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Findings On Prenatal Echocardiography Suggesting The Risk Of Cardiac Anomaly In Neonates-An Observational Study

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Abstract

Background: Congenital heart disease (CHD) is one of the most common congenital anomalies and contributes significantly to neonatal morbidity and mortality. Prenatal fetal echocardiography has become an essential tool for early detection, prenatal counseling, and perinatal management of congenital cardiac abnormalities. This study aimed to evaluate the spectrum of fetal cardiac abnormalities detected on prenatal echocardiography and assess their association with maternal factors, echocardiographic parameters, and neonatal outcomes.

Results: Most pregnant women belonged to the 26–31-year age group, with a mean maternal age of 27.21 ± 4.04 years. The majority were multigravida and multiparous, and fetal echocardiography was commonly performed between 16–35 weeks of gestation. Most participants had no significant maternal risk factors, although consanguinity was present in 38.96% of cases. Normal fetal cardiac findings were observed in 72.73% of fetuses, while 27.27% showed cardiac abnormalities, with echogenic intracardiac focus being the most common finding. Mild anomalies predominated among abnormal cases. No significant association was observed between maternal age or maternal risk factors and fetal cardiac anomalies. Significant associations were noted between prenatal diagnosis, neonatal outcomes, and echocardiographic parameters including 3VTV, 3VV, 5CV, RVOT, LVOT, Bicaval view, Ductal and aortic arche view and 4CV findings ($p<0.05$). Crown-rump length showed moderate predictive significance, whereas nuchal translucency thickness and gestational age were not reliable predictors of fetal cardiac anomalies.

Conclusion: Routine prenatal fetal echocardiography is an effective modality for early detection of congenital cardiac anomalies. Advanced echocardiographic views, including 4CV, 5CV, 3VTV, 3VV, RVOT, LVOT, Bicaval view, Ductal and aortic arche view significantly enhance diagnostic accuracy and aid in timely prenatal planning, thereby improving neonatal and perinatal outcomes.

Keywords: Prenatal echocardiography, Fetal cardiac anomaly, Neonatal congenital heart disease, Early risk detection, Cardiac Screening

Introduction

Prenatal echocardiography can reveal structural or functional abnormalities that suggest an increased risk of cardiac anomalies in neonates. Key indicators may include chamber asymmetry, abnormal blood flow patterns, valve abnormalities, or irregular cardiac rhythms observed during fetal assessment. These findings allow clinicians to anticipate congenital heart defects before birth and plan appropriate perinatal management. Early identification also supports timely referral to specialized centers for advanced evaluation and intervention. Overall, such prenatal findings play

a vital role in improving neonatal outcomes through early detection and preparedness.

Prenatal echocardiography images the fetal heart's chambers, valves, and major vessels to identify structural abnormalities. Abnormalities in chamber size, wall thickness, or asymmetry may suggest conditions like ventricular hypoplasia or septal defects. Additionally, color and Doppler interrogation assess inflow and outflow tracts for stenosis, regurgitation, or turbulent flow, which indicate the functional significance of these structural lesions.1 The alignment of great arteries on outflow-tract imaging is crucial in identifying conotruncal anomalies such as transposition and double-outlet ventricles, which affect neonatal circulation and management. Combining anatomical and hemodynamic data from fetal echocardiograms assists in risk stratification, delivery planning, and arrangement of immediate neonatal cardiology care.2

Congenital heart disease (CHD) is one of the most common congenital anomalies globally, imposing a substantial burden on neonatal morbidity and mortality. The estimated global prevalence of CHD ranges between 6 and 12 per 1,000 live births, depending on the region and detection methods.3 In India, the burden is particularly high: a large cross-sectional echocardiographic screening study of 20,307 neonates in North India found a prevalence of significant CHD at 8.07 per 1,000 live births.4 Such data underscores the critical public-health importance of CHD in low- and middle-income countries, where resources for diagnosis, treatment, and follow-up may be limited.

