Quality of Life in Children With Cyanotic Congenital Heart Disease With and Without Right Ventricular Failure After Corrective Surgery: A Prospective Comparative Study

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ABSTRACT

BACKGROUND: Surgical progress has significantly facilitated survival in patients with cyanotic congenital heart disease (CCHD), but postoperative complications, particularly right ventricular failure (RVF), may substantially impair long-term quality of life (QOL).
OBJECTIVE: This study aims to evaluate and compare the QOL of children with CCHD who developed right ventricular failure (RVF) after surgery with those who maintained preserved right ventricular function.
METHODS: A prospective comparative study was conducted from January 2025 to March 2026 at the Sulaimani Children's Heart Hospital. A total of 400 children aged 3–13 years with corrective surgery for cyanotic CHD, with and without RVF, were included. Quality of life was evaluated using a structured questionnaire based on the Pediatric Quality of Life Inventory (PedsQL) Cardiac module and the Pediatric Cardiac Quality of Life Inventory (PCQLI), encompassing six domains. Data were analyzed using ANCOVA and two-way ANCOVA, adjusted for age, sex, and age at corrective surgery. Multivariate linear regression was additionally used to identify factors independently associated with QOL. $P \leq 0.05$ was considered statistically significant.
RESULTS: After controlling for age, sex, and age at corrective surgery, children with RVF had significantly lower overall QoL scores than those without RVF ($F = 135.35$, $p < 0.001$, partial $\eta^2 = 0.26$). All QoL domains were significantly lower among children with RVF (all $p < 0.001$), with the largest effects observed for heart problems (partial $\eta^2 = 0.27$) and physical well-being (partial $\eta^2 = 0.18$), followed by general health (partial $\eta^2 = 0.15$). No significant RVF × age-group interaction was observed. In multivariable linear regression, child sex was independently associated with total QoL score ($B = -2.88$, $p = 0.001$), whereas child age ($B = -0.12$, $p = 0.569$) and age at corrective surgery ($B = -0.25$, $p = 0.454$) were not significantly associated with QoL.
CONCLUSIONS: Right ventricular failure was independently associated with poorer quality of life in children with cyanotic congenital heart disease following corrective surgery. Children with RVF had significantly lower quality-of-life scores across all assessed domains, even after adjustment for age, sex, and age at corrective surgery. These findings highlight the importance of routine assessment of right ventricular function and integration of multidisciplinary supportive care during postoperative follow-up.
Keywords: Cyanotic congenital heart disease; right ventricular failure; quality of life; pediatric cardiology; postoperative outcomes

INTRODUCTION

Congenital heart disease (CHD) comprises a group of structural heart abnormalities that affect cardiac function. The condition can result from genetic factors inherited from one or both parents. It can be classified into non-cyanotic and cyanotic types,

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also known as critical congenital heart disease (CCHD). Congenital heart disease encompasses a wide spectrum of defects ranging from simple to complex conditions. In recent years, early diagnosis, improved medical care, and advances in surgical treatment have significantly improved the outlook for children with congenital heart disease, reducing mortality and morbidity rates (Zimmerman and Sable, 2020). Cyanotic congenital heart disease, also known as critical congenital heart disease (CCHD), is characterized by a right-to-left shunt, leading to deoxygenated blood entering the systemic circulation. The prevalence of cyanotic CHD is approximately 11%, including TOF (Khasawneh et al., 2020), followed by complex heart defects, such as transposition of the great arteries (TGA; 5%) and tricuspid atresia (TAr), and pulmonary atresia. In addition, two types of complex cardiac anomalies include double-outlet right ventricle (DORV) and double-inlet left ventricle (DILV), or univentricular atrioventricular connection, which is also a rare condition in which one ventricle is developed and both atria pump blood into this chamber. Among congenital heart defects, which more commonly affect the right heart, are Tetralogy of Fallot (TOF), pulmonary stenosis (PS), Ebstein anomaly, arrhythmogenic right ventricular cardiomyopathy (ARVC), and pulmonary valve atresia, all of which are due to chronic pressure or volume overload before and after corrective surgery. In many of these patients, prevention of irreversible right heart failure (RHF) will require timely corrective surgery or, when not possible, surgical palliation. (Baumgartner et al., 2010). These conditions typically present early in life, exhibit significant symptoms, and often require early surgical or interventional treatment (Amel-Shahbaz et al., 2014, Teteli et al., 2014). Consequently, RV function may be impaired by pressure or volume overload, or by a combination of both. An accurate understanding of RV anatomy and assessment of RV volumes and function is thus paramount for clinicians involved in the care of CHD patients (Alonso-González et al., 2010).

