






Retrospective evaluation of mortality due to congenital heart disease in the neonatal intensive care unit

 ¹Azize BÜYÜKKOÇ
 ²Yusuf İzzet AYHAN
 ³Nurdan EROL
 ⁴İlke MÜNGAN AKIN
 ⁵Derya BÜYÜKKAYHAN

¹Division of Developmental Behavior, Department of Pediatrics, University of Health Sciences, Turkey. Istanbul Zeynep Kamil Maternity and Children's Diseases Health Training and Research Center, Istanbul, Turkey

²Division of Pediatric Cardiology, Department of Pediatrics, Bezmialem Vakıf University, Dragos Hospital, Istanbul, Turkey

³Division of Pediatric Cardiology, Department of Pediatrics, University of Health Sciences, Turkey. Istanbul Zeynep Kamil Maternity and Children's Diseases Health Training and Research Center, Istanbul, Turkey

⁴Division of Neonatal Intensive Care, Department of Neonatology, University of Health Sciences, Umraniye Research and Training Hospital, Istanbul, Turkey

⁵Division of Neonatal Intensive Care, Department of Neonatology, University of Health Sciences, Haseki Research and Education Hospital, Istanbul, Turkey

ORCID ID

AB : 0000-0002-2105-162X
YIA : 0000-0003-2041-1221
NE : 0000-0002-9650-2077
İMA : 0000-0002-3677-1582
DB : 0000-0001-7172-0812



ABSTRACT

Objective: Congenital heart disease (CHD) is one of the most common congenital anomalies and a leading cause of neonatal morbidity and mortality. Early identification of risk factors associated with mortality in affected newborns is essential for improving outcomes. This study aimed to determine the prevalence, mortality rate, and independent risk factors associated with mortality among newborns with CHD admitted to the neonatal intensive care unit (NICU).

Material and Methods: This retrospective study examined newborns with CHD followed up in the NICU of Medeniyet University, Göztepe Training and Research Hospital between January 2010 and January 2014. Sociodemographic, perinatal, and clinical data were extracted from a detailed review of medical records.

Results: The prevalence of CHD was 6.5% in 3023 neonates followed up in the NICU. The most common CHD types were PDA (21.3%), PFO (15.7%), and VSD (14.2%). The mortality rate in newborns with CHD was 13.2% (n=26). Factors independently associated with mortality in these newborns included a low first-minute Apgar score (OR: 0.777, p=0.039), hypoplastic left heart syndrome (OR: 19.397, p=0.005), cardiomyopathy (OR: 7.607, p=0.042), and the need for endotracheal intubation (OR: 9.731, p=0.005).

Conclusion: The prevalence of CHD diagnosis in our NICU setting was 6.5%, and the mortality rate in these newborns was 13.2%. Neonates with low Apgar scores, hypoplastic left heart syndrome, cardiomyopathy, and those undergoing endotracheal intubation should be monitored closely to allow for prompt life-saving interventions. Larger population-based studies are warranted to improve perinatal and postnatal management strategies for CHD.

Keywords: Cardiomyopathy, congenital heart defects, infant, newborn, mortality, neonatal intensive care units, risk factors.

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Correspondence: Azize BÜYÜKKOÇ, MD. Sağlık Bilimleri Üniversitesi, İstanbul Zeynep Kamil Kadın ve Çocuk Hastalıkları Sağlık Uygulama ve Araştırma Merkezi, Çocuk Sağlığı ve Hastalıkları Anabilim Dalı, Gelişimsel Davranış Kliniği, İstanbul, Türkiye

