did not have a viral infection (13). On the other hand, *Li et al., 2016* found no statistically significant differences in the incidence of CHD between moms who were infected with a virus and those who were not; in fact, one study found a considerably lower risk of CHD. (14).

Limitation of our study:

Our study was subjected to several limitations, which should be considered when interpreting the results:

1. The sample size of the study was not that large to cover all the possibilities.

2. Decrease knowledge of patients about 1st trimester scan.
3. The acquisition of the image requires an expert operator & proper fetal position.

5. Conclusion :

Echocardiography revealed an extremely substantial correlation between ductus venosus waveforms and heart abnormalities., denoting the importance of performing 1st trimester scan on ductus venosus followed by 2nd trimester fetal echocardiography for early detection of CHD in high-risk pregnant women.

Case presentation:

Case 1:

Clinical picture: 22 years old pregnant woman in 1st trimester with single fetus, average BMI, with history of positive consanguinity, not diabetic or HTN.

1st trimester scanning show:

- ***GA: 12+4days wk.***
- ***CRL: 50 mm.***
- ***NT: 1.6 mm.***
- ***DV Doppler: a –wave was absent.***



2nd trimester scanning show Fetal heart echo show: A-VSD.



Case 2:

25 years old pregnant woman in 1st trimester with single fetus, BMI more than 30, not diabetic or HTN.

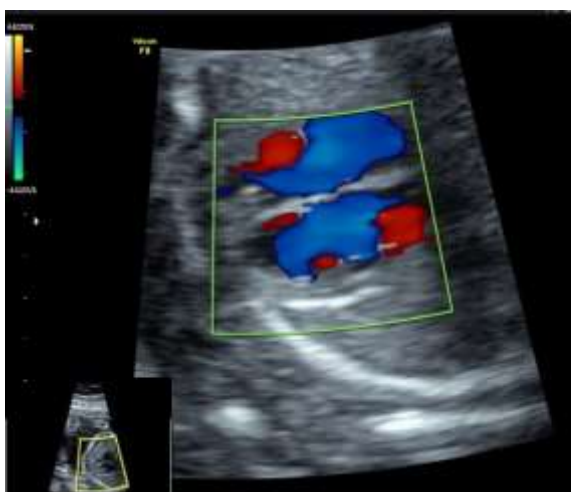
1st trimester scanning show:

- ***GA was 12 weeks +1day.***
- ***CRL: 58.1 mm.***
- ***NT: 3 mm.***
- ***DV Doppler: a –wave was reversed.***



2nd trimester scanning show:

**Fetal heart echo at 18wk +3days show:
normal.**



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