Children with congenital heart defects may experience multiple factors that affect their health-related quality of life, which may vary with their developmental stage. These factors may include delayed physical growth, general health, cognitive impairment, limitations in physical activity, treatment-related factors, family environment, relationship domains, and the patient's perception of how the illness and its treatment have affected their life. When evaluating and managing the quality of life in children with congenital heart defects, it is crucial to consider these factors (Germain et al., 2019, Daliento et al., 2006). Children diagnosed with cyanotic congenital heart disease are at a higher risk of experiencing significant delays in physical growth, which can be observed from an early stage of their life (Daliento et al., 2006, Nakou, 2001). Children with congenital heart disease experience difficulties related to physical appearance changes during preoperative and postoperative periods. This issue affects children at all stages of physical growth and is especially pronounced after surgery, as the large chest incision becomes a visible symbol of their disease. Those who have surgically corrected cyanotic lesions experience significantly lower academic function in school. Multiple interrelated factors, including disease severity, chronic hypoxemia, pulmonary hypertension, and ventricular dysfunction, influence quality of life in children with cyanotic congenital heart disease. Despite successful surgical management, postoperative complications due to residual lesions, arrhythmias, and right ventricular failure continue to present as a burden on function and exercise (Akhmedova et al., 2026).

Neurodevelopmental, socioeconomic, and

psychological factors also adversely contribute to reductions in physical, emotional, and social well-being. Knowing the determinants of quality of life is essential in this population for long-term, post-survival optimization (Nakou, 2001, Wray and Sensky, 2001). Nonetheless, although the association of right ventricular dysfunction with functional complications is becoming increasingly evident, relatively few data have been collected on its own relevance to health-related quality of life in postoperative conditions of children with cyanotic congenital heart disease, especially in resource-poor settings. Therefore, this study aimed to compare the quality of life of children with cyanotic congenital heart disease who developed right ventricular failure after corrective surgery with those who maintained preserved right ventricular function. Additionally, the study sought to identify clinical and demographic factors associated with quality of life outcomes in this population.

METHODS

Study Design

A prospective comparative study was conducted to compare the quality of life of children with cyanotic CHD with and without right ventricular failure following corrective surgery. This study was conducted and reported in accordance with the STROBE guidelines for observational studies.

Setting

The study was conducted at Sulaimani Children's Heart Hospital from January 2025 to March 2026. The Children's Heart Hospital (CHH) provides health care services exclusively to children with heart conditions, including treatment, surgery, and catheterization. This hospital is the main and the largest hospital located in the center of Sulaimani City.

Sample size

The sample size was determined according to a previously published study (Rometsch et al., 2019). Based on the expected mean difference in quality of life (QoL) between the two groups and the pooled standard deviation, a total of 400 children with postoperative cyanotic congenital heart disease, both with and without right ventricular failure (RVF), were included.

Ethics approval and consent to participate

Ethical approval for this study was obtained from the Ethics Committee of the Sulaimani Technical Institute (Approval No. 195, February 2026). The study was conducted in accordance with the Declaration of Helsinki. Permission was obtained from the Sulaimani Children's Heart Hospital. Written informed consent was obtained from the parents or legal guardians of all participants.

Participants

A total of 400 children who underwent surgery for cyanotic CHD of any sex and aged 3 to 13 years, residing in Sulaimani province, were recruited for the study. Children who had previously undergone corrective surgery for cyanotic congenital heart disease were identified from the hospital registry and recruited during the study period. After recruitment, all eligible participants underwent echocardiographic assessment of right ventricular function to determine the presence or absence of right ventricular failure. Right ventricular failure was defined as a right ventricular ejection fraction (RVEF) <45% and a TAPSE Z-score <−2, indicating abnormally reduced right ventricular systolic function.cm.

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Inclusion criteria: Children with cyanotic CHD who had undergone corrective surgery, with and without right ventricular failure, were included in the study.

Exclusion criteria: Children with cyanotic CHD who had not undergone corrective surgery, regardless of the presence or absence of RVF, as well as those with non-cyanotic CHD, were excluded.