Tel: +90 501 320 70 35 **e-mail:** buyukkocazize@gmail.com

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INTRODUCTION

Congenital heart disease (CHD), the leading cause of morbidity and mortality among birth defects, results from abnormal cardiac and great vessel development during embryogenesis or failure of structural maturation after birth.^[1] CHD is detected in approximately 0.8–1.2% of all live births.^[2,3] The most common types include ventricular septal defect (VSD), atrial septal defect (ASD), patent ductus arteriosus (PDA), pulmonary artery stenosis, coarctation of the aorta, tetralogy of Fallot, and transposition of the great arteries (TGA).^[4] Some risk factors that may lead to the development of CHD include excessive alcohol and drug use during pregnancy, viral infections such as measles and rubella in the first trimester of pregnancy, and a family history.^[5] Current limitations in the detection of some cardiac lesions by prenatal screening make careful evaluation of symptoms suggestive of CHD in the neonatal period critical.^[6] Before the advent of corrective cardiac surgery, only about one-third of children with CHD survived to adulthood. Advances in medical care and surgical techniques have now reduced CHD-related mortality and improved survival to adulthood to nearly 85%.^[7–9] However, if critical CHD are not recognized or treatments are unavailable/unsuccessful, serious complications and death may occur.^[8] Neonates with CHD often require prolonged intensive care support and are at risk of developing serious complications compared to older children.^[10] The main mortality risk factors reported in neonatal CHD include low Apgar (Activity, Pulse, Grimace, Appearance, Respiration) score, preterm birth (<37 weeks), low birth weight (<2500 grams), multiple pregnancy, comorbid conditions, neonatal sepsis, maternal history of gestational diabetes, and home delivery.^[9–11] In Türkiye, mortality rates associated with critical CHD remain high and vary across centers, underscoring the need for further research to improve neonatal outcomes.^[12] Therefore, this study aimed to describe the clinical characteristics of neonates with CHD admitted to our NICU, determine the frequency of mortality, and identify independent risk factors associated with mortality.

MATERIAL AND METHODS

Study Design and Setting

This retrospective observational study was conducted in the Neonatal Intensive Care Unit (NICU) of Medeniyet University Göztepe Training and Research Hospital. Between January 2010 and January 2014, a total of 3023 neonates were admitted to the NICU. Among these, the medical records of 197 term and preterm infants diagnosed with congenital heart disease (CHD) by echocardiography were reviewed. All echocardiographic examinations were performed by the same pediatric cardiologist using a VIVID 3 system (General Electric Medical Systems) to minimize inter-observer variability. Infants with isolated patent foramen ovale (PFO) or patent ductus arteriosus (PDA) identified within the first few days after birth underwent repeat echocardiography on day 3, and those with spontaneous closure of PFO or PDA were excluded. No formal sample size calculation was performed, as all eligible neonates admitted during the study period were included.

Data Collection

The study data were generated by evaluating the medical records. We collected and recorded sociodemographic characteristics,

descriptive and clinical characteristics related to pregnancy and delivery, distribution of CHD diagnoses, clinical findings related to CHD, duration of hospitalization, and accompanying risk factors in patients with CHD who were hospitalized in NICU. Reasons for hospitalization were stratified: infection, respiratory causes (respiratory distress syndrome, transient tachypnea of the newborn, pneumonia, meconium aspiration syndrome), metabolic causes (hypoglycemia, hyperbilirubinemia), hematological causes (anemia, polycythemia), cardiological causes, neurological causes (convulsion, asphyxia, intraventricular hemorrhage), genetic causes, renal causes (renal failure, renal agenesis, vesicoureteral reflux), jaundice, and prematurity. The primary outcome was in-hospital mortality. Independent variables included demographic, perinatal, and clinical characteristics, as well as Apgar scores and CHD subtypes. Apgar scores were routinely assessed at 1 and 5 minutes after birth. Although widely used as a rapid method to identify neonates in need of advanced resuscitation, Apgar scoring may be influenced by factors such as prematurity, maternal medications, congenital anomalies, or inter-observer variability.^[13]

Ethical Considerations

The study was conducted between February and June 2014 after receiving approval from the Clinical Research Ethics Committee of Istanbul Medeniyet University Göztepe Training and Research Hospital (Approval No: 2014/0022, dated January 28, 2014). The study was designed and reported in accordance with the STROBE guidelines and conducted in compliance with the principles of the Declaration of Helsinki.

Statistical Analysis

Data were analyzed using SPSS version 25.0 (IBM Corp., Armonk, NY, USA). Normality was assessed using histograms and Q-Q plots. Continuous variables were summarized as mean \pm standard deviation (normally distributed) or median (interquartile range) (non-normally distributed). Categorical variables were expressed as frequencies and percentages. Group comparisons were performed using Student's t-test or Mann–Whitney U test for continuous variables, and chi-square, Fisher's exact, or Fisher–Freeman–Halton tests for categorical variables, as appropriate. Variables significant in univariable analysis were entered into a multivariable logistic regression model using forward conditional selection to identify independent predictors of mortality. Statistical significance was set at a two-tailed p-value <0.05.

