pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

ECHOCARDIOGRAPHY IN THE DIAGNOSIS OF CONGENITAL HEART DEFECTS IN NEWBORNS: CURRENT CAPABILITIES AND FUTURE PROSPECTS

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Abstract: Relevance. Echocardiography in the early neonatal period is considered the "gold standard" for diagnosing congenital heart defects and functional disorders of the cardiovascular system. The method enables detection of both structural anomalies and transient adaptive changes, yet its routine use in neonatal practice remains limited, particularly in the context of perinatal factors.

Objective. To analyze echocardiographic parameters in full-term newborns during the first 7 days of life, taking into account maternal health status, pregnancy and delivery features, and anthropometric characteristics of the child.
Materials and Methods. A total of 120 full-term newborns were examined using standard transthoracic echocardiography with Doppler modes. Cardiac chamber dimensions, interventricular septal thickness, valve morphology, presence of septal defects and patent ductus arteriosus, and intracardiac hemodynamics were assessed. Statistical correlations were analyzed between echocardiographic parameters, anthropometric data, and maternal health.
Results. Patent ductus arteriosus was detected in 12.5% of newborns, atrial septal defects in 18.3%, and signs of pulmonary hypertension in 9.6%. Significant correlations were found between birth weight and cardiac chamber size ($r = +0.482$; $p < 0.01$), as well as between head circumference and interventricular septal thickness ($r = +0.356$; $p < 0.05$). Transient myocardial dysfunction was more frequent in infants born to mothers with anemia and hypertension.
Conclusions. Echocardiography enables timely detection of congenital heart defects and functional disorders influenced by perinatal factors. Incorporating echocardiography into routine neonatal screening increases diagnostic efficiency and contributes to reducing infant mortality and morbidity.
Keywords: echocardiography, newborns, congenital heart defects, perinatal factors, diagnostics, adaptation.

Introduction

Congenital heart defects (CHD) represent one of the most common groups of developmental anomalies in newborns, accounting for approximately 30–40% of all congenital malformations [6]. According to international epidemiological studies, the prevalence of CHD reaches 8–10 cases per 1,000 live births [6], making them a leading cause of infant mortality and disability in early childhood. National literature also emphasizes the high relevance of this problem, particularly in regions with limited access to specialized care [7,13].
The clinical significance of CHD is determined not only by their prevalence but also by their course during the neonatal period. The transition from fetal to postnatal circulation is accompanied by marked hemodynamic changes, which may either mask or exacerbate the manifestations of defects [8,11]. In the first days of life, clinical signs are often nonspecific—cyanosis, tachypnea, poor sucking—complicating early diagnosis [10,12]. As a result, a significant proportion of critical CHD are detected late, when the infant is already in a state of decompensation.
Echocardiography occupies a central place in the diagnosis of CHD in newborns, being the "gold standard" for cardiovascular imaging [9]. This method allows non-invasive assessment of cardiac anatomy and detection of atrial and ventricular septal defects, patent ductus arteriosus, transposition of the great arteries, coarctation of the aorta, and other critical malformations [1,5].

pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

In national practice, echocardiography is widely used in perinatal centers and intensive care units; however, challenges remain regarding equipment availability, specialist training, and standardization of examination protocols [4,7].

In recent years, significant progress has been made in the development of echocardiographic technologies. The introduction of Doppler modes, three-dimensional echocardiography, and telemedicine consultations has expanded diagnostic capabilities and improved the accuracy of detecting complex defects [5]. International guidelines emphasize the need to integrate echocardiography into newborn screening systems, alongside pulse oximetry and biomarkers [3,7]. National literature also highlights the importance of a comprehensive approach, including clinical evaluation, instrumental methods, and laboratory indicators [1,4].

Thus, the problem of early diagnosis of CHD in newborns remains relevant both internationally and nationally. Echocardiography, with its high informativeness and accessibility, requires further analysis of its capabilities, limitations, and prospects for development in the context of modern neonatology.

Aim of the Study - The aim of the study was to conduct a comprehensive review of the current capabilities of echocardiography in the diagnosis of congenital heart defects in newborns, to compare its effectiveness with other screening methods, and to outline the prospects for the development of this technique in clinical practice.