Beyond prevalence, the morbidity associated with CHD is wide-ranging - from mild, asymptomatic septal defects to complex cyanotic lesions requiring immediate neonatal intervention. These anomalies contribute not only to early neonatal mortality but also to long term sequelae such as heart failure, growth retardation, and neurodevelopmental delay. The high burden of disease, coupled with variable access to specialized paediatric cardiac care, makes early detection and risk stratification vital.

Prenatal detection of CHD offers major advantages. When cardiac anomalies are identified in utero, multidisciplinary planning becomes possible: obstetricians, fetal medicine specialists, neonatologists, and paediatric cardiologists can collaborate to optimize delivery timing and location, counsel parents, and prepare for immediate postnatal interventions.[5] In low and middle- income countries, including India, the adoption of routine fetal echocardiography remains limited. There are logistical challenges - such as cost, a shortage of trained fetal cardiologists or sonographers, and weak referral pathways—that impede widespread implementation.[6] Nevertheless, given the high prevalence and potential for improved outcomes, strengthening prenatal screening protocols is crucial.

In India, there is growing but still limited data on prenatal CHD detection and fetal echocardiography.

A retrospective study from a primary referral centre in India examined over 11,760 fetuses during routine second- and third-trimester ultrasounds and identified 104 cardiac anomalies, with an incidence of 8.8 per 1,000 fetuses.[7] This aligns with broader data suggesting that CHD prevalence in India is comparable to global levels, but detection during pregnancy remains suboptimal.

An observational study conducted in Rajasthan, India, evaluated 880 high-risk pregnancies undergoing detailed fetal echocardiography between 18-36 weeks.[8] The authors documented a variety of CHD types in these high-risk fetuses, reinforcing that expanded echo protocols (beyond just the four-chamber view) are valuable in Indian high-risk referrals.

These Indian studies underscore both the potential and the current limitations of fetal echocardiography in India. There remains a pressing need for systematic, region-specific research correlating prenatal echo findings with neonatal outcomes.

Objectives:

To analyze the type of cardiac abnormalities detected during prenatal echocardiography in subjects referred to the Department of Radio Diagnosis of Bapuji Hospital, Chigateri General Hospital and Women and children Hospital : Davangere for antenatal / anomaly scan.

Materials And Methods:

1. **Source of data**: The main source of data for the study are subjects from the following teaching hospitals attached to Bapuji Education Association J.J.M. Medical College, Davangere and satisfying

Volume 9, Issue 3; May-June 2026; Page No 648-658

the inclusion criteria: Bapuji Hospital, Chigateri General Hospital and Women and Children Hospital**.**

2. **Study design:** Prospective observational Study
3. **Study period:** 18 months (March 2024 to September 2025)
4. **Study area:** Department of Radiodiagnosis, JJM Medical College Davangere (Bapuji Hospital),
5. **Sample size: 77 participants**
6. **Sampling method:** By non-probability consecutive sampling method.

Method of Collection of Data: It includes pregnant female subjects referred to the Department of Radiodiagnosis of Bapuji Hospital, Chigateri General Hospital and Women and Children Hospital, Davangere for Antenatal/Anomaly scan over a period of 18 months. All the included subjects will be explained the details of the study protocol and a written informed consent in English and subject's native language will be taken. A structural Performa will be used to collect relevant information of each subject and confidentiality of the subject's information will be maintained.

Inclusion Criteria:

1. Willingness to participate in the study.
2. All pregnant females of gestational age between 16 to 37 weeks based on the dating scan.
3. Singleton pregnancy.

Exclusion Criteria:

1. Pregnant females not willing to participate in the study.
2. Any emergency fetal scans of the above mentioned gestational age.
3. Multiple pregnancy.

Methodology:

Patients Laboratory Report

The study group will consist of all pregnant females of the gestational age between 16 to 37 weeks. All included mothers will be subjected to a lace to face interview for collection of data on the following:

1. Maternal age.
2. Obstetric history.
3. Gestational age (GA).
4. Mode of pregnancy.
5. Parity and related details.
6. Family history of Congenital Heart Diseases or chromosomal or other congenital anomalies.
7. Prenatal risk factors will be extracted:
8. Maternal medical illnesses, infections, medications.
9. Indications for referral, anomaly scan report and fetal echocardiography diagnosis if previously done and reported.

