



ASSOCIATION BETWEEN GLYCAEMIC CONTROL AND CARDIAC FUNCTION IN CHILDREN WITH DIABETES MELLITUS

M Ridho^{1*}, Siska Mayasari Lubis^{1,2}, Putri Amelia^{1,2}, Juliandi Harahap³, Rita Evalina^{1,2}, Fathia Meirina¹

¹Department of Pediatrics, Faculty of Medicine, Universitas Sumatera Utara, Jl. Dr. Mansyur No.5, Padang Bulan, Medan Baru, Medan, Sumatera Utara 20155, Indonesia

²Adam Malik Hospital, Jl. Bunga Lau No.17, Kemenangan Tani, Medan Tuntungan, Medan, Sumatera Utara 20136, Indonesia

³Department of Public Health and Community Medicine, Faculty of Medicine, Universitas Sumatera Utara, Jl. Dr. Mansyur No.5, Padang Bulan, Medan Baru, Medan, Sumatera Utara 20155, Indonesia

*ridho@students.usu.ac.id

ABSTRACT

The prevalence of Diabetes Mellitus (DM) among children and adolescents has been progressively increasing, with Type 1 DM constituting the majority of cases. Cardiovascular disease (CVD) is a major long-term complication, yet early cardiac involvement remains poorly understood in this population. This study aimed to assess the association between glycaemic control and cardiac function in paediatric patients with DM. A cross-sectional observational study was conducted involving 30 children with type 1 or type 2 DM at H. Adam Malik General Hospital, Medan. Glycaemic control was assessed using HbA1c levels. Cardiac function was evaluated using electrocardiography (ECG) and echocardiographic parameters, including ejection fraction (EF), fractional shortening (FS), tricuspid annular plane systolic excursion (TAPSE), and E/A ratio. Data were analysed using Chi-Square and Mann-Whitney Test. Most subjects (90%) had poor glycaemic control (HbA1c $\geq 7\%$). Cardiac dysfunction (reduced EF $< 55\%$) was identified in 16.7% of patients. However, no statistically significant associations were found between cardiac function and HbA1c, duration of diagnosis, blood pressure, or body mass index (BMI) ($p > 0.05$). There was no significant relationship found between glycaemic control and cardiac function, highlighting the need for more sensitive diagnostic tools and long-term follow-up to detect subclinical cardiovascular complications.

Keywords: cardiac function; diabetes mellitus; HbA1C

How to cite (in APA style)

Ridho, M., Lubis, S. M., Amelia, P., Harahap, J., Evalina, R., & Meirina, F. (2025). Association Between Glycaemic Control and Cardiac Function in Children with Diabetes Mellitus. *Indonesian Journal of Global Health Research*, 7(5), 943-948. <https://doi.org/10.37287/ijghr.v7i5.7020>.

INTRODUCTION

Type 1 Diabetes Mellitus (DM) is a chronic metabolic disease commonly found in children, characterised by absolute insulin deficiency due to autoimmune destruction of pancreatic β -cells (Ozdemir et al., 2016; Skyler et al., 2017). In Indonesia, the prevalence of type 1 DM has increased sevenfold over the past decade, with more than 1,000 cases recorded up to 2014. This rise is largely attributed to high rates of underdiagnosis (AAP et al., 2015; Pulungan et al., 2021). Type 2 DM, once considered a disease of adulthood, is now increasingly observed in children and adolescents, accounting for 8–45% of all newly diagnosed diabetes cases. Studies in the United States report the highest prevalence in the 15–19-year age group, particularly among Black, Asian, and Pacific Islander populations (Kao & Sabin, 2016; Or et al., 2016).

One of the most significant comorbidities of early-onset DM is cardiovascular disease (CVD), with a risk up to eight times higher than in the general adult population. This risk is notably higher in females and may manifest early, including signs such as cardiovascular remodeling, subclinical cardiac dysfunction, and increased aortic thickness. Endothelial dysfunction is also frequently observed five years after diagnosis, serving as an early marker of atherosclerosis (Frías et al., 2021; Jones et al., 2019; Livingstone et al., 2015).

Cardiac disease in young individuals with DM progresses more rapidly and is a leading cause of mortality in early adulthood. However, to date, there is insufficient data on the prevalence of specific cardiovascular risk factors in children and adolescents with DM, which is crucial for planning preventive interventions and cardioprotective therapy (Jones et al., 2019). Pathophysiologically, cardiac complications in DM are associated with impaired glucose metabolism, elevated oxidative stress, cardiac autonomic dysfunction, and pathological myocardial remodeling (Frías et al., 2021). Diabetic cardiomyopathy, particularly diastolic dysfunction, is frequently observed and leads to structural changes and impaired left ventricular myocardial relaxation in children with DM (El Razaky et al., 2018).

Poor glycaemic control significantly exacerbates the risk of cardiovascular morbidity (Sousa et al., 2019). Glycated haemoglobin (HbA1c), a marker reflecting average blood glucose levels over the previous 2–3 months, is recognised as a strong independent biomarker that correlates with an increased risk of cardiovascular disease—by up to 42% for each 1% rise in HbA1c levels (Jensen et al., 2019). This study aims to assess the association between glycaemic control and cardiac function in children with DM.