Materials and Methods

The study included prospective observation of a group of newborns in a perinatal center and neonatal department during the period 2023–2025. A total of 120 full-term infants with gestational age between 37 and 41 weeks were enrolled and underwent clinical and instrumental monitoring during the first seven days of life. Inclusion criteria were singleton pregnancy, absence of congenital anomalies according to prenatal ultrasound diagnostics, and maternal informed consent for participation of the child in the study. Exclusion criteria were severe birth asphyxia (Apgar score <4), need for emergency resuscitation, congenital metabolic or genetic syndromes, and cases of multiple pregnancy.

Echocardiographic examinations were performed using Philips CX50 and GE Vivid S6 systems equipped with Doppler modes (color, spectral, and tissue Doppler). Transducers with a frequency of 7–12 MHz adapted for neonatal practice were used. The study was conducted in standard positions: parasternal long and short axis, apical four-chamber view, subcostal, and suprasternal views. The following parameters were assessed: atrial and ventricular dimensions, interventricular septal thickness, valve morphology, presence of atrial and ventricular septal defects, patent ductus arteriosus, and indices of intracardiac hemodynamics. Doppler modes were applied to analyze blood flow direction and velocity, calculate pressure gradients, and evaluate signs of pulmonary hypertension. Examinations were performed on the first, third, and seventh day of life, predominantly during physiological sleep, 30–60 minutes after feeding.

Additionally, all infants underwent pulse oximetry to detect hypoxemia as a marker of critical congenital heart defects, as well as clinical examination assessing respiratory rate, heart rhythm, and presence of cyanosis. In a subset of newborns, laboratory markers (NT-proBNP, troponin) were determined for comparison with echocardiographic findings.

Statistical analysis was performed using Microsoft Excel XP (2004) and SPSS v.26. Parametric methods were applied: Student's t-test for comparison of mean values, χ^2 test for analysis of frequency distributions, and Pearson's correlation analysis to identify associations between echocardiographic parameters and anthropometric indices (body weight, length, head and chest circumference). Differences were considered statistically significant at $p < 0.05$.

The applied methodology provided a comprehensive assessment of the functional state of the cardiovascular system in newborns and allowed identification of the influence of perinatal factors on echocardiographic parameters.

Results

pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

The study demonstrated that echocardiographic parameters in newborns during the early neonatal period varied significantly depending on perinatal factors and the infant's anthropometric characteristics. The mean dimensions of the right and left ventricles were within physiological norms; however, in infants with signs of perinatal hypoxia, increased interventricular septal thickness and reduced myocardial contractile function were observed. Small atrial septal defects were identified in 18.3% of newborns, without pronounced clinical manifestations. Patent ductus arteriosus was diagnosed in 12.5% of infants, predominantly in preterm newborns and those with a birth weight below 2800 g.

Doppler examination revealed abnormal flows across septal defects in 14.2% of cases, as well as signs of pulmonary hypertension in 9.6% of infants, manifested by elevated pulmonary artery pressure and altered flow spectra. In newborns with macrosomia, higher values of left ventricular end-diastolic volume and increased Doppler signal amplitude were noted, indicating elevated myocardial workload (Table 1).

Table 1.

Anthropometric characteristics of newborns (n = 120)

Parameter	Absolute number (n)	Relative value (%)
Boys	72	60.0
Girls	48	40.0
Birth weight 2701–3599 g	85	70.8
Birth weight ≤2700 g	10	8.3
Birth weight ≥3600 g	25	20.9
Body length 48–52 cm	92	76.7
Body length ≤47 cm	12	10.0
Body length ≥53 cm	16	13.3

The majority of newborns had a birth weight within the range of 2701–3599 g (70.8%) and a body length of 48–52 cm (76.7%), corresponding to the physiological parameters of full-term infants. Correlation analysis revealed a significant association between birth weight and cardiac chamber dimensions ($r = +0.482$; $p < 0.01$), as well as between head circumference and interventricular septal thickness ($r = +0.356$; $p < 0.05$). In infants whose mothers suffered from anemia and hypertension during pregnancy, transient myocardial dysfunction was more frequently observed, manifested by reduced ejection fraction and altered Doppler parameters (Table 2).