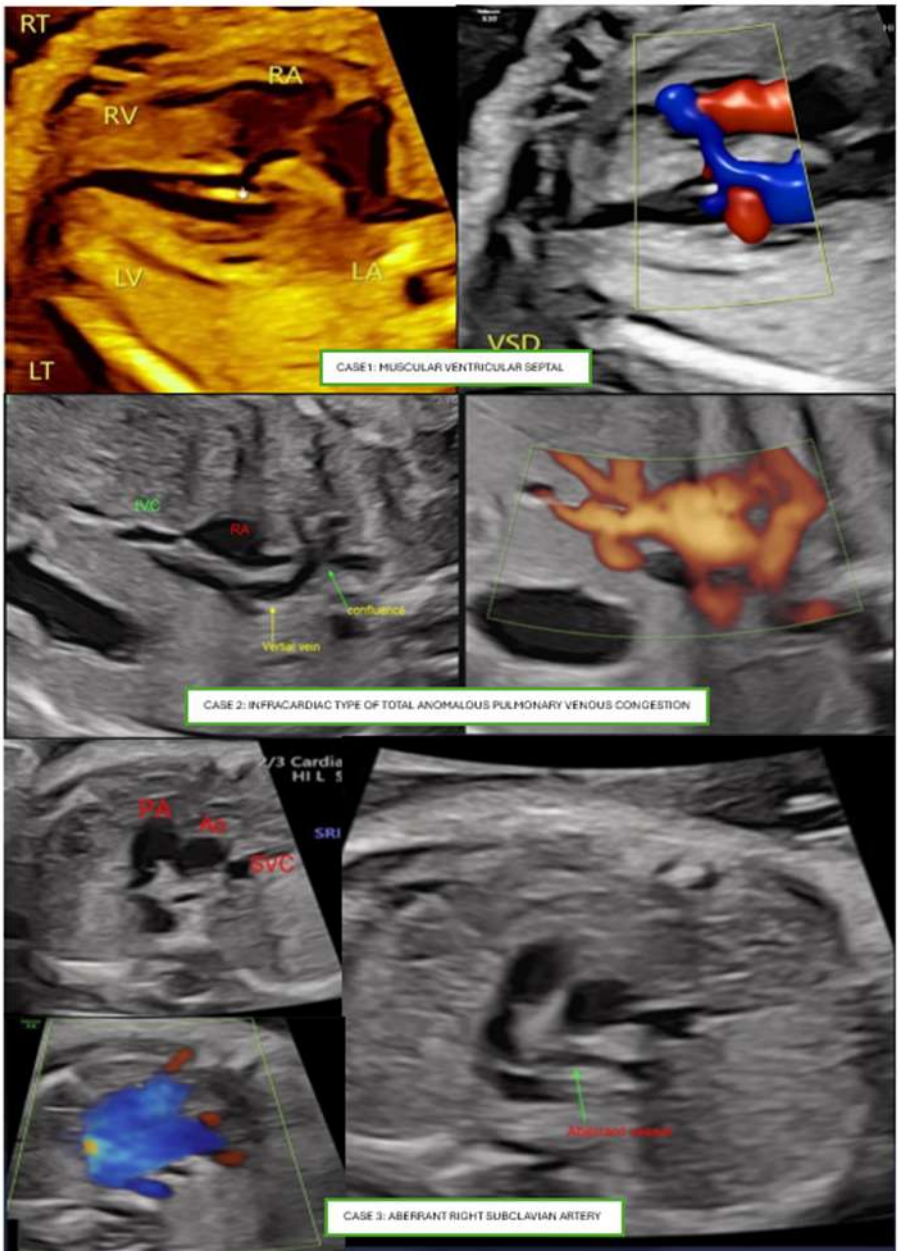
Fetal Echocardiography was done for all cases to detect any structural or rhythm abnormalities in the fetal heart according to the guidelines and standards of the "American Society of Echocardiography for performance of fetal echocardiogram" using GE Voluson E6 high-end 4D OB/GYN ultrasound machine and transducer probe with a frequency range of 5-8 MHz, EPIQ CV X will be made by Philips with transducer 8 MHz.

