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COMPARISON OF CLINICAL CHARACTERISTICS AND CARDIAC PARAMETERS IN CHILDREN WITH HEART FAILURE DUE TO CONGENITAL AND ACQUIRED HEART DISEASE

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ABSTRACT
Heart failure in children is a serious clinical syndrome caused by congenital heart disease (CHD) and acquired heart disease (AHD). Differences in clinical profiles and cardiac parameters between these two etiologies are important for accurate diagnosis and appropriate management. The primary objective of this study was to compare the clinical characteristics and cardiac parameters in children with heart failure due to congenital heart disease (CHD) and acquired heart disease (AHD). An analytic observational retrospective cross-sectional study was conducted using medical records of 26 children with heart failure (13 CHD and 13 AHD) at H. Adam Malik General Hospital, Medan, from January to May 2026. Variables included age, sex, nutritional status, Ross classification, dominant symptoms, as well as left ventricular ejection fraction (LVEF), fractional shortening (FS), tricuspid annular plane systolic excursion (TAPSE), troponin, valvular involvement, left atrial enlargement, QRS duration, and QTc interval. Descriptive and bivariate analyses were performed according to data distribution. There were no significant differences in age, sex, and nutritional status between groups, with most patients being undernourished. The predominant symptom was dyspnea/tachypnea, and Ross classification did not differ significantly, although AHD more often presented in higher Ross classes. Median LVEF (63.1 vs 59, p=0.005) and FS (35 vs 30, p=0.007) were significantly higher in the CHD group, whereas QTc interval prolongation was more common in AHD. TAPSE, troponin, QRS duration, valvular involvement, and left atrial enlargement did not differ significantly between groups. Clinical manifestations of pediatric heart failure due to CHD and AHD are similar and insufficient to distinguish etiology, but AHD tends to be associated with more severe left ventricular systolic dysfunction.

Keywords: acquired heart disease; cardiac parameters; clinical characteristics; congenital heart disease; pediatric heart failure

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INTRODUCTION

Heart failure in children is a rare but serious clinical syndrome that represents the adverse evolution of most cardiac diseases. It is a significant cause of morbidity and mortality in pediatric patients, with etiology and pathogenesis differing substantially from adults (Leye et al., 2020; Masarone et al., 2017). In children, the condition is frequently caused by congenital heart disease (CHD) or cardiomyopathies. The clinical picture in infants and young children is characterized by failure to thrive, feeding difficulties, respiratory distress, exercise intolerance, and fatigue, associated with circulatory, neurohormonal, and molecular abnormalities (Leye et al., 2020; Masarone et al., 2017).

In Indonesia, CHD has a prevalence of approximately 9 per 1,000 live births, consistent with global figures (Hinton & Ware, 2017; Sastroasmoro & Djer, 2020). With an annual birth rate of 4.2–4.8 million, an estimated 71,400–81,600 newborns with CHD are born each year. CHD-related heart failure is among the leading causes of neonatal morbidity and mortality in Indonesia, with mortality reaching 11–13% in neonates at referral hospitals (Dipchand, 2024; Hinton & Ware, 2017).

Acquired heart diseases, including dilated cardiomyopathy and myocarditis, contribute to heart failure in older children and adolescents, with pediatric cardiomyopathy incidence of approximately 1–2 per 100,000 children per year (Dipchand, 2024; Liao et al., 2021).

In clinical practice, echocardiography is the standard examination for diagnosing and evaluating cardiac function in pediatric heart failure, yet access is limited in many regions of Indonesia (Dipchand, 2024). Electrocardiography (ECG) offers advantages in terms of accessibility, speed, noninvasiveness, and low cost, and differences in ECG patterns between CHD and AHD may help distinguish the etiology of heart failure when echocardiography is unavailable (Kemenkes RI, 2023; Liao et al., 2021; Qanitha et al., 2022). Although symptoms in CHD often appear in the first year of life (approximately 65–70% of cases), AHD presents predominantly in older children and adolescents (Restuadi et al., 2023). To date, no local systematic data has compared these two groups at Adam Malik General Hospital, Medan, the regional tertiary referral center. This study aimed to compare clinical characteristics and cardiac parameters in children with heart failure due to CHD and AHD, with the goal of providing evidence-based data to improve diagnostic and management approaches for pediatric heart failure.