RESULTS

Among 3023 neonates admitted to the NICU for various reasons, 197 (6.5%) were diagnosed with CHD. The leading causes for NICU admission were prematurity (25.9%), respiratory disorders (24.9%), metabolic disease (15.2%), cardiological causes (13.7%), and infection (5.6%). The most frequent CHD subtypes were PDA (21.3%), PFO (15.7%), VSD (14.2%), ASD (10.6%), septal hypertrophy (9.1%), pulmonary stenosis (7.1%), and aortic coarctation (4.1%). The overall mortality rate among neonates with CHD was 13.2% (n=26). Birth weight was significantly lower in deceased neonates compared to survivors (p=0.014). Mortality rates did not differ by mode of delivery (vaginal vs. cesarean, p=1.000), and there was no significant association between gestational age and mortality (p=0.130). Both 1st-minute (p=0.001) and 5th-minute (p<0.001) Apgar scores were significantly lower among deceased infants (Table 1).

Table 1: Natal and maternal characteristics with regard to mortality

	Total (n=197)	Mortality		p
		No (n=171)	Yes (n=26)	
Birth place				
Our hospital	123 (62.44%)	105 (61.40%)	18 (69.23%)	0.582 [§]
Another hospital	74 (37.56%)	66 (38.60%)	8 (30.77%)	
Age at admission, days	1 (1–6)	1 (1–7)	1 (1–3)	0.228 [‡]
Delivery				
Vaginal	63 (31.98%)	55 (32.16%)	8 (30.77%)	1.000 [§]
Cesarean section	134 (68.02%)	116 (67.84%)	18 (69.23%)	
Birth weight, g	2910 (1900–3490)	2920 (2040–3580)	2460 (735–3130)	0.014[‡]
Small for gestational age (SGA)	9 (4.57%)	9 (5.26%)	0 (0.00%)	0.661 [¶]
Appropriate for gestational age (AGA)	183 (92.89%)	157 (91.81%)	26 (100.00%)	
Large for gestational age (LGA)	5 (2.54%)	5 (2.92%)	0 (0.00%)	
Gestational status	38 (33–38)	38 (34–38)	35.5 (27–38)	0.130 [‡]
Term	131 (66.50%)	118 (69.01%)	13 (50.00%)	0.091 [§]
Preterm	66 (33.50%)	53 (30.99%)	13 (50.00%)	
Sex				
Girl	80 (40.61%)	68 (39.77%)	12 (46.15%)	0.687 [§]
Boy	117 (59.39%)	103 (60.23%)	14 (53.85%)	
Apgar, 1 st minute	6 (5–8)	6 (5–8)	5 (3–7)	0.001[‡]
Apgar, 5 th minute	8 (7–9)	9 (7–9)	7 (5–8)	<0.001[‡]
Mother age, years	29.50±6.19	29.65±6.04	28.50±7.13	0.377 [†]
Maternal disease / natal complications	66 (33.50%)	58 (33.92%)	8 (30.77%)	0.925 [§]
Diabetes during pregnancy	29 (14.72%)	28 (16.37%)	1 (3.85%)	0.136 [#]
Drug use during pregnancy	42 (21.32%)	37 (21.64%)	5 (19.23%)	0.982 [§]
Smoking/alcohol use during pregnancy	8 (4.06%)	8 (4.68%)	0 (0.00%)	0.600 [#]
Regular follow-up during pregnancy	181 (91.88%)	158 (92.40%)	23 (88.46%)	0.449 [#]
Antenatal diagnosis	13 (6.60%)	9 (5.26%)	4 (15.38%)	0.074 [#]
Assisted reproductive techniques	3 (1.52%)	2 (1.17%)	1 (3.85%)	0.348 [#]
Multiple pregnancy	12 (6.09%)	10 (5.85%)	2 (7.69%)	0.662 [#]
Gravidity	2 (1–3)	2 (1–3)	2 (1–3)	0.130 [‡]
Live birth	2 (1–3)	2 (1–3)	1.5 (1–2)	0.143 [‡]
Abortions	0 (0–1)	0 (0–1)	0 (0–1)	0.806 [‡]
Intrauterine exitus	4 (2.03%)	4 (2.34%)	0 (0.00%)	1.000 [#]
Consanguinity	26 (13.20%)	26 (15.20%)	0 (0.00%)	0.029[#]
Congenital heart disease (CHD) in family	6 (3.05%)	5 (2.92%)	1 (3.85%)	0.577 [#]
Reason of hospitalization				
Respiratory problems	49 (24.87%)	45 (26.32%)	4 (15.38%)	0.090 [¶]
Infection	11 (5.58%)	10 (5.85%)	1 (3.85%)	