A standard two-dimensional (2D), color flow (CF), Doppler Echocardiography examination was done. Views to be included are:

1. Four chamber view.
2. Five chamber view.
3. Long axis (left and right ventricular outflow) view.
4. 3-Vessel and Tracheal view.
5. Ductal and Aortic arch view.
6. Bicaval view and bilateral subclavian Arteries

Volume 9, Issue 3; May-June 2026; Page No 648-658

Figure 1:



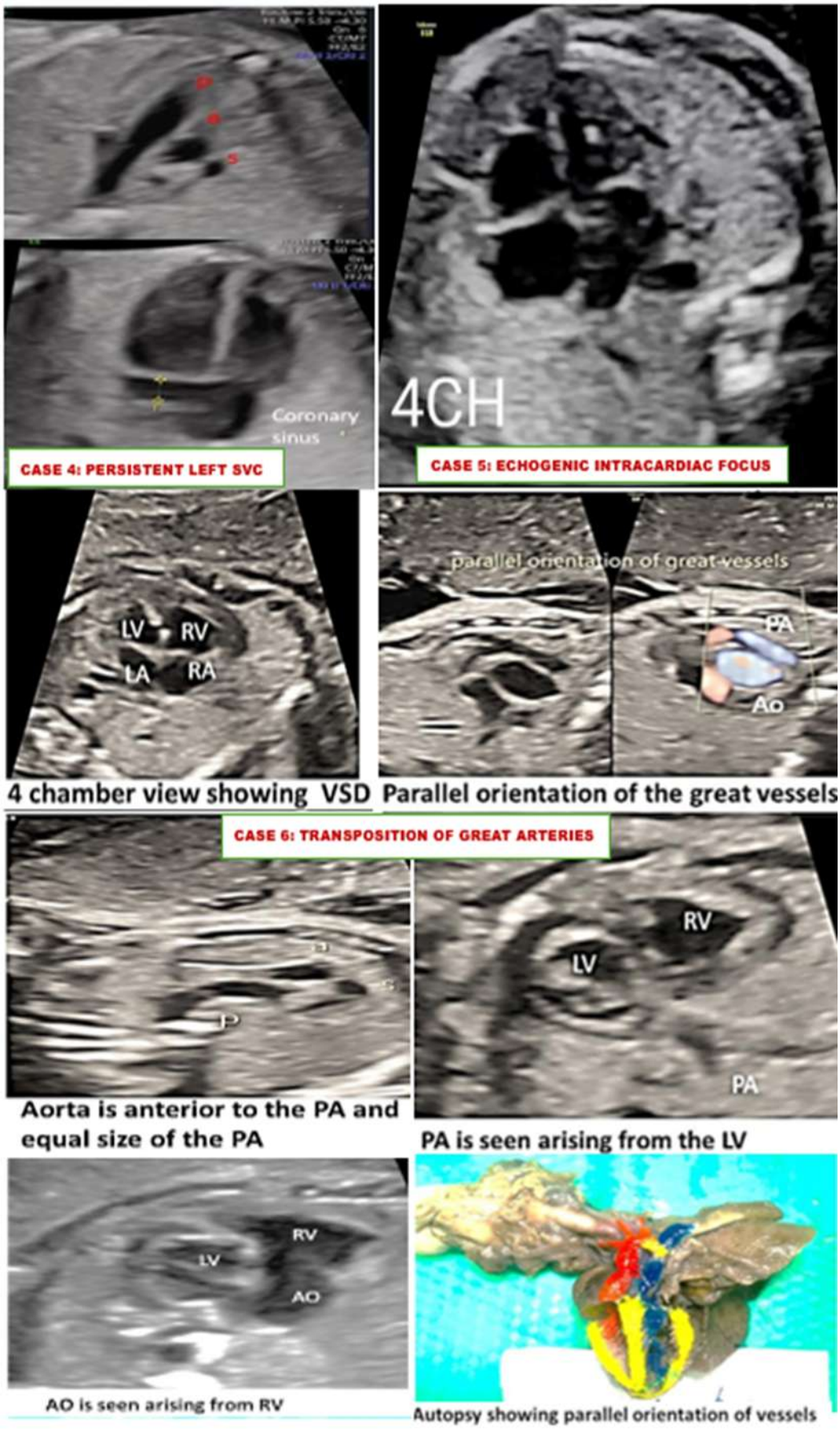
Case 1: Muscular ventricular septal defect: Defect in the middle of the ventricular septum with echogenic borders.