METHOD

This study was an observational analytical study with a cross-sectional design. The research was conducted at H. Adam Malik General Hospital, Medan, during the period of February to May 2025. The study population consisted of all paediatric and adolescent patients diagnosed with diabetes mellitus (DM) at H. Adam Malik General Hospital. Ethical approval for this study was obtained from the Health Research Ethics Committee of the University of North Sumatra (USU) with approval number 1351/KEPK/USU/2024.. Samples were selected using consecutive sampling, which all subjects who met the inclusion criteria during the study period were enrolled until the minimum required sample size was reached. The inclusion criteria were children and adolescents (<18 years) diagnosed with type 1 or type 2 DM, with a disease duration of more than two years, and who regularly underwent HbA1c testing. Exclusion criteria included congenital heart disease, other types of DM (other than type 1 and type 2), and chronic conditions such as malignancies or kidney disease. Based on Slovin's formula, the minimum required sample size was calculated to be 30 subjects. The dependent variable in this study was cardiac function, assessed through echocardiographic parameters including ejection fraction (EF), fractional shortening (FS), tricuspid annular plane systolic excursion (TAPSE), E/A ratio, and electrocardiography (ECG) findings. The independent variables included the type of diabetes mellitus, HbA1c levels, body mass index (BMI), and blood pressure. For categorical data, the Chi-Square test was used, with Fisher's Exact test as an alternative when applicable. For numerical data, an independent t-test was used if the data were normally distributed; otherwise, the Mann–Whitney U test was applied.

RESULT

This study involved 30 paediatric and adolescent patients who met the inclusion criteria. The mean age of the participants was 13.6 ± 3.3 years, with a majority being female (56.7%). Based on type of diabetes, most patients were diagnosed with type 1 diabetes mellitus (73.3%). The majority had normal nutritional status based on Body Mass Index (BMI) (76.7%), while 23.3% were classified as overweight. Most patients had a diabetes duration of 2–5 years (80%). The majority of subjects exhibited poor glycaemic control, with HbA1c levels $\geq 7\%$ (90%), while only 10% had good glycaemic control. Systolic blood pressure was within the normal range in most patients (80%), with a mean of 115.1 ± 11.4 mmHg. All patients had normal diastolic blood pressure, with a mean of 70.9 ± 15.2 mmHg.

Cardiac dysfunction was identified in 5 patients (16.7%), while the remaining 25 patients (83.3%) had normal cardiac function. Evaluation of cardiac function markers showed that all

patients had normal values for ECG, fractional shortening (FS), tricuspid annular plane systolic excursion (TAPSE), and E/A ratio. However, 5 patients (16.7%) showed abnormal ejection fraction (EF) values (<55%). Bivariate analysis revealed no statistically significant associations between cardiac function and age, sex, type of diabetes, glycaemic control, duration of diabetes, blood pressure, or BMI (p>0.05). Patients with cardiac dysfunction tended to be older (mean age 14.2±4.0 years), predominantly female, and mostly diagnosed with type 1 diabetes. All patients with HbA1c <7% had normal cardiac function, while all patients with cardiac dysfunction had HbA1c ≥7%. However, there was no significant association between HbA1c levels and any specific cardiac function parameters, including ECG, EF, FS, TAPSE, or E/A ratio.

RESULT

Table 1.
Demography Characteristics of Patient (n=30)

Characteristics	Cardiac Function		Total (n=30)	p-value
	Normal (n=25)	Abnormal (n=5)		
Age	13.5±3.3	14.2±4.0	13.6±3.3	0.656
Sex, n (%)				1.000
Male	11 (84.6)	2 (15.4)	13 (43.3)	
Female	14 (82.4)	3 (17.6)	17 (56.7)	
Type of DM, n (%)				0.589
T1DM	19 (86.4)	3 (13.6)	22 (73.3)	
T2DM	6 (75.0)	2 (25.0)	8 (26.7)	
HbA1c, n(%)				1.000
<7% (Good)	3 (100.0)	0 (0)	23 (76.7)	
≥7% (Poor)	22 (81.5)	5 (18.5)	7 (23.3)	
Duration of Diagnosis, n (%)				1.000
>2-5 years	20 (83.3)	4 (16.7)	24 (80.0)	
>5-10 years	5 (83.3)	1 (16.7)	6 (20.0)	
Systolic Blood Pressure, n (%)				0.553
Normal	19 (79.2)	5 (20.8)	3 (10.0)	
Hypertension	6 (100.0)	0 (0)	27 (90.0)	
Diastolic Blood Pressure, n (%)			115.1±11.4	-
Normal	25 (83.3)	5 (16.7)	24 (80.0)	
Hypertension	0 (0)	0 (0)	6 (20.0)	
Indeks Massa Tubuh (IMT) , n (%)			70.9±15.2	1.000
Normoweight	19 (82.6)	4 (17.4)	30 (100.0)	
Overweight	6 (85.7)	1 (14.3)	0 (0)	