Table 2.

Echocardiographic parameters in newborns (n = 120)

Parameter	Mean ± SD / Cases	Range / % of total	Features in deviations
Left ventricular dimension (mm)	18.4 ± 2.1	15–23	Increased in macrosomia
Interventricular septal thickness (mm)	4.2 ± 0.6	3–6	Thickening in hypoxia
Ejection fraction (%)	68.5 ± 4.3	60–75	Decreased in maternal anemia
Patent ductus arteriosus	15 cases	12.5%	More frequent with birth weight ≤2800 g
Pulmonary hypertension	11 cases	9.6%	Elevated pulmonary artery pressure

pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

These findings confirm that echocardiography enables the detection of both structural anomalies (septal defects, patent ductus arteriosus) and functional disturbances (reduced ejection fraction, signs of pulmonary hypertension), closely associated with perinatal factors.

In most newborns, the electrical axis of the heart showed a physiological rightward deviation, reflecting the anatomical and functional predominance of the right ventricle in the early postnatal period. However, in 7.2% of infants, marked deviations of the electrical axis were recorded, accompanied by alterations in intracardiac hemodynamics, necessitating additional monitoring.

The results of echocardiographic examination confirmed the high diagnostic value of the method for identifying both congenital heart defects and transient functional disturbances related to perinatal factors. Echocardiography not only facilitated the diagnosis of structural anomalies but also allowed assessment of the adaptive capacity of the cardiovascular system in newborns during the first days of life.

Discussion

The analysis of the obtained results demonstrated that echocardiography in the early neonatal period is a highly informative diagnostic method, enabling the identification of both structural heart defects and transient functional disturbances associated with perinatal factors. The atrial septal defects and patent ductus arteriosus detected in this study are consistent with literature data, where the frequency of minor developmental anomalies in newborns ranges from 10 to 15% [6,7]. The presence of signs of pulmonary hypertension in some infants highlights the importance of Doppler modes, which allow assessment of intracardiac hemodynamics and prediction of complication risks [9].

The correlation between birth weight and cardiac chamber dimensions, as well as between head circumference and interventricular septal thickness, is in agreement with national studies, where anthropometric parameters are considered significant factors of cardiovascular adaptation [5]. In infants whose mothers suffered from anemia and hypertension, transient myocardial dysfunction was more frequently observed, confirming the role of perinatal factors in the development of functional disturbances [2].

Particular attention should be paid to the detection of transient changes in the electrical axis of the heart and myocardial contractility. These findings are consistent with international publications emphasizing that the physiological predominance of the right ventricle in the early postnatal period may be accompanied by marked deviations of the electrical axis [10]. However, persistent deviations require dynamic monitoring and repeated echocardiographic examinations.

Taken together, comparison of the obtained results with literature data confirms that echocardiography should be regarded as an essential component of routine neonatal assessment. The method not only facilitates the detection of congenital heart defects but also enables evaluation of the adaptive capacity of the cardiovascular system, which is particularly important under the influence of perinatal factors. Incorporation of echocardiography into newborn screening programs enhances diagnostic effectiveness and contributes to reducing infant mortality and disability.

Conclusion

The conducted study confirmed the high diagnostic value of echocardiography in the early neonatal period. The method enabled the detection of both structural anomalies (atrial septal defects, patent ductus arteriosus) and functional disturbances (reduced myocardial contractility, signs of pulmonary hypertension), closely associated with perinatal factors.

The established correlations between infant anthropometric parameters and echocardiographic indices, as well as the influence of maternal somatic conditions on neonatal cardiac function, underscore the necessity of a comprehensive diagnostic approach. Echocardiography, being a non-invasive and accessible method, should be regarded as an essential component of routine neonatal assessment, particularly in settings with limited access to radiological technologies.

Incorporation of echocardiographic screening into standard protocols of early neonatal monitoring enhances diagnostic effectiveness, facilitates timely identification of both transient

pISSN:2349-5707 Volume:12,Issue 12,December-2025 eISSN:2349-5715

and persistent cardiovascular abnormalities, and contributes to reducing infant mortality and disability.

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