Case 2: Infracardiac Type of Total anomalous pulmonary venous congestion: Vertical vein arising from the confluence behind the left atrium descending down across the diaphragm and draining into inferior vena cava.

Case 3: Aberrant Right Subclavian Artery: Abnormal 4th vessel arising from the distal aortic arch at the junction of ascending aorta and ductus arteriosus coursing from the left posterior thoracic side towards the right upper arm from behind the trachea and esophagus.

Volume 9, Issue 3; May-June 2026; Page No 648-658

Figure 2:



Volume 9, Issue 3; May-June 2026; Page No 648-658

Case 4: Persistent Left Superior Vena Cava: Abnormal 4th vessel of similar calibre as SVC noted left to the pulmonary artery coursing parallel and lateral to it to drain into Coronary sinus giving a cigar shape appearance.

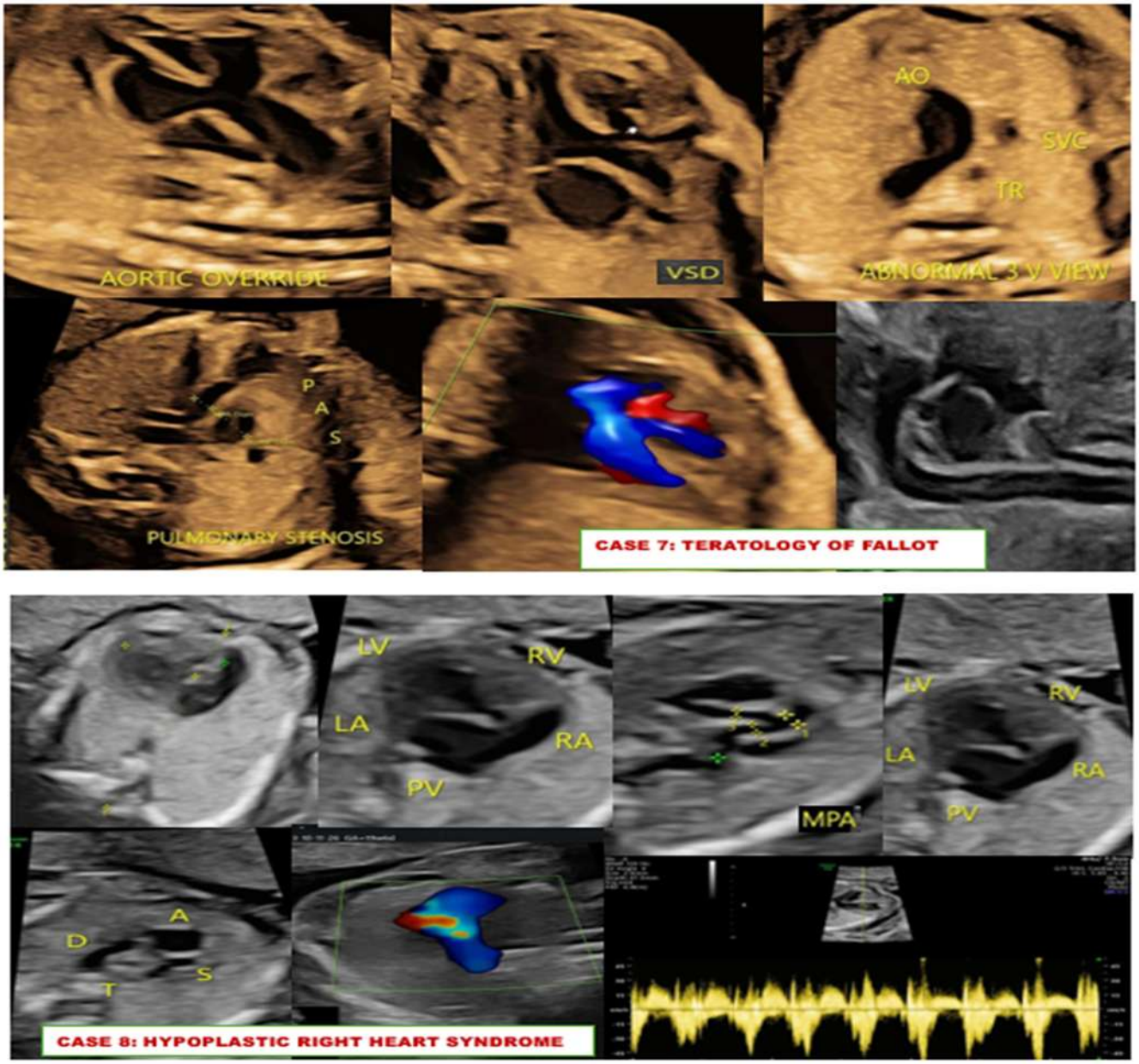
Case 5: Echogenic intracardiac focus in the left lateral ventricle: isolated and benign..