Data collection

A structured questionnaire was used to collect data on quality of life among postoperative children with cyanotic CHD, with and without RVF. The hospital patient registry was reviewed to identify children with cyanotic congenital heart disease who had previously undergone corrective surgery since 2010. Eligible children were subsequently enrolled in the study and underwent prospective clinical and echocardiographic assessment to evaluate right ventricular function and determine the presence or absence of right ventricular failure. Children and their parents were recruited for a face-to-face interview at the Children's Heart Hospital to collect data. The questionnaire was developed based on the review of the PedsQL Cardiac Module (parent-report version) and PCQLI. The first section collects demographic data, including sex, age, residence, and weight. The second section includes data on quality of life. It comprised 33 items, divided into six domains: general health condition (6 items), social health (2 items), physical well-being (7 items), heart problems with limited activities (9 items), medical treatment conditions (3 items), and psychological well-being (6 items). The five-point Likert scale (ranging from 1 to 5) was adjusted to test the association between quality of life and each group: not at all (1), little (2), and moderate to severe (3), using item 3 combined with items 4 and 5. Responses were converted to a 0–100 scale, with higher scores indicating better quality of life.

The questionnaire was reviewed by three pediatric cardiologists for content validity, and a pilot study was conducted with several children to assess reliability. The Cronbach's alpha for the questionnaire was 0.90, indicating excellent internal consistency.

Statistical Analysis

The analyses were conducted using SPSS version 26 (IBM Corp., Armonk, NY, USA). Descriptive statistics were expressed as frequencies and percentages

for categorical variables and as means ± standard deviations for continuous variables. Cronbach's alpha was used to estimate the internal consistency of the quality of life questionnaire. Baseline comparisons between children with RVF and controls without RVF were performed using chi-square tests on categorical variables. The primary outcome was the total quality of life (QoL) score. Analysis of covariance (ANCOVA) was used, adjusting for child age, sex, and age at corrective surgery, to compare total and domain-specific QoL scores in children with and without RVF. Adjusted means with standard errors (SE), mean differences with 95% confidence intervals (CI), F statistics, p-values, and partial eta squared (η^2) effect sizes were presented. To determine whether the effect of RVF on QoL was age-dependent, a two-way ANCOVA was performed with RV status and age group as fixed factors, adjusting for sex and age at corrective surgery. Unadjusted differences between groups were analyzed by independent-samples t-tests, and ANCOVA models adjusted for confounder effects and estimated group effects. Multivariable linear regression was used to identify factors associated with total quality of life. A two-tailed p-value < 0.05 was considered statistically significant.

RESULTS A cohort of 400 children with cyanotic congenital heart disease was compared according to the presence or absence of right ventricular failure (200 RVF and 200 without RVF). No statistical difference was observed between males and females (p=0.2). The two groups differed significantly in place of residence, with a higher proportion of children without right ventricular failure residing in urban areas than those with right ventricular failure (93.5% vs. 71.5%, respectively; P < 0.001. The two groups did not differ significantly in childhood weight categories (12–24 kg, 25–37 kg, and 38–50 kg; P = 0.9). Age distribution and age at corrective surgery differed significantly between groups (P = 0.001 and P = 0.001, respectively). The mean age of children was 8.8 ± 2.5 years, with ages ranging from 3 to 13 years. Similarly, educational status did not differ significantly between children with and without right ventricular failure (e.g., kindergarten, primary, secondary, no formal education) (P = 0.1).

Table 1. Baseline characteristics of children with postoperative cyanotic congenital heart disease with and without right ventricular failure

Characteristics.	Postoperative CCHD with RVF n (%)	Postoperative CCHD without RVF n (%)	p-value
Child gender			
Male	100 (48.1)	108 (51.9)	0.2
Female	100 (52.1)	92 (47.9)	
Residents			
Urban	143 (71.5)	187 (93.5)	< 0.001
Rural	57 (28.5)	13 (6.5)	
Child weight (Kg)			
12-24	59 (29.5)	62 (31.0)	0.9
25-37	115 (57.5)	108 (54.0)	
38-50	26 (13.0)	30 (15.0)	
Age group (years)			
3-5	15 (7.5)	26 (13.0)	0.001
6-9	84 (42.0)	109 (54.5)	
10-13	101 (50.5)	65 (32.5)	
Child education			
Kindergarten	26 (13)	34 (17)	0.1
Primary	122 (61)	124 (62)	
Secondary	22 (11)	10 (5)	
None	30 (15)	32 (16)	
Age at corrective surgery (Years)			
2-5	132 (66.0)	174 (87.0)	0.001
6-9	63 (31.5)	25 (12.5)	
10-13	5 (2.5)	1 (0.5)	