Table 2.
Glycaemic control and Marker of Cardiac Function

Marker of Cardiac Function	HbA1C		Total	p-value
	<7% (Good)	≥7% (Poor)		
ECG				-
Normal	3 (10.0)	27 (90.0)	30 (100.0)	
Abnormal	0 (0)	0 (0)	0 (0)	
Ejection Fraction (EF)				1.000
Normal	3 (12.0)	22 (88.0)	25 (83.3)	
Abnormal	0 (0)	5 (100.0)	5 (16.7)	
Fractional Shortening (FS)				-
Normal	3 (10.0)	27 (90.0)	30 (100.0)	
Abnormal	0 (0)	0 (0)	0 (0)	
TAPSE				-
Normal	3 (10.0)	27 (90.0)	30 (100.0)	
Abnormal	0 (0)	0 (0)	0 (0)	
EA Ratio				-
Normal	3 (10.0)	27 (90.0)	30 (100.0)	
Abnormal	0 (0)	0 (0)	0 (0)	

DISCUSSION

This study found that the majority of paediatric and adolescent patients with diabetes mellitus (DM) were diagnosed with type 1 DM, with most patients being female. These findings are consistent with national registry data showing that type 1 DM is more frequently reported in children compared to type 2 DM, although the true incidence of type 2 DM is believed to be higher due to low awareness among both the public and healthcare providers regarding early-onset DM (Ikatan Dokter Anak Indonesia, 2017). This is supported by the fact that a significant proportion of children with type 1 DM are diagnosed only after presenting with complications such as diabetic ketoacidosis (White, 2015).

In terms of cardiac function evaluation, nearly all parameters—including electrocardiography (ECG), fractional shortening (FS), tricuspid annular plane systolic excursion (TAPSE), and the E/A ratio—were within normal limits. Ejection fraction (EF) was also within the normal range in the majority of patients (83.3%), with only 16.7% exhibiting reduced EF. Although EF is frequently used as a marker of systolic function, several studies suggest it is not sensitive for detecting early myocardial dysfunction, as it may remain normal due to ventricular compensatory mechanisms (Lavine & Prcevski, 2023; Schäfer et al., 2020). EF tends to reflect ventricular impairment only at more advanced stages. Therefore, more sensitive techniques such as speckle-tracking echocardiography or myocardial deformation imaging are recommended for early detection of myocardial dysfunction (Schäfer et al., 2020).

This study also showed that the patients' blood pressure values were generally within normal limits. Although 20% of patients had elevated systolic blood pressure, no significant association was found between hypertension and cardiac dysfunction. Previous studies support this finding, indicating that the more elastic vascular system in children allows them to tolerate transient increases in blood pressure without causing significant structural or functional cardiac damage (Himawan et al., 2012; Marcon et al., 2019). The duration of DM diagnosis was also not significantly associated with cardiac dysfunction. However, literature suggests that early-onset diabetes increases the risk of cardiac impairment due to chronic hyperglycaemic exposure. This includes mechanisms such as oxidative stress, inflammation, and endothelial dysfunction, which affect the microcirculation and myocardial tissue over time. Likewise, no significant relationship was found between body mass index (BMI) and cardiac dysfunction. This aligns with previous studies noting that the cardiovascular effects of excess body weight typically emerge only after prolonged metabolic stress, whereas in children, the heart can still adapt to increased workload without showing measurable changes in function (Ghanem et al., 2010; Šileikienė et al., 2021).

Most patients in this study exhibited poor glycaemic control ($\text{HbA1c} \geq 7\%$), yet no significant association was observed between HbA1c levels and cardiac dysfunction. Although elevated HbA1c is a known marker for long-term complications, cardiovascular events remain relatively rare in children due to the shorter duration of the disease. Several studies also note that while high HbA1c may influence subclinical markers such as myocardial strain, conventional parameters like ejection fraction remain within normal ranges and do not indicate overt cardiac dysfunction (Hodzic et al., 2016; Labombarda et al., 2014).

This study has several limitations. First, the sample size was relatively small. Second, the study was conducted in a single tertiary care centre, which may limit generalizability to other settings. Despite these limitations, the findings suggest that in children and adolescents with DM, cardiac dysfunction is not significantly associated with disease duration, blood pressure, BMI, or glycaemic control. Longitudinal studies are recommended to monitor the progression of cardiac function over time and clarify the causal relationship between

glycaemic. control and cardiac outcomes in paediatric DM patients. Further research with larger sample sizes and longer follow-up periods is also needed to better understand the development of DM complications. In addition, interventional studies should be conducted to assess the effectiveness of lifestyle education programmes in preventing cardiac dysfunction, along with the use of more advanced echocardiographic techniques for early detection of myocardial impairment.

CONCLUSION

Several paediatric patients with DM were found to have cardiac impairment. No significant associations were found between cardiac function and HbA1c levels, duration of diagnosis, blood pressure, or BMI. These results emphasize the importance of long-term monitoring and the use of more sensitive diagnostic tools to detect early cardiovascular complications in this population.

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