Case 6: Transposition of great arteries (TGA):

Findings :

1. VSD in 4CV
2. Parallel orientation of great vessels
3. PA arising from LV
4. Aorta arising from RV, situated anterior to PA and equal in size as PA

Figure 3



Case 7: Tetralogy Of Fallot (TOF):

Volume 9, Issue 3; May-June 2026; Page No 648-658

Findings: Subaortic peri membranous VSD, Overriding of aorta, Narrow Pulmonary artery-Pulmonary stenosis, Antegrade flow in both outflows (LVOT and RVOT)

Case 8: Transposition of great arteries (TGA):

Left axis deviation of heart- 92.48o. Ventricular chamber size discrepancy- Right ventricle hypoplastic with wall thickening, normal to small sized right atria. Foramen ovale flap opening to left side. Main pulmonary artery & its branches - severely narrowed with no evidence of flow within on colour doppler. Aorta dilated with aliasing noted in DA- indicating reversal of flow in ductus arteriosus. Tricuspid valve is dysplastic. Mild mitral regurgitation noted.

Results:

Figure 1: Spectrum of cardiac anomalies detected among patients and their severity classification

Cardiac Anomaly	Number of participants (n)	Percentage (%)
Aberrant Right Subclavian Artery (ARSA)	2	2.60
Atrial Septal Defect (ASD)	1	1.30
Double Outlet Right Ventricle (DORV)	1	1.30
Echogenic Intracardiac Focus (EIF)	7	9.09
Hypoplastic Left Heart Syndrome (HLHS)	2	2.60
Hypoplastic Right Heart Syndrome (HRHS)	1	1.30
Normal fetal echocardiography	56	72.73
Persistent Left Superior Vena Cava (PLSVC)	1	1.30
Tetralogy of Fallot (TOF)	1	1.30
Total Anomalous Pulmonary Venous Connection (TAPVC)	1	1.30
Transposition of Great Arteries (TGA)	1	1.30
Ventricular Septal Defect (VSD)	3	3.90
Total	77	100.00

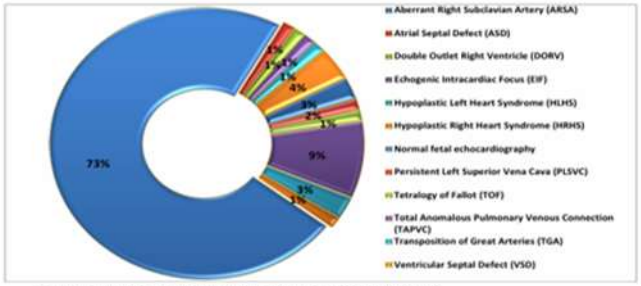


Fig: Spectrum of cardiac anomalies detected among participants

Severity Category	Number of participants (n)	Percentage (%)
Mild	10	12.99
Moderate	4	5.19
Severe	7	9.09
Normal	56	72.73
Total	77	100.00