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Table 2 compares the mean current age and age at corrective surgery between postoperative children with cyanotic congenital heart disease (CCHD) with and without right ventricular failure (RVF). The mean current age of children with RVF was 9.32 ± 2.44 years, compared with 8.26 ± 2.44 years among children without RVF. The mean difference was 1.06 years ($P < 0.001$). The mean age at corrective surgery was 5.08 ± 1.72 years among children with RVF, compared with 4.18 ± 1.36 years among those without RVF. The mean difference was 0.90 years ($P < 0.001$).

Table 2. Comparison of mean age and age at corrective surgery between postoperative cyanotic congenital heart disease children with and without right ventricular failure

Type	Mean ± SD	Mean difference	Minimum - Maximum	p-value
Age year				
CCHD RVF	9.32 ± 2.44	1.06	3-13	<0.001
CCHD No RVF	8.26 ± 2.44			
Age at corrective surgery				
CCHD RVF	5.08 ± 1.72	0.90	2-13	<0.001
CCHD No RVF	4.18 ± 1.36			

Table 3 Table 3 presents comparisons of quality-of-life subdomains between children with and without right ventricular failure, showing significantly lower scores across most subdomains in children with RVF.

Table 3. Comparison of mean quality of life subdomain scores between normal and impaired right ventricular function

QoL subdomains	Normal RV Mean ± SD	Abnormal RV Mean ± SD	t	p-value
General health				
General health condition	89.94 ± 21.49	77.50 ± 19.74	-5.77	<0.001
Nutritional status	82.10 ± 21.06	75.30 ± 21.77	-3.17	0.002
Daily life activity	80.10 ± 15.72	73.40 ± 19.45	-3.79	<0.001
Development disorder	84.00 ± 16.65	79.40 ± 19.83	-2.51	0.01

Disease disturbance	87.80 ± 24.04	76.12 ± 27.79	-4.47	<0.001
Sleep disorder and insomnia	94.00 ± 13.74	88.04 ± 17.90	-3.71	<0.001
Social health life				
Family and friends' relationship	97.60 ± 7.10	91.20 ± 19.71	-4.32	<0.001
Keeping up when playing with other children	92.80 ± 12.52	84.50 ± 22.18	-4.60	<0.001
Physical well-being				
Exercise tolerance	89.50 ±18.25	75.50 ± 25.01	-6.38	<0.001
Fatigue during walking	93.70 ±13.23	77.40 ±23.74	-8.47	<0.001
Overall energy levels	88.70 ±17.31	80.00 ± 19.12	-4.76	<0.001
Physical activity compared with peers	79.40 ±17.12	71.60 ± 21.62	-3.99	<0.001
Difficulty climbing high places and stairs	91.30 ±18.97	78.65 ± 25.02	-5.66	<0.001
Limitations in vigorous physical activities	90.90 ±18.78	82.37 ± 23.40	-3.99	<0.001
Need more rest	95.10 ±13.37	82.80 ± 24.64	-6.20	<0.001
Heart problems				
Shortness of breath during physical activity	96.10 ±10.35	90.60 ± 16.15	-4.05	<0.001
Chest pain during exertion	94.10 ± 14.84	82.90 ± 24.09	-5.49	<0.001
Heart arrhythmia	97.10 ±11.41	91.60 ± 17.28	-3.75	<0.001
His/her lips turn blue when running	96.00 ± 12.99	83.70 ± 25.04	-6.16	<0.001
Waking up at night with trouble breathing	97.60 ± 12.12	91.90 ± 21.32	-3.29	0.001
Recurrent respiratory symptoms	96.40 ± 14.83	87.10 ± 25.27	-4.48	<0.001
Easy fatigability during eating	89.20 ± 13.12	83.50 ± 15.32	-3.99	<0.001
Feeling dizzy	92.00 ± 14.73	87.10 ± 19.11	-2.87	0.004