METHOD

This was an analytic observational retrospective cross-sectional study using electronic medical records from January to May 2026 at H. Adam Malik General Hospital, Medan, Indonesia. The study population included all children (aged 0–18 years) diagnosed with heart failure due to CHD or AHD. Inclusion criteria were: (1) clinical diagnosis of heart failure supported by investigations; (2) clearly identifiable etiology (CHD or AHD); and (3) complete medical records including echocardiography and relevant laboratory parameters. Exclusion criteria included cardiomyopathy secondary to systemic disease that could not be classified as pure AHD, post-operative CHD with fully corrected and normalized cardiac function, and overlapping CHD/AHD that could not be clearly categorized. Sample size was calculated using a two-proportion comparison formula, with proportion of heart failure in CHD as P1 = 0.062 and in AHD as P2 = 0.59, $\alpha = 0.05$, and power = 80%, yielding 11 subjects per group with 20% attrition adjustment, totaling 26 subjects. Consecutive sampling was used.

The following variables were collected: demographic data (age, sex, nutritional status), Ross classification, dominant symptoms, and cardiac parameters: LVEF, FS, TAPSE, troponin level, valvular involvement (regurgitation/stenosis), left atrial enlargement, QRS duration, and QTc interval (Bazett correction). Nutritional status was assessed using WHO growth charts. Cardiac function categories were defined as: LVEF normal ≥55%, mild dysfunction 41‑54%, moderate dysfunction 30‑40%, severe dysfunction <30%; FS normal ≥28%; TAPSE normal >17 mm; troponin elevated ≥0.03 ng/mL; QRS prolonged ≥100 ms; QTc prolonged ≥450 ms for males and ≥ 460 ms for females.

Data were analyzed using SPSS version 24.0. Categorical variables were presented as frequencies and percentages and compared using Chi-square or Fisher's Exact test. Normality of continuous variables was assessed by the Shapiro-Wilk test. Normally distributed variables (TAPSE, QTc) were analyzed using independent t-test; non-normally distributed variables (LVEF, FS, troponin, QRS duration) were analyzed using Mann-Whitney U test. Statistical significance was set at $p < 0.05$. This study was approved by the Ethics Committee of Universitas Sumatera Utara under the ethical approval number 1411/KEPK/USU/2025..

RESULT

Result of 26 subjects analyzed (13 CHD, 13 AHD), demographic and clinical characteristics are presented in Tables 1 and 2.

Table 1.
Demographic Characteristics of Study Subjects (n=26)

Variable	CHD Group (n=13)	AHD Group (n=13)	Total (n=26)
Age group, f (%)			
0–11 months (Infant)	1 (7.7%)	0 (0%)	1 (3.8%)
1–4 years (Toddler)	3 (23.1%)	0 (0%)	3 (11.5%)
5–9 years (Child)	1 (7.7%)	2 (15.4%)	3 (11.5%)
10–14 years (Pre-adolescent)	6 (46.2%)	4 (30.8%)	10 (38.5%)
15–18 years (Adolescent)	2 (15.4%)	7 (53.8%)	9 (34.6%)
Sex, f (%)			
Male	7 (53.8%)	7 (53.8%)	14 (53.8%)
Female	6 (46.2%)	6 (46.2%)	12 (46.2%)
Nutritional status, f (%)			
Severe malnutrition (<−3 SD)	4 (30.8%)	1 (7.7%)	5 (19.2%)
Malnutrition (−3 to −2 SD)	4 (30.8%)	5 (38.5%)	9 (34.6%)
Normal (−2 to +1 SD)	4 (30.8%)	4 (30.8%)	8 (30.8%)
Overweight (+1 to +2 SD)	0 (0%)	0 (0%)	0 (0%)
Obese (>+2 SD)	1 (7.7%)	3 (23.1%)	4 (15.4%)

CHD = Congenital Heart Disease; AHD = Acquired Heart Disease

Table 2.
Clinical Characteristics and Bivariate Analysis of Dominant Symptoms and Ross Classification