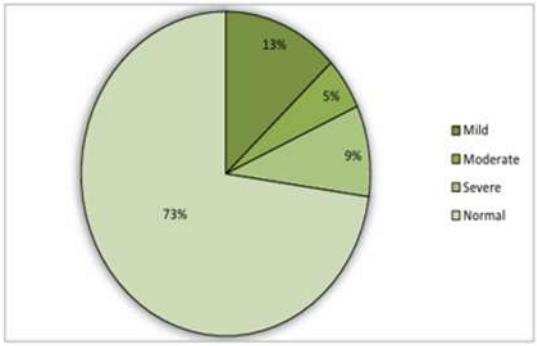


Fig: Severity classification of detected cardiac anomalies

Figure 2: ROC Curve analysis for factors like CRL, NT Thickness and gestational age

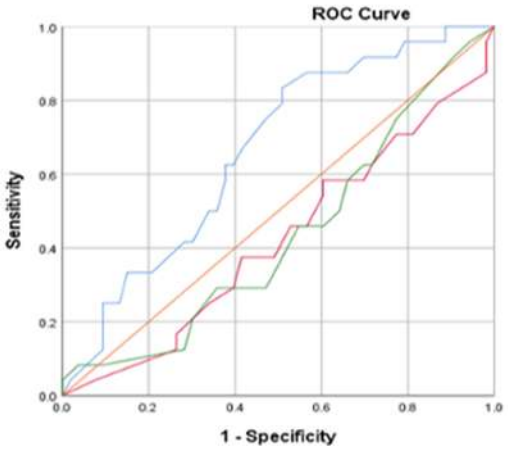


Fig: ROC Curve for CRL, NT Thickness and Gestational age in predicting fetal cardiac anomalies

Source of the Curve

CRL (mm)
NT Thickness (mm)
Gestational Age (in weeks)
Reference Line

Area Under the Curve

Test Result Variable(s)	Area	Std. Error[a]	p-value	Asymptotic 95% Confidence Interval	
				Lower Bound	Upper Bound
CRL (mm)	0.662	0.064	0.023	0.537	0.787
NT Thickness (mm)	0.421	0.070	0.269	0.283	0.559
Gestational Age (in weeks)	0.434	0.070	0.356	0.297	0.571

The test result variable(s): CRL (mm), NT Thickness (mm), Gestational Age (in weeks) has at least one tie between the positive actual state group and the negative actual state group. Statistics may be biased.

a. Under the nonparametric assumption

b. Null hypothesis: true area = 0.5

Fig: ROC curve analysis of predictve variables for fetal cardiac anomalies

Volume 9, Issue 3; May-June 2026; Page No 648-658

Discussion

A total of 77 singleton pregnancies underwent prenatal fetal echocardiographic evaluation during the study period. The mean maternal age was 27.2 ± 4.0 years (interquartile range, 24–30 years), and the mean gestational age at examination was 26.4 ± 6.7 weeks. Most women were multigravida, and fetal echocardiography was predominantly performed between 16 and 35 weeks of gestation. Consanguinity was present in 30 (38.9%) pregnancies, while maternal hypertension and diabetes were observed in five (6.5%) cases each. All examinations were performed as part of routine antenatal screening in singleton pregnancies.

Normal fetal echocardiographic findings were observed in 56 of 77 fetuses (72.7%), whereas 21 (27.3%) demonstrated cardiac abnormalities. Echogenic intracardiac focus (EIF) was the most common abnormality (7/77, 9.1%), followed by ventricular septal defect (3/77, 3.9%). Aberrant right subclavian artery and hypoplastic left heart syndrome were identified in two fetuses each (2.6%), while atrial septal defect, double outlet right ventricle, hypoplastic right heart syndrome, persistent left superior vena cava, tetralogy of Fallot, total anomalous pulmonary venous connection, and transposition of the great arteries were each detected in one fetus (1.3%).

Based on severity, 56 (72.7%) fetuses had normal cardiac findings, whereas 10 (13.0%), 4 (5.2%), and 7 (9.1%) demonstrated mild, moderate, and severe congenital cardiac anomalies, respectively.

Maternal age and maternal medical risk factors showed no significant association with fetal cardiac abnormalities ($\chi^2 = 3.59$, $p = 0.61$ and $\chi^2 = 20.47$, $p = 0.967$, respectively).

Evaluation of standard fetal echocardiographic views demonstrated significant associations with the final prenatal diagnosis. The four-chamber view (4CV) showed the strongest association with congenital cardiac anomalies ($\chi^2 = 332.247$, $p < 0.001$), accurately identifying characteristic findings such as atrial septal defects, ventricular septal defects, ventricular hypoplasia, persistent left superior vena cava, and echogenic intracardiac focus.

The three-vessel tracheal view (3VTV) also demonstrated excellent diagnostic performance ($\chi^2 = 224.554$, $p < 0.001$). Characteristic abnormalities included aberrant vessel course in aberrant right subclavian artery, abnormal venous drainage in TAPVC, altered great vessel alignment in tetralogy of Fallot and ventricular septal defect, parallel great vessels in transposition of the great arteries, and reduced great vessel calibre in hypoplastic heart syndromes.

Similarly, significant associations were observed for the three-vessel view (3VV) ($\chi^2 = 147.483$, $p < 0.001$), right ventricular outflow tract (RVOT) ($\chi^2 = 207.563$, $p = 0.001$), and left ventricular outflow tract (LVOT) ($\chi^2 = 161.319$, $p = 0.012$). These views demonstrated characteristic imaging patterns corresponding to individual congenital cardiac anomalies, thereby improving diagnostic confidence beyond the four-chamber assessment alone.

Receiver operating characteristic analysis demonstrated modest predictive performance for crown-rump length (AUC = 0.662, 95% CI: 0.537–0.787, $p = 0.023$). In contrast, nuchal translucency thickness (AUC = 0.421, $p = 0.269$) and gestational age (AUC = 0.434, $p = 0.356$) did not demonstrate significant predictive ability for fetal cardiac abnormalities.

Prenatal diagnosis showed a significant association with neonatal survival outcomes ($\chi^2 = 41.936$, $p = 0.032$), whereas no significant association was observed with abortion history ($\chi^2 = 21.426$, $p = 0.565$).

Based on fetal echocardiographic findings, routine antenatal care was appropriate in 53 pregnancies (68.8%), while the remaining cases required serial fetal echocardiography, multidisciplinary counselling, planned delivery at tertiary cardiac centres, or immediate neonatal intervention according to the severity of the detected cardiac abnormality.

Conclusion:

The present study, conducted among 77 pregnant women, provides important insights into the role of prenatal echocardiography in the detection and evaluation of fetal cardiac anomalies. The study population predominantly consisted of young adult women with a mean age of 27.21 ± 4.04 years, and a higher proportion of multigravida and multiparous participants. Most fetal echocardiographic examinations were performed during the mid-gestational period, highlighting its optimal timing for

Volume 9, Issue 3; May-June 2026; Page No 648-658

early diagnosis. The majority of participants had no significant maternal risk factors, although consanguinity was relatively common. Importantly, 72.73% of fetuses showed normal cardiac findings, while the remaining cases exhibited a low prevalence of anomalies, with echogenic intracardiac focus being the most frequent minor abnormality.

Statistical analysis revealed no significant association between maternal age or common maternal risk factors and the occurrence of fetal cardiac anomalies. However, a significant relationship was observed between prenatal diagnosis and neonatal living outcomes, emphasizing the clinical relevance of early detection. Advanced echocardiographic views such as 3VTV, 3VV, RVOT, LVOT, and 4CV demonstrated strong statistical significance in identifying and differentiating congenital heart diseases, confirming their diagnostic reliability. Among predictive parameters, CRL showed moderate significance, while NT thickness and gestational age were not reliable predictors. Overall, the study underscores that routine prenatal echocardiography is an effective screening tool for early detection of congenital cardiac anomalies, facilitating timely intervention planning and improving neonatal outcomes through risk-based management strategies

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Volume 9, Issue 3; May-June 2026; Page No 648-658

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Volume 9, Issue 3; May-June 2026; Page No 648-658

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Volume 9, Issue 3; May-June 2026; Page No 648-658