Table 1 (cont): Natal and maternal characteristics with regard to mortality

	Total (n=197)	Mortality		p
		No (n=171)	Yes (n=26)	
Metabolic diseases	30 (15.23%)	29 (16.96%)	1 (3.85%)	0.090 [¶]
Hematological problems	2 (1.02%)	2 (1.17%)	0 (0.00%)	
Cardiac problems	27 (13.71%)	20 (11.70%)	7 (26.92%)	
Neurological problems	7 (3.55%)	5 (2.92%)	2 (7.69%)	
Genetic	11 (5.58%)	11 (6.43%)	0 (0.00%)	
Kidney problems	4 (2.03%)	4 (2.34%)	0 (0.00%)	
Icterus	5 (2.54%)	5 (2.92%)	0 (0.00%)	
Prematurity	51 (25.89%)	40 (23.39%)	11 (42.31%)	

Descriptive statistics are presented using mean±standard deviation for normally distributed continuous variables, median (25th percentile - 75th percentile) for non-normally distributed continuous variables and frequency (percentage) for categorical variables. † Student's t test, ‡ Mann Whitney U test, § Chi-square test, ¶ Fisher's exact test, ¶ Fisher-Freeman-Halton test, * Statistically significant category for the variables with three or more categories. Statistically significant p values are shown in bold. NCPAP: Nasal continuous positive airway pressure.

Certain CHD subtypes—PDA, hypoplastic left heart syndrome (HLHS), cardiomyopathy (CMP), and dextrocardia—were more common in neonates who died ($p=0.001$). Among treatment-related factors, intensive care requirement ($p=0.003$) and endotracheal intubation ($p<0.001$) were significantly associated with mortality (Table 2). In multivariable logistic regression analysis, independent predictors of mortality were: low 1st-minute Apgar score (OR: 0.777, 95% CI: 0.611–0.988, $p=0.039$), HLHS (OR: 19.397, 95% CI: 2.427–155.020, $p=0.005$), CMP (OR: 7.607, 95% CI: 1.080–53.569, $p=0.042$), and endotracheal intubation (OR: 9.731, 95% CI: 2.014–47.010, $p=0.005$). Specifically, HLHS increased mortality risk 19.4-fold, CMP 7.6-fold, and intubation 9.7-fold. Other variables—including birth weight ($p=0.703$), 5th-minute Apgar score ($p=0.951$), consanguinity ($p=0.998$), PDA ($p=0.148$), dextrocardia ($p=0.999$), and medical treatment ($p=0.153$)—were not significantly associated with mortality (Table 3).

DISCUSSION

In Türkiye, CHD was the fourth leading cause of infant mortality between 2007 and 2012,^[14] whereas the more detailed 2012–2018 Infant Mortality Report ranked congenital anomalies as the second leading cause of infant mortality (25%), with CHDs being the most common anomaly within this group.^[15] Expansion of antenatal and newborn screening programs and improvements in diagnostic methods have contributed to a significant reduction in neonatal CHD-related mortality over time.^[16] Despite these advances, mortality rates remain notable, and factors influencing this risk necessitate ongoing research and intervention. Epidemiological data from Türkiye report CHD prevalence in NICUs between 6% and 12% in recent large-center studies: Korkmaz et al.,^[17] 10.7%; Zan et al.,^[18] 6.6%; Şimşek et al.,^[19] 11.7%; Ertürk et al.,^[20] 7.5%. Older studies show wider variability (1.0–16.7%), reflecting differences in geographic regions, diagnostic