Variable	CHD Group (n=13)	AHD Group (n=13)	p-value
Ross Classification, f (%)			
Class I	2 (15.4%)	0 (0%)	
Class II	6 (46.2%)	4 (30.8%)	0.308[a]
Class III	2 (15.4%)	3 (23.1%)	
Class IV	3 (23.1%)	6 (46.2%)	
Dominant Symptom, f (%)			
Dyspnea/tachypnea	8 (61.5%)	12 (92.3%)	
Failure to thrive/feeding difficulty	3 (23.1%)	0 (0%)	0.187[a]
Fatigue/exercise intolerance	1 (7.7%)	0 (0%)	
Arrhythmia/palpitation	1 (7.7%)	1 (7.7%)	

[a]*Chi-square test*

No significant differences were found between groups in age (p=0.111), sex (p=1.000), or nutritional status (p=0.406). Most patients across both groups had malnutrition to severe malnutrition. Dyspnea/tachypnea was the predominant symptom in both groups. The AHD group had a higher proportion in Ross class IV (46.2%) compared to the CHD group where Ross class II was predominant (46.2%), though this difference was not statistically significant (p=0.308). Cardiac parameters and bivariate analysis are presented in Tables 3 and 4.

Table 3.
Distribution of Cardiac Parameters in Study Subjects

Parameter	CHD Group (n=13)	AHD Group (n=13)	Total (n=26)
LVEF category, n (%)			
Normal (≥55%)	13 (100%)	10 (76.9%)	23 (88.5%)
Mild dysfunction (41–54%)	0 (0%)	1 (7.7%)	1 (3.8%)
Severe dysfunction (<30%)	0 (0%)	2 (15.4%)	2 (7.7%)
LVEF, median (range)	63.1 (56–72)	59 (15.6–66.2)	
FS category, n (%)			
Normal (≥28%)	13 (100%)	8 (61.5%)	21 (80.8%)
Abnormal (<28%)	0 (0%)	5 (38.5%)	5 (19.2%)
FS, median (range)	35 (28–42)	30 (6.9–37.1)	
TAPSE category, n (%)			
Normal (>17 mm)	8 (61.5%)	7 (53.8%)	15 (57.7%)
Abnormal (≤17 mm)	5 (38.5%)	6 (46.2%)	11 (42.3%)

TAPSE, mean ± SD (mm)	18.42 ± 3.46	19.61 ± 6.37	
Troponin, median (range) ng/mL	0.01 (0.01–8.90)	0.01 (0.01–0.06)	
Valvular involvement, n (%)	11 (84.6%)	11 (84.6%)	22 (84.6%)
Left atrial enlargement, n (%)	3 (23.1%)	4 (30.8%)	7 (26.9%)
QRS duration, median (range) ms	86 (70–168)	85 (54–112)	
QTc interval category, n (%)			
Normal	7 (53.8%)	5 (38.5%)	12 (46.2%)
Prolonged	6 (46.2%)	8 (61.5%)	14 (53.8%)
QTc interval, mean ± SD (ms)	465.15 ± 39.17	473.38 ± 46.20	

LVEF = Left Ventricular Ejection Fraction; FS = Fractional Shortening; TAPSE = Tricuspid Annular Plane Systolic Excursion; SD = Standard Deviation

Table 4.
Bivariate Comparison of Cardiac Parameters between CHD and AHD Groups

Parameter	CHD Group (n=13)	AHD Group (n=13)	p-value
LVEF, median (range)	63.1 (56–72)	59 (15.6–66.2)	0.005[b]
FS, median (range)	35 (28–42)	30 (6.9–37.1)	0.007[b]
TAPSE, mean ± SD (mm)	18.42 ± 3.46	19.61 ± 6.37	0.559[a]
Troponin, median (range) ng/mL	0.01 (0.01–8.90)	0.01 (0.01–0.06)	0.307[b]
Valvular involvement, n (%)	11 (84.6%)	11 (84.6%)	1.000[c]
Left atrial enlargement, n (%)	3 (23.1%)	4 (30.8%)	1.000[c]
QRS duration, median (range) ms	86 (70–168)	85 (54–112)	0.355[b]
QTc interval, mean ± SD (ms)	465.15 ± 39.17	473.38 ± 46.20	0.629[a]

[a]Independent t-test; [b]Mann-Whitney U test; [c]Fisher's Exact test

Among all cardiac parameters, only LVEF and FS showed statistically significant differences between groups (p=0.005 and p=0.007, respectively), with both parameters higher in the CHD group. No significant differences were found for TAPSE (p=0.559), troponin (p=0.307), valvular involvement (p=1.000), left atrial enlargement (p=1.000), QRS duration (p=0.355), or QTc interval (p=0.629).