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Reduced exercise tolerance and easy fatigability	91.70 ± 16.68	74.90 ± 23.03	-8.35	<0.001
Treatment status				
Getting anxious while taking heart medicine	99.10 ± 5.41	98.20 ± 7.55	-1.36	0.1
Heart medicine is making him/her feel sick	87.40 ± 19.98	75.00 ± 24.61	-5.53	<0.001
Getting anxious about going to the doctor	88.90 ± 18.56	73.80 ± 24.50	-6.94	<0.001
Psychological behavior				
Feeling afraid or scared	83.73 ± 20.16	65.40 ± 23.86	-8.27	<0.001
Feeling sad or blue	97.40 ± 9.25	93.20 ± 14.51	-3.45	0.001
Feeling angry	92.60 ± 16.32	88.08 ± 18.45	-2.58	0.01
Worrying about what will happen to him or her	96.60 ± 8.04	94.20 ± 12.45	-2.28	0.02
Memory	91.40 ± 13.96	86.60 ± 16.54	-3.13	0.002
Difficulty paying attention	80.10 ± 25.63	77.60 ± 29.02	-9.13	<0.001

Independent t-test

Table 4. Children with cyanotic congenital heart disease who developed postoperative right ventricular failure had significantly lower quality-of-life scores across all domains than those without right ventricular failure. Significant differences were observed in general health, social health, physical well-being, heart problems, medical treatment, psychological well-being, and the overall quality-of-life score (all $p < 0.001$).

Table 4. Comparison of quality of life domain scores between children with postoperative cyanotic congenital heart disease with and without right ventricular failure

Condition	No RVF	RVF		
Quality of life domains	Mean ± SD	Mean ± SD	t	p-value
General health	87.65±7.97	80.68±11.90	-6.83	<0.001
Social health	95.20±8.14	87.85±19.35	-4.95	<0.001
Physical well-being	89.80±8.78	78.12±15.26	-9.34	<0.001
Heart problem	94.92±5.14	86.61 ± 8.87	-11.4	<0.001

			6	
Medical treatment	91.80±11.35	82.33±15.33	-7.01	<0.001
Psychological well-being	90.33±6.59	84.18±10.75	-6.87	<0.001
All domains	91.57 ± 3.88	83.32 ± 9.29	-11.51	<0.001

Table 5 shows ANCOVA analysis adjusted for confounder factors such as child age, sex, and age at corrective surgery, revealing significantly lower quality of life scores across all domains in postoperative cyanotic congenital heart disease children with and without right ventricular failure. The strongest effects were found in the heart problem domain ($F = 142.78$, $p < 0.001$, partial $\eta^2 = 0.266$) and overall quality of life ($F = 135.35$, $p < 0.001$, partial $\eta^2 = 0.260$). Significant differences were also observed in physical well-being ($F = 87.77$, $p < 0.001$, partial $\eta^2 = 0.184$) and general health ($F = 66.35$, $p < 0.001$, partial $\eta^2 = 0.148$). Moderate effect sizes were found for medical treatment ($F = 46.64$, $p < 0.001$, partial $\eta^2 = 0.107$); smaller but statistically significant effects were noted in social health life ($F = 26.62$, $p < 0.001$, partial $\eta^2 = 0.063$) and psychological well-being ($F = 25.63$, $p < 0.001$, partial $\eta^2 = 0.062$). Across domains, adjusted mean differences consistently favored children without RVF, with the greatest absolute difference experienced in physical well-being (12.58 points; 95% CI: 9.94–15.22)

Table 5. Adjusted comparison of quality-of-life domain scores using ANCOVA between children with and without right ventricular failure

QoL Domain	No RVF (Adjusted mean ± SE)	RVF (Adjusted mean ± SE)	Mean difference (95% CI)	F	p-value	Partial η^2
General health	88.49 ± 0.72	79.82 ± 0.73	8.67 (6.57-10.76)	66.35	<0.001	0.148
Social health life	95.69 ± 1.10	87.36 ± 1.10	8.33 (5.15-11.58)	26.62	<0.001	0.063
Physical well-being	90.25 ± 0.90	77.66 ± 0.92	12.58 (9.94-15.22)	87.77	<0.001	0.184
Heart problem	95.43 ± 0.53	86.11 ± 0.53	9.31 (7.78-10.58)	142.78	<0.001	0.266
Medical treatment	92.04 ± 0.98	82.09 ± 0.98	9.96 (7.11-12.81)	46.64	<0.001	0.107
Psychological well-being	89.69 ± 0.66	84.81 ± 0.65	4.88 (2.98-6.78)	25.63	<0.001	0.062
All domains	91.89 ± 0.52	82.99 ± 0.52	8.89 (7.39-10.40)	135.35	<0.001	0.260

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Values are adjusted means ± standard error (SE). ANCOVA was adjusted for child age, sex, and age at corrective surgery. Mean differences represent No RVF − RVF. η^2 = partial eta squared.