capabilities, and study comprehensiveness.^[19,21–24] In the present study, CHD prevalence in NICU-admitted neonates was 6.5%, consistent with prior regional data.^[23] Variations in prevalence may also reflect diagnostic tool availability, categorization criteria, consanguinity rates, and access to prenatal and postnatal care. Heart murmur remains an important indicator of CHD, and timely echocardiography is critical for accurate diagnosis. While innocent murmurs are common among hospitalized neonates, many neonates with murmurs demonstrate abnormal echocardiographic findings.^[25] In previous NICU studies, heart murmur accounted for 72–87.5% of cardiology consultations,^[17,20,23,26,27] whereas other reasons included tachypnea and feeding difficulties.^[26,27] In this study, heart murmur was the most common reason for cardiology consultation (39.6%), reinforcing its clinical significance. Some studies, such as Mir et al.,^[28] reported tachypnea (43.4%), feeding difficulties (20.8%), and cyanosis (17.2%) as the most common signs, with murmurs detected in only 6.0%, possibly reflecting greater disease severity in these cases. The prevalence of some heart defects, especially mild types, has been reported to increase over time, while others remain stable. The most common congenital heart defect is generally described as VSD.^[29] In a study by Şimşek and Baysal, among neonates with CHD admitted to the NICU, the most common acyanotic CHD were VSD (31.3%), ASD (30.1%), and PDA (21.6%).^[19] Similarly, Yalaki et al.^[30] reported VSD (30.2%), ASD (22.2%), PDA (22.2%), and peripheral pulmonary stenosis (11.1%) as the most frequent diagnoses. Other studies also reported VSD as the most common defect, though at lower proportions (15–20%).^[17,20,23] In a NICU-based study evaluating neonates requiring emergency intervention, the most frequent diagnoses were transposition of the great arteries (33.7%) and pulmonary atresia (19.3%).^[31] Another study identified transposition of the great arteries (14.1%), complete atrioventricular septal defect, and aortic hypoplasia among the most common diagnoses.^[22] We defined the most common CHD in our study as being PDA (21.3%), PFO (15.7%), and VSD (14.2%), respectively. The relatively high

Table 2: Clinical findings and diagnostic features with regard to mortality

	Total (n=197)	Mortality		p
		No (n=171)	Yes (n=26)	
Cardiomegaly	10 (5.08%)	7 (4.09%)	3 (11.54%)	0.130 [#]
ECG findings	6 (3.05%)	5 (2.92%)	1 (3.85%)	0.577 [#]
Heart murmur	78 (39.59%)	70 (40.94%)	8 (30.77%)	0.440 [§]
Age at echocardiography, days	5 (2–10)	5 (3–11)	4 (2–6)	0.112 [‡]
Diagnosis				
Ventricular septal defect	28 (14.21%)	26 (15.20%)	2 (7.69%)	
Septal hypertrophy	18 (9.14%)	18 (10.53%)	0 (0.00%)	
Atrial septal defect	21 (10.66%)	20 (11.70%)	1 (3.85%)	
Transposition of the great arteries	3 (1.52%)	3 (1.75%)	0 (0.00%)	
Patent ductus arteriosus	42 (21.32%)	31 (18.13%)	11 (42.31%)*	
Hypoplastic left heart syndrome	6 (3.05%)	2 (1.17%)	4 (15.38%)*	
Patent foramen ovale	31 (15.74%)	29 (16.96%)	2 (7.69%)	
Atrioventricular septal defect	3 (1.52%)	3 (1.75%)	0 (0.00%)	
Tetralogy of Fallot	2 (1.02%)	2 (1.17%)	0 (0.00%)	
Aortic coarctation	8 (4.06%)	7 (4.09%)	1 (3.85%)	0.001[†]
Interrupted aortic arch	1 (0.51%)	1 (0.58%)	0 (0.00%)	
Pulmonary valve stenosis	14 (7.11%)	14 (8.19%)	0 (0.00%)	
Total anomalous pulmonary venous return	4 (2.03%)	4 (2.34%)	0 (0.00%)	
Aortic stenosis	2 (1.02%)	2 (1.17%)	0 (0.00%)	
Cardiomyopathy	5 (2.54%)	2 (1.17%)	3 (11.54%)*	
Dextrocardia	1 (0.51%)	0 (0.00%)	1 (3.85%)*	
Supraventricular tachycardia	3 (1.52%)	3 (1.75%)	0 (0.00%)	
Tricuspid valve regurgitation	3 (1.52%)	2 (1.17%)	1 (3.85%)	
Pulmonary hypertension	2 (1.02%)	2 (1.17%)	0 (0.00%)	
Type of CHD				
Cyanotic	26 (13.20%)	22 (12.87%)	4 (15.38%)	0.756 [#]
Acyanotic	171 (86.80%)	149 (87.13%)	22 (84.62%)	
Duct-dependent CHD	24 (12.18%)	20 (11.70%)	4 (15.38%)	0.531 [#]
Accompanying anomaly	33 (16.75%)	29 (16.96%)	4 (15.38%)	1.000 [#]
Genetic consultation	18 (9.14%)	16 (9.36%)	2 (7.69%)	1.000 [#]
Intervention at hospitalization	1 (0.51%)	1 (0.58%)	0 (0.00%)	1.000 [#]
Medical treatment	43 (21.83%)	31 (18.13%)	12 (46.15%)	0.003[§]
NCPAP	65 (32.99%)	56 (32.75%)	9 (34.62%)	1.000 [§]
Oxygen hood use	94 (47.72%)	85 (49.71%)	9 (34.62%)	0.221 [§]
Endotracheal intubation	89 (45.18%)	65 (38.01%)	24 (92.31%)	<0.001[§]
Length of stay in hospital, days	13 (6–28)	14 (7–28)	8 (2–27)	0.167 [‡]