DISCUSSION

This study found that while age, sex, nutritional status, and dominant clinical symptoms did not differ significantly between children with CHD and AHD-related heart failure, LVEF and FS were significantly higher in the CHD group. These findings align with the underlying pathophysiological differences between the two conditions. In CHD, heart failure primarily results from volume or pressure overload due to structural defects such as left-to-right shunts (VSD, ASD, PDA), leading to chamber dilatation with relatively preserved systolic function in the early phase (Agrawal et al., 2024; Castaldi et al., 2023; Khalil et al., 2020; Rath & Weintraub, 2021). Conversely, AHD, particularly dilated cardiomyopathy and myocarditis, directly impairs myocardial contractility, resulting in lower LVEF and FS (Restuadi et al., 2023; Susanto et al., 2024). Previous studies confirm that approximately 60–70% of pediatric patients with dilated cardiomyopathy have LVEF <40%, while many CHD patients maintain normal or near-normal LVEF (Rath & Weintraub, 2021; Susanto et al., 2024). Rolfs et al. (2021) demonstrated that myocardial involvement in pediatric myocarditis significantly reduces left ventricular function even when LVEF appears in the normal range. These patterns explain the current findings.

The absence of significant differences in clinical symptoms is consistent with the convergent neurohormonal activation that occurs in heart failure regardless of etiology. Sympathetic nervous system and renin-angiotensin-aldosteron system activation produce similar manifestations, including dyspnea, fatigue, and exercise intolerance, irrespective of the underlying cause (Kirk et al., 2014; Rosenthal et al., 2004). Monda et al. (2021) similarly reported that advanced heart failure in children, whether due to CHD or AHD, frequently presents with comparable symptom profiles. The predominance of dyspnea/tachypnea in both groups reflects elevated pulmonary venous pressure from increased left ventricular end-diastolic pressure, a shared pathophysiological pathway in all types of heart failure. The higher proportion of severe dysfunction (Ross class IV) in the AHD group compared to CHD likely reflects the progressive and often delayed diagnosis of conditions

such as rheumatic heart disease and cardiomyopathy, consistent with previous literature showing that 75–80% of AHD patients are diagnosed in older childhood (Dipchand, 2024; Restuadi et al., 2023).

The lack of significant differences in right ventricular function (TAPSE) between groups may reflect that most patients had not yet developed severe right ventricular compromise or were in the compensated phase. Similarly, the absence of significant differences in troponin is consistent with the chronic nature of most cases, where acute myocardial injury markers tend to be elevated primarily in acute conditions such as fulminant myocarditis (Dione et al., 2022; Park, 2014). Malnutrition was prevalent in both groups, consistent with the established association between pediatric heart failure and increased metabolic demand, reduced intake, and chronic metabolic disturbance (Chinali et al., 2021; Uzark et al., 2020). This study has several limitations. The retrospective design and small sample size (n=26) limit statistical power and generalizability. Additionally, detailed information about disease severity, duration, and prior treatment were not fully captured. Advanced imaging modalities such as global longitudinal strain echocardiography and cardiac MRI, which may detect subtle myocardial dysfunction not apparent on conventional echocardiography, were not available for all patients.

CONCLUSION

Clinical manifestations of pediatric heart failure due to CHD and AHD are similar and insufficient to differentiate the etiology. However, AHD is associated with significantly lower LVEF and FS, reflecting more severe left ventricular systolic dysfunction compared to CHD. TAPSE, troponin, QRS duration, QTc interval, valvular involvement, and left atrial enlargement did not differ significantly between groups. Comprehensive evaluation integrating clinical assessment with echocardiographic and ECG parameters is essential for the accurate diagnosis and appropriate management of pediatric heart failure.

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