A two-way ANCOVA showed that right ventricular function was significantly associated with total QoL scores ($F = 89.45$, $p < 0.001$, partial $\eta^2 = 0.196$). Child sex was also significantly associated with QoL ($F = 16.42$, $p < 0.001$, partial $\eta^2 = 0.043$), whereas age group ($F = 2.94$, $p = 0.050$) and surgery year ($F = 1.37$, $p = 0.150$) were not statistically significant. The RVF × age-group interaction was not significant ($F = 2.18$, $p = 0.120$), indicating that the association between RV function and QoL did not differ significantly across age groups. The overall model was significant ($p < 0.001$; partial $\eta^2 = 0.340$).

Table 6:Two-way ANCOVA analysis of the effects of right ventricular function and age group on total quality of life scores

Source	df	F	p-value	Partial η^2
Right ventricular function (RVF vs No RVF)	1	89.45	<0.001	0.196
Age group	2	2.94	0.05	0.016
RVF × Age group	2	2.18	0.12	0.012
Child sex	1	16.42	<0.001	0.043
Surgery year	16	1.37	0.15	0.056
Corrected model	22	8.56	<0.001	0.34

The model was adjusted for sex and age at corrective surgery. η^2 indicates partial eta squared.

Multivariable linear regression analysis was used to identify factors associated with the total quality-of-life score (Table 7). Child sex was the only significant independent predictor of total quality of life after adjusting for the other variables in the model ($B = -2.875$, $\beta = -0.175$, $P = 0.001$). This indicates a significant difference in quality-of-life scores between the sexes after adjusting for current child age and age at corrective surgery. Current child age was not significantly associated with total quality of life ($B = -0.121$, $\beta = -0.037$, $P = 0.569$). Similarly, age at corrective surgery was not significantly associated with total quality of life ($B = -0.247$, $\beta = -0.048$, $P = 0.454$).

Table 7. Multivariate linear regression analysis of factors associated with total quality of life score

Predictor	B	Std. Error	β (Standardized)	t	p-value	95% CI for B
Constant	93.955	1.927	—	48.751	<0.001	90.166 – 97.744
Child age	− 0.121	0.213	− 0.037	− 0.570	0.569	− 0.540-0.297
Child sex	−2.875	0.819	− 0.175	−3.510	0.001	− 4.485 −1.265
Age at corrective surgery	− 0.247	0.329	− 0.048	− 0.750	0.454	− 0.895 – 0.401

DISCUSSION

This study demonstrated that right ventricular failure is strongly associated with poorer quality of life in children with cyanotic congenital heart disease following corrective surgery. Even after adjustment for age, sex, and age at corrective surgery. Importantly, this association remained significant after adjustment for key confounders, indicating that RVF is independently associated with reduced QoL. These findings indicate that right ventricular dysfunction continues to markedly affect long-term quality of life in this population despite surgical correction. Our result is in line with previous studies reporting the compromise of quality of life in children and adolescents with complex or cyanotic congenital heart disease, especially in the presence of residual ventricular dysfunction. Research has shown that right ventricular dysfunction following corrective surgery is negatively correlated with exercise tolerance, fatigue, and daily activities in both the physical and psychosocial domains of quality of life (Tajima et al., 2019, Ardianti et al., 2023, Sista et al., 2017).

The most pronounced impairment was observed in the heart problems domain, followed by psychological well-being and general health. This pattern corresponds to ongoing functional limitations and symptom burden associated with RVF: reduced exercise tolerance, fatigue, and ongoing cardiopulmonary symptoms. Such limitations may restrict children's participation in normal physical activities and social interactions, contributing to emotional distress and a loss of self-confidence. Fatigue significantly impairs physical, social, and emotional well-being, reducing overall quality of life. This finding corresponds with a systematic review (Ishida and Makaya, 2017). These large effect sizes indicate that RVF is associated with clinically meaningful impairments in daily functioning. The results align with previous studies (Al-Sutari and Abdalrahim, 2024, Kovacs et al., 2022, Kamal, 2025). The heart problems domain, which may be attributed to persistent symptoms such as shortness of breath, cyanosis, chest pain, sleep disturbances, and recurrent respiratory infections. These manifestations substantially impair the quality of life among children with right ventricular failure. This finding is consistent with previous studies (Javaheri and Germany, 2022, Gharzeddine et al.,

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2022, Gharzeddine et al., 2021).

The results also revealed moderate impairments in four key well-being domains: general health, physical well-being, social health, and medical treatment. Overall, study findings revealed a potential impact of RVF across several domains of children's lives, including perceptions of health, physical activity capacity, peer interactions, and care-seeking (Ladak et al., 2019). Chronic cardiac conditions often require frequent hospital visits, ongoing medical monitoring, and long-term medication use, which may contribute to increased anxiety, social restrictions, and emotional stress. The observed quality of life deficits are multifaceted, underscoring the need to address physical and psychosocial needs in postoperative follow-up. These results are consistent with earlier findings that impaired quality of life in children with congenital heart disease tends to affect physical and psychological domains (Mustafa Kamal, 2026) predominantly. Clinically, these results emphasize the need for routine screening of right ventricular function and early identification of patients at risk for poor quality of life.

Notably, right ventricular failure negatively affected quality of life across all age groups. The absence of interaction between age and RV dysfunction impairment persists throughout childhood and early adolescence, rather than being limited to a particular developmental stage. Previous studies have found age-associated disparities in perceptions of quality of life that are pronounced during adolescence (Masoudi et al., 2004, Lu et al., 2010). Another study showed that residual cardiac dysfunction has adverse effects across age groups (Lawson et al., 2023). Multivariable regression analysis further indicated that child sex and age at corrective surgery were independently associated with overall quality of life, whereas child age was not. These observations suggest that variation in quality of life is influenced by demographics and timing, so that differences in quality of life are not restricted to clinical groups. Sex differences in quality of life may reflect psychosocial and contextual influences rather than purely biological factors. The negative association with later surgical intervention suggests that delayed correction may have lasting effects on postoperative well-being, underscoring the importance of timely surgery and long-term follow-up. The study's findings align with several previous studies (Heusch et al., 2014, Chen et al., 2011).

Furthermore, their report highlights the importance of early diagnosis and long-term follow-up of RVF, as impaired QOLs may appear and persist at any age in the assessment group. From a clinical perspective, study results highlight the importance of incorporating routine quality of life assessments into the follow-up care of children with congenital heart disease and those with a history of right ventricular failure. Previous studies indicate that early rehabilitation programs, structured physical activity, and psychosocial support may further improve functional capacity and psychosocial outcomes in this population. The consistent impact of RVF across all domains reinforces its role as a key target for long-term postoperative management and follow-up strategies. Our results further support a multidisciplinary recovery approach that addresses both physical and emotional needs after corrective surgery.

Strengths and limitations

Several strengths of this study should be noted. The strengths of this study include the relatively large sample size, a reliable quality of life instrument, and the use of adjusted statistical models with effect size reporting. However, the study has several limitations that must be noted. The single-center design limits generalizability to other settings; parent-reported assessments also create reporting bias. Additionally, the absence of detailed echocardiographic parameters limits the ability to correlate the severity of right ventricular dysfunction with quality-of-life

outcomes. The outcomes are also relevant for low-resource health care environments in which limited access to specialized follow-up services may further worsen the lifelong functional and psychosocial challenges among children with CCHD and right ventricular failure. Longitudinal follow-up studies are needed to assess whether improvements in right ventricular function translate into sustained improvements in patient-reported measures over the long term. Multicenter studies using objective measures of functional capacity and detailed imaging data may also guide risk stratification and individualized postoperative care strategies.

CONCLUSIONS

Right ventricular failure was significantly associated with poorer health-related quality of life among children with cyanotic congenital heart disease after corrective surgery, with lower scores observed across all QoL domains. This association remained significant after adjustment for age, sex, and age at corrective surgery and did not differ significantly across age groups. Child sex was independently associated with total QoL, whereas child age and age at corrective surgery were not significant predictors. These findings highlight the importance of routine assessment of right ventricular function and QoL as part of the long-term follow-up of children after corrective surgery.

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COMPETING INTERESTS

No potential conflict of interest was reported by the author(s).

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پوختە

پێشینە: پێشکەوتنی نەشتەرگەری بە شێوەیەکی بەرچاو ئاسانکاری بۆ مانەوە لە نەخۆشانی تووشبوو بە نەخۆشی زگماکی دڵی شینبوونە وە کردووە، بەڵام ئاڵۆزییەکانی دوای نەشتەرگەری، بە تایبەتی شکستی سکۆڵەی ڕاست(RVF) ، ڕەنگە بە شێوەیەکی بەرچاو کاریگەری لەسەر کوالیتی ژیانی (QOL) هەبێت.

شێوازەکان: توێژینەوەیەکی بەراوردکاری ئایندەیی لە کانونی دووم ٢٠٢٥ تا مارت ٢٠٢٦ لە نەخۆشخانەی دڵی منداڵانی سلێمانی ئەنجامدرا. کۆی گشتی ٤٠٠ منداڵی تەمەن ٣–١٣ ساڵ کە نەشتەرگەری چاکسازییان بۆ نەخۆشی زگماکی دڵی سیانۆتیک هەبووە، لە گروپی شکستی ئەرکی سکۆڵەی ڕاست و گروپی کارکردنی ئاسایی سکۆڵەی ڕاست بەشداربوون. کوالیتی ژیان بە بەکارهێنانی پرسیارنامەیەکی پێکهاتەیی هەڵسەنگێندرا کە لەسەر بنەمای مۆدێولی دڵی PedsQL و PCQLI بوو و شەش دۆمەینی لەخۆ دەگرت. داتاکان بە بەکارهێنانی ANCOVA و ANCOVAی دوولایەنە شیکرانەوە، کە بەپێی تەمەن، ڕەگەز و تەمەن لە کاتی نەشتەرگەری چاکسازیدا ڕێکخراون. پاشەکشەی هێڵی فرەگۆڕاو بەکارهێنرا بۆ دیاریکردنی فاکتەرانەی بە شێوەیەکی سەربەخۆ پەیوەست بە QOL.

وشە سەرەکییەکان: نەخۆشی زگماکی دڵی سیانۆتیک؛ شکستی سکۆڵەی ڕاست؛ کوالیتی ژیان؛ نەخۆشی دڵی منداڵان؛ دەرئەنجامەکانی دوای نەشتەرگە

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الملخص

الخلفية: لقد ساهم التقدم في جراحة القلب بشكل كبير في تحسين معدلات البقاء على قيد الحياة لدى المرضى المصابين بأمراض القلب الخلقية المزرقة (CCHD) ، إلا أن المضاعفات بعد الجراحة (RVF)، قد تؤثر ولا سيما فشل البطين الأيمن على المدى الطويل (QOL) بصورة ملحوظة في نوعية الحياة.

الطرق: أُجريت دراسة مقارنة مستقبلية خلال الفترة من كانون الثانى ٢٠٢٥ إلى اذار ٢٠٢٦ في مستشفى السليمانية التخصصي لطب وجراحة قلب الأطفال. شملت الدراسة ما مجموعه ٤٠٠ طفل تتراوح أعمارهم بين ٣ و١٣ سنة، ممن خضعوا لعملية تصحيحية لأمراض القلب الخلقية المزرقة، سواء مع وجود فشل البطين الأيمن أو بدونه. جرى تقييم نوعية الحياة باستخدام استبيان منظم استند إلى وحدة أمراض القلب في مقياس جودة حياة الأطفال (PedsQL Cardiac Module) ومقياس جودة الحياة ، وشمل ستة مجالات. حُللت (PCQLI) لمنظمة الصحة العالمية البيانات باستخدام تحليل التباين المصاحب (ANCOVA) وتحليل التباين المصاحب ثنائي الاتجاه (Two-way ANCOVA) ، مع ضبط العمر والجنس والعمر عند إجراء الجراحة التصحيحية. كما استُخدم الانحدار الخطي متعدد المتغيرات لتحديد العوامل المرتبطة بشكل مستقل بنوعية الحياة. ذات دلالة إحصائية $P \leq 0.05$ واعتُبرت قيمة.

الكلمات المفتاحية: أمراض القلب الخلقية المزرقة؛ فشل البطين الأيمن؛ نوعية الحياة؛ طب قلب الأطفال؛ النتائج بعد الجراحة