Descriptive statistics are presented using mean±standard deviation for normally distributed continuous variables, median (25th percentile - 75th percentile) for non-normally distributed continuous variables and frequency (percentage) for categorical variables. [†] Student's t test, [‡] Mann Whitney U test, [§] Chi-square test, [#] Fisher's exact test, [¶] Fisher-Freeman-Halton test, * Statistically significant category for the variables with three or more categories. Statistically significant p values are shown in bold. NCPAP: Nasal continuous positive airway pressure.

Table 3: Significant factors independently associated with the mortality, multivariable logistic regression analysis

	β coefficient	Standard error	p	Exp(β)	95% CI for Exp(β)	
Cardiomegaly	-0.252	0.122	0.039	0.777	0.611	0.988
ECG findings	2.965	1.060	0.005	19.397	2.427	155.020
Heart murmur	2.029	0.996	0.042	7.607	1.080	53.569
Age at echocardiography, days	2.275	0.804	0.005	9.731	2.014	47.010
Diagnosis	-2.415	1.043	0.021	0.089		

Nagelkerke $R^2=0.368$, CI: Confidence interval. Significant p values are shown in bold. Apgar: Appearance, Pulse, Grimace, Activity and Respiration.

prevalence of PDA and PFO likely reflects the inclusion of preterm infants and routine echocardiography for all neonates born under 1000 grams, emphasizing the importance of patient profile and timing in determining CHD prevalence.

In the last decade, mortality rates in newborns with CHD have decreased, but major neonatal morbidity rates have increased in parallel.^[32] In a study by Çaylan et al.^[3] using national data from 2018 to 2021, the critical CHD-specific neonatal mortality rate in Türkiye was reported as 4.6 per 10,000 live births. Dilli et al.,^[12] in their study examining nine tertiary healthcare institutions, found that the in-hospital mortality rate due to critical CHD was 20.1% and the postoperative mortality rate was 19.6% between 2021–2022. In a study in which newborns with CHD were followed up for a period of three months, the incident mortality rate was 81 per 100,000 live births.^[9] Mortality rates from different studies employing various designs and analyses appear to range from 4.5% to 50%.^[11,18,20,22,24,26–28,31,33–35] In the present study, the mortality rate in neonates with CHD in the NICU was 13.2%. This is lower than the corresponding values from other research—barring two studies.^[11,24] Variations may be explained by the inclusion of only cases with critical CHD or those requiring surgical intervention in some studies. Relatively higher mortality may also be explained by the fact that these studies largely consisted of patients admitted to the NICU. Although the mortality rate in the present study was found to be lower compared to many studies, this rate is still at a level that cannot be ignored. Our center has a pediatric cardiology clinic and offers comprehensive fetal echocardiography services, which may have contributed to the increase in the number of cases due to early detection and the referral of suspected cases in the antenatal period. However, the lack of interventional angiography and limited surgical treatment facilities in this center limited the implementation of critical interventions that could reduce mortality. This situation once again demonstrates the importance of multidisciplinary approaches and fully equipped centers in the treatment of newborns with CHD.

