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Short Communication

Association between type of congenital heart disease with child growth and development status: A cross-sectional study in Medan, Indonesia

Putri Amelia[1,2*], Astrid G. Yosephine[3], Tina CL. Tobing[1,2], Maya Savira[4], Vincent Viandy[1] and Mark Inglin[5]

[1]Department of Pediatrics, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia; [2]Department of Pediatrics, Adam Malik General Hospital, Medan, Indonesia; [3]Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia; [4]Department of Physiology, Faculty of Medicine, Universitas Sumatera Utara, Medan, Indonesia; [5]Department of Chemistry, University of Basel, Switzerland

*Corresponding author: putri.amelia@usu.ac.id

Abstract

Congenital heart disease (CHD) is a congenital disorder primarily affecting newborns and children. Children with CHD have a greater risk of experiencing growth delays or disorders compared to healthy children. CHD also affects various aspects of a child's development. The aim of this study was to determine the association of CHD types (cyanotic and acyanotic) with the growth and development status of children. A cross-sectional study was conducted among CHD patients at a national reference hospital in Sumatra, H. Adam Malik General Hospital in Medan, Indonesia. The children's growth status was assessed using the WHO growth chart, and the developmental condition was evaluated through the Denver Developmental Screening Test-II. Chi-squared test and Fisher's exact test were used to assess the association between the type of CHD with growth and development status in children. Using a consecutive sampling method, a total of 53 individuals were included in this study. Almost half of CHD patients (48.1%) were within the age group of 0–2 years and more than half (61.1%) were girls. Acyanotic CHD (74.1%) was more prevalent than cyanotic CHD (25.9%), with ventricular septum defect (VSD) as the most common diagnosis. A total of 37% of children with CHD suffered from malnutrition, whereas the remaining 62.9% had good nutrition. The Denver Developmental Screening Test-II indicated that 81.4% of the children were normal, whereas 18.5% had developmental disorders. Our data suggested a significant association between cyanotic CHD and poor growth status in children based on weight-for-age, weight-for-length, and body mass index (BMI)-for-age. However, there was no association between the type of CHD and developmental status in children. This study highlights that the type of CHD is significantly associated with the growth status of children, but not with their developmental status.

Keywords: Congenital heart disease, cyanotic, acyanotic, child development, child growth

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Introduction

Congenital heart disease (CHD) is defined as a structural disorder characterized by malformations in the heart, heart valves, or large blood vessels [1]. The incidence of CHD contributes to a relatively high mortality rate among children, especially in those less than one

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year of age [2]. In 2019, there were 217,000 deaths due to CHD, with more than half of the cases (150,000 deaths) occurring in children <1 year old and approximately 3.12 million births with CHD [2]. According to the data of the Global Burden of Disease Study in 2017, CHD-associated mortality rate was higher in areas with low to very low socio-demographic indexes such as Oceania, North Africa and the Middle East, the Caribbean, sub-Saharan Africa and Southeast Asia [3]. In Indonesia, the estimated incidence of CHD is 9 out of 1,000 births, with an estimated 43,200 cases of 4.8 million live births each year [4].

A study has shown that children with CHD have a greater risk of experiencing delays or growth disorders than normal children [5]. Malnutrition such as being underweight, stunting, and wasting was more commonly observed in children with cyanotic CHD than those with the acyanotic type, which significantly impacts children's growth and development [6]. A study reported that the number of cyanotic CHD children experiencing underweight was four times higher (43.3%) as compared to those with acyanotic type CHD (10%) [6]. Similarly, stunting cases were also greater in cyanotic CHD patients (23.3%) compared to acyanotic CHD (13.3%) [6].

Cognitive development is one of the most commonly affected developmental factors by CHD [7,8]. Children with cyanotic CHD often exhibited poorer fine and gross motor skills development and receptive language skills compared to those with acyanotic CHD. These factors later affect the early learning phase and interaction with other children [6]. Given the aforementioned issues, it is important to assess the growth and development of children with CHD in order to increase their life expectancy, as well as enable them to lead a normal life, both physically and psychosocially. Nevertheless, to date, studies regarding the growth and development status of children with CHD in Indonesia in particular in Sumatra are still limited. The aim of this study was to assess the association of CHD types with the growth and development status of children.

Methods

Study design and patients

A cross-sectional study was conducted among CHD children at H. Adam Malik General Hospital, Medan, Indonesia, from August to November 2022. Clinical data, basic demographic, anthropometric, developmental status and echocardiography were performed in all patients. The patients were categorized into two types of CHD: cyanotic and acyanotic CHD. Cyanotic CHD was defined as all types of congenital heart defects in which the blood from the systemic veins bypasses the pulmonary circulation and is redirected to the left side of the heart therefore systemic arterial desaturation is present [9]. A few examples of cyanotic CHD include tetralogy of Fallot, transposition of great arteries, truncus arteriosus, total anomalous pulmonary venous connection, tricuspid atresia, and pulmonary atresia [10]. Acyanotic CHD was defined as all types of congenital heart defects that do not disturb oxygen delivery throughout the body such as atrial septal defect, ventricular septal defect, atrioventricular septal defect, patent ductus arteriosus, and coarctation of aorta [11].

Sampling method

We used a consecutive sampling method in this study. Consecutive sampling refers to a non-parametric sampling method in which patients were recruited based on inclusion and exclusion criteria until the sample size was achieved. Inclusion criteria of this study were children diagnosed with CHD and 0–18 years of age who were treated in the pediatric cardiology outpatient center of H. Adam Malik General Hospital. CHD children with Down syndrome or Turner syndrome, cerebral palsy, or other congenital gastrointestinal malformations, as well as those who had undergone corrective surgeries for their heart defects, were excluded.

Study variables and measurements

The independent variable in this study was the type of CHD, categorized as acyanotic or cyanotic heart disease. The independent variables were the growth and development statuses of the CHD patients. The growth status was further categorized into four aspects: weight-for-age, length or height-for-age, weight-for-length or height and body mass index-for-age. The development status was categorized into four aspects: personal-social, gross motor, fine motor and language. In

addition, children's demographic (age, gender) and clinical characteristics of CHD (diagnosis of CHD) were also collected.

To assess the growth status, anthropometric measurements were carried out using the WHO Growth Chart curves according to the child's age. The growth status was determined based on four factors, namely the weight-for-age, length/height-for-age, the weight-for-length/height, and the body mass index-for-age. For the weight-for-age curve, a Z-score less than -2 standard deviations (SD) from the median of the reference population indicates underweight and when the Z-score is less than -3 SD indicates severe underweight. Children were considered stunