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Impact Of Perinatal And Neonatal Risk Factors, Including Fetal Echocardiography Referral, On Echocardiographic Abnormalities In Neonates: A Cross-Sectional Study Of 1062 Patients

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Abstract

Background: Congenital heart defects (CHDs) are the most frequent congenital anomalies, contributing substantially to neonatal death and morbidity. While fetal echocardiography is increasingly used for antenatal detection, its diagnostic yield varies, and the contribution of perinatal and neonatal risk factors remains uncertain.
Objective: To assess the impact of perinatal and neonatal risk factors, including fetal echocardiography referral, on echocardiographic abnormalities in neonates.
Methods: This cross-sectional study included 1062 neonates born in 2024 who underwent transthoracic echocardiography at Prince Sultan Cardiac Center, Saudi Arabia. Perinatal and neonatal data—including gestational maturity, infant of diabetic mother (IDM) status, mode of delivery, NICU admission, dysmorphic features, and fetal echocardiography referral—were collected from medical records. Echocardiograms were performed by pediatric cardiologists and classified as normal or abnormal. Statistical analyses involved logistic regression and chi-square/Fisher's exact tests.
Results: Echocardiographic abnormalities were identified in 69 neonates (6.5%). NICU admission was significantly associated with abnormal echocardiograms ($p = 0.004$), whereas maturity, IDM status, mode of delivery, dysmorphic features, and fetal echocardiography referral showed no significant associations. Logistic regression analysis confirmed that none of the studied variables were independent predictors of neonatal CHD.
Conclusion: Echocardiographic abnormalities were present in 6.5% of neonates, with NICU admission being the only associated factor. Neither fetal echocardiography referral nor other perinatal variables predicted neonatal CHD. These findings support targeted postnatal echocardiographic screening for NICU-admitted neonates and highlight the need for multicenter studies to refine risk stratification.

Keywords: congenital heart defects, neonates, fetal echocardiography, NICU admission.

Introduction

CHD is characterized by a defect in the structure of the heart or great vessels caused throughout fetal development **(1)**. The global occurrence of congenital heart defects is approximately eight per thousand live births, with a death rate of 3.9 per 100,000 populations **(2)**.
The prenatal identification of congenital heart defects is very important due to the significant death and morbidity related to these defects; moreover, antenatal detection aids the planning of subsequent

treatments. Fetal echocardiography is increasingly recognized as a vital screening tool capable of identifying numerous structural heart illnesses. However, it is greatly variable, based on gestational age, operator expertise, and the kind of cardiac defect, as well as fetal position. Nevertheless, recent advancements have enhanced the identification of CHD **(3)**.

The efficacy of fetal echocardiography in identifying congenital heart defects is based on both the expertise of the performer and the indication of referral. However, it's a crucial instrument for the early recognition of congenital heart defects, and with the accessibility of greater and newer sophisticated dedicated machines, congenital heart defects might be recognized in utero throughout the 2nd trimester or even the late 1st trimester, with a detection rate of eighty-five to ninety-five percent in specialized units **(4)**.

Multiple risk factors are related to the development of coronary heart defects, with pregestational diabetes being an essential and most documented one by several authors **(5**), (6). In 2014, the American Heart Association gave a list of risk factors for screening high-risk mothers resulting in congenital heart defect in their babies. The referral pattern for fetal echocardiography among pregnant women reflects the spectrum of women needing the examination and aids in the identification and understanding of CHD and their related risk factors **(7)**.

This research aimed to assess the impact of perinatal and neonatal risk factors, including fetal echocardiography referral, on echocardiographic abnormalities in neonates.

Patients and methods

This cross-sectional investigation has been done on 1062 neonates born in 2024 who underwent transthoracic echocardiographic evaluation during the same year at Prince Sultan Cardiac Center, Qassim, Saudi Arabia, from January to December 2024.

Inclusion criteria: All neonates born in 2024 with available echocardiographic results and availability of perinatal/neonatal variables (prematurity, IDM, NICU admission, mode of delivery, dysmorphic features, fetal echo referral).

Exclusion criteria: Incomplete perinatal or echocardiographic data and duplicated records.

Methods

All patients have been subjected to the following:

Data collection

Clinical and demographic variables have been obtained from medical records, involving:

Perinatal factors: gestational age, prematurity status, infant of diabetic mother (IDM), and mode of delivery.

Neonatal factors: NICU admission, jaundice, cyanosis, dysmorphic features, and associated congenital anomalies.

Fetal echocardiography referral: categorized as “yes” or “no.”

Echocardiographic assessment

Transthoracic echocardiography was performed using commercially available ultrasound machines with pediatric probes. Studies were conducted by experienced pediatric cardiologists following American Society of Echocardiography guidelines. Echocardiographic findings were classified as normal or **abnormal**, with abnormalities defined as structural congenital heart defects (CHDs) or significant functional abnormalities.

Statistical analysis

Information has been examined utilizing SPSS software (version 20, IBM Corp., Armonk, NY, United States of America). Continuous parameters have been expressed as mean ± standard deviation (SD), whereas categorical parameters have been represented as percentages and frequencies. Relationships between categorical parameters have been assessed by applying the chi-square test or Fisher’s exact test, if suitable. A logistic regression analysis has been conducted to determine independent predictors of neonatal echocardiographic abnormalities. A p-value less than 0.05 has been regarded statistically significant.

Results

Table (1): Baseline characteristics in the studied group.

	Studied group N=1062
Gender	
male	601 (56.6%)
female	460 (43.3%)
Gestational Age (weeks) Mean ±SD	37.9±1.96
Height (cm) Mean ±SD	61.6±10.66
Birth Weight (Kg) Mean ±SD	2.96±0.57
Current weight (Kg) Mean ±SD	6.03±2.58
Systolic BP (mmHg) Mean ±SD	83.7±18.1
Diastolic BP (mmHg) Mean ±SD	45.6±12.7
Temperature (°C) Mean ±SD	36.7±0.5
Heart Rate (bpm) Mean ±SD	144.69±61.5
O_2 Sat RUL (%) Mean ±SD	96.8±4.4
O_2 Sat LLL (%) Mean ±SD	94.8±4.5
Respiratory Rate (breaths/min) Mean ±SD	45.1±8.6
Maturity	
extremely preterm	22 (2.1%)
late preterm	155 (14.6%)
early term	218 (20.5%)
full term	667 (62.8%)
Mode of Delivery	
CS	32 (3%)
vaginal	1030 (97%)
IDM	37 (3.5%)
NICU admission	462 (43.5%)
Fetal Echo	214 (20.2%)

SD: standard deviation; BP: Blood Pressure; O_2 Sat RUL: Oxygen Saturation in Right Upper Limb; O_2 Sat LLL: Oxygen Saturation in Left Lower Limb; CS: Cesarean Section; IDM: Infant of Diabetic Mother; NICU: Neonatal Intensive Care Unit.

The study included 1062 neonates, predominantly male (56.6%), with a mean gestational age of 37.9 ± 1.96 weeks and an average birth weight of 2.96 ± 0.57 kg. Most were full term (62.8%) and delivered vaginally (97%). Mean vital signs were within normal ranges, with slightly higher oxygen saturation in

the right upper limb (96.8% vs. 94.8%). Infants of diabetic mothers comprised 3.5%, while 43.5% required NICU admission and 20.2% underwent fetal echocardiography. (Table 1)

Table (2): Neonatal echocardiographic abnormalities by perinatal risk factors.

	Abnormal Echo N=69	**Normal Echo N=993**	
Maturity			
extremely preterm	0 (0%)	22 (2.2%)	0.31
late preterm	10 (14.5%)	145 (14.6%)	
early term	19 (27.5%)	199 (20%)	
full term	40 (58%)	627 (63.1%)	
IDM			
yes	2 (2.9%)	35 (3.5%)	0.56
no	67 (97.1%)	958 (96.5%)	
NICU admission			
yes	19 (27.5%)	443 (44.6%)	**0.004**
no	50 (72.5%)	550 (55.4%)	
Dysmorphic features			
yes	0 (0%)	12 (1.2%)	0.44
no	69 (100%)	981 (98.8%)	
Mode of Delivery			
CS	0 (0%)	32 (3.2%)	0.11
vaginal	69 (100%)	961 (96.8%)	

P value < 0.001 is highly significant, P <0.05 is statistically significant, P >0.05: Not significant.
There is a statistically insignificant variance among infants with abnormal and normal echocardiograms regarding maturity, IDM, dysmorphic features, and mode of delivery (P>0.05). while there was a statistically insignificant variance among infants with abnormal and normal echocardiograms regarding NICU admission (P below 0.05). (Table 2)

Table (3): Abnormal echo prevalence in neonates with vs. without fetal echo.

	with fetal echo N=214	**without fetal echo N=848**	
Neonatal echocardiographic abnormalities			
yes	10 (4.7%)	59 (7%)	0.14
no	204 (95.3%)	789 (93%)	

A statistically insignificant variance among infants who had a fetal echocardiogram regarding the rate of neonatal echocardiographic abnormalities (P above 0.05). (Table 3)

Table (4): Logistic regression 4. To identify independent predictors of neonatal CHD.

						95%C.I.for EXP(B)	
	B	**S.E.**	**Wald**	**Sig.**	**Exp(B)**	Lower	Upper
Maturity	- 0.534	0.719	0.552	0.458	0.586	0.143	2.398
IDM	-14.96	6607.6	0.000	0.998	0.000	0.000	-
NICU admission	0.262	1.416	0.034	0.853	1.299	0.081	20.829
Dysmorphic Features	-14.94	11602.7	0.000	0.999	.000	0.000	-
Fetal Echo	1.380	1.416	0.950	0.330	3.977	0.248	63.834

According to univariate logistic regression analysis, none of the studied variables, including maturity, infant of diabetic mother (IDM), NICU admission, dysmorphic features, and fetal echocardiography, were found to be statistically significant independent predictors of neonatal congenital heart disease (CHD). (Table 4)

Discussion

This study revealed that the studied group included 1062 neonates, with a slight male predominance (56.6%). The average gestational age was 37.9 ± 1.96 weeks, with most being full term (62.8%). Mean birth weight was 2.96 ± 0.57 Kilograms, and present weight was 6.03 ± 2.58 kg. Average vital signs were temperature 36.7 ± 0.5 Celsius, heart rate 144.7 ± 61.5 bpm, respiratory rate 45.1 ± 8.6 breaths/min, systolic BP 83.7 ± 18.1 mmHg, and diastolic BP 45.6 ± 12.7 mmHg. Oxygen saturation was slightly higher in the right upper limb (96.8%) than the left lower limb (94.8%). Most were delivered vaginally (97%), while 3% were by cesarean section. Infants of diabetic mothers made up 3.5%; 43.5% required NICU admission, and 20.2% underwent fetal echocardiography.

In agreement with our results, Khorshid et al., (8) reported that their investigation comprised sixty newborns with a gestational age ranging from thirty-four to forty weeks.Their ages varied from two to thirty-five days, and their weights varied from 1.1 to 4.5 kilograms.Their lengths varied from forty to forty-seven centimeters, and 58.3 percent of the study group were males.

Similarly, Zehra et al., (9) studied The referral pattern for fetal echocardiography (FE) at a tertiary pediatric cardiac center was analyzed, in addition to the identification of several risk factors related to CHD.The gestational age of referrals ranged from sixteen weeks to over thirty-seven weeks, with a mean gestational age of 30.36±5.14 weeks.

Our results showed that there was a statistically insignificant variance among infants with abnormal and normal echocardiograms regarding maturity, IDM, dysmorphic features, and mode of delivery, while NICU admission was significantly related to a greater prevalence of echocardiographic abnormalities. This research revealed a statistically insignificant variance among infants who had a fetal echocardiogram regarding the rate of neonatal echocardiographic abnormalities.

According to univariate logistic regression analysis, our results showed that none of the studied variables, including maturity, infant of diabetic mother (IDM), NICU admission, dysmorphic features, and fetal echocardiography, were found to be statistically significant independent predictors of neonatal congenital heart disease (CHD).

An investigation performed by Bhambani et al., (10) A total of 1445 fetal echos have been conducted, with 1183 women demonstrating no risk factor related to congenital heart defects. A total of 76 fetuses (52.6 per 1000) exhibited cardiac abnormality, of which 12 (8.3 per 1000) have been diagnosed with congenital cardiac defect.

Also, the investigation by Zehra et al., (9) revealed that eleven fetuses (5.5 percent) have been discovered with congenital heart defects, whereas fourteen fetuses (seven percent) exhibited functional cardiac abnormalities. The primary reason for referrals was gestational diabetes mellitus, accounting for fifty-five percent. Nevertheless, only four percent of them had congenital cardiac defects in their babies, and the correlation between gestational diabetes mellitus and CHD detection wasn't statistically significant (p-value equal to 0.201). Additionally, five percent of the referrals had pregestational diabetes mellitus; however, none of their fetuses demonstrated congenital heart defects.

However, our results disagreed with Øyen et al., (11) who conducted A cohort study including two million newborns over thirty-four years revealed a fourfold rise in the risk of congenital heart defects in cases of maternal pre-gestational diabetes mellitus (both types 1 and 2). In a systematic review, Depla et al. (12) identified that maternal diabetes (gestational and pregestational) correlates with ventricular diastolic dysfunction, fetal cardiac hypertrophy, and overall impaired myocardial performance.

Similarly, our results disagreed with Chung et al., (13) who revealed that prenatal diagnosis and planned delivery in a tertiary neonatal intensive care unit are factors affecting CHD results, particularly when defects are 'complex.' They concluded that fetal echocardiography raised the frequency of prenatal congenital heart disease detection, modified the spectrum of cardiac anomalies encountered in the

neonatal intensive care unit (NICU), and contributed to improved one-year survival outcomes among affected neonates.

Also, Elmakaty et al., (14) who reported that birth weight is the most reliable predictor of LV dimension, since it exhibits a significant association with LV mass, LV mass/Vol, LVIDs, LVIDd, IVSs, IVSd, LVPWs, as well as LVPWd, all showing a positive coefficient. This recommends that a greater BW corresponds with a rise in these variables. These correlations may suggest that the size of the left ventricular chamber is directly proportional to baby weight, a correlation that has been identified in the literature (15)**.** A previous single-center cross-sectional research study including twenty SGA kids at twenty-four months demonstrated that children with SGA exhibited early and mild cardiovascular dysfunction in comparison with AGA controls, with these alterations closely related to BW (16)**.**

Conclusion

Echocardiographic abnormalities were detected in 6.5% of neonates, with NICU admission as the only significant associated factor. Other perinatal variables showed no predictive value, and logistic regression confirmed none were independent predictors of CHD. The findings support postnatal echocardiographic screening for NICU-admitted neonates and highlight the requirement for larger multicenter researches to refine risk stratification and screening strategies.

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