Prematurity, caesarean section, low birth weight, neonatal necrotizing enterocolitis, preoperative mechanical ventilation, prolonged cardiopulmonary bypass time, surgical experience, and peri/post-operative complications (kidney injury, thrombosis or stroke) are recognized as the main risk factors for CHD mortality in the neonatal period.^[36] In addition, sepsis, cyanotic CHD, home birth, and other congenital anomalies can significantly predict neonatal mortality.^[11]

Lopes et al.^[9] reported that low gestational age (<37 weeks), low birth weight (<2500 g), multiple pregnancy, and presence of comorbidities increased mortality. In a study conducted in India, low birth weight and duct-dependent systemic circulation were shown to be important predictors of neonatal mortality due to CHD.^[37] Among neonates hospitalized in the NICU with CHD requiring early intervention, SNAP-II scores and vasopressor use were found to be the main parameters predicting mortality; however, no significant relationship was reported for sex and age.^[31] Another study emphasized that extreme low birth weight, severe and moderate asphyxia, pulmonary hypertension, sepsis, and severe forms of CHD are the major determinants of mortality in newborns with CHD.^[34] In a Brazilian study, low birth weight, low 1st minute Apgar score, and CHD complexity were reported as independent risk factors for hospital mortality.^[38] Consistently, low birth weight, low Apgar scores, and CHD complexity emerge as common independent risk factors.^[39] These risk factors are also prevalent in Türkiye. A study analyzing the database of critical CHD cases in Türkiye identified that 24.8% of infant deaths had a diagnosis of HLHS. In addition, premature birth, low birth weight, multiparity, maternal age of 35 years or older, twin/triplet pregnancy, male sex, maternal education (secondary school or less), and caesarean section were associated with higher mortality in critical CHD.^[3] In a study conducted by Çaylan et al.^[40] using the Turkish national database, preterm birth, low birth weight, maternal age, and region were reported as factors associated with mortality risk. According to the study by Zübarioğlu et al.,^[41] prematurity, low birth weight, and additional organ anomaly are risk factors independent of the severity of cardiac malformation in terms of perioperative mortality in critical CHD. In the present study, we found that the mortality risk increased with low Apgar (1st minute), HLHS, CMP, and endotracheal intubation independently of other factors, which are factors that have been described in separate studies.^[3,9,12,36,38,39,41] Neonates with low Apgar scores who require invasive ventilation support have a higher risk of death when more complex procedures are required.^[9] Reducing mortality in newborns with CHD requires a multidisciplinary approach and planned delivery in centers capable of providing interventional treatments. Prenatal diagnosis, delivery of these babies in highly equipped centers, and optimization of neonatal care may significantly increase survival. Implementation of mandatory newborn screening policies in the United States of America resulted in a significant reduction in CHD-related infant mortality compared to non-implemented states, demonstrating once

again the importance of these practices.^[42] As such, prenatal care and presence of multidisciplinary teams (mainly neonatology, anesthesia, pediatric cardiology, and cardiothoracic surgery specialists) are of vital importance in the management of neonates with CHD. Based on our results and available literature, it appears that survival can be improved by prioritization of neonates with a diagnosis of HLHS or CMP and close follow-up of subjects with low 1-minute Apgar score or recipients of intubation, as well as possible early transfer of these patients to better-equipped centers.

Limitations

Despite being conducted in a tertiary healthcare institution receiving considerable referrals for CHD cases, this study is single-center, which may limit generalizability. Inclusion was restricted to neonates followed up in the NICU, potentially biasing the study population toward more severe forms of CHD and artificially increasing observed mortality rates. Conversely, mortality could have been underestimated because some patients requiring advanced surgical interventions were transferred to other centers due to limited surgical facilities at our institution. Consequently, the impact of surgical treatment on mortality could not be assessed. In addition, the lack of information on the total number of births in the same period or the number of newborns diagnosed with CHD outside our NICU might have had a minor impact on reported prevalence values. Despite examining a vast set of variables, the retrospective design limited the completeness of various data which were not included in the analyses, possibly influencing the accuracy of the model used to assess mortality risk factors and causing the lack of long-term outcome analyses. Prospective studies may provide stronger conclusions in this regard. Despite these limitations, this study evaluated a comprehensive set of parameters in NICU-admitted neonates with CHD, allowing detailed characterization of high-risk groups and providing clinically relevant insights for neonatal care and risk stratification.

CONCLUSION

The prevalence of CHD among neonates admitted to the NICU was 6.5%, with a mortality rate of 13.2%. Low Apgar score, HLHS, CMP, and the need for endotracheal intubation emerged as independent predictors of mortality. These findings highlight the importance of close monitoring and early intervention in neonates with such risk factors. To reduce CHD-related neonatal mortality, population-based prospective studies encompassing prenatal, neonatal, and postnatal periods are needed, along with strategies to strengthen early diagnosis, referral, and multidisciplinary management.

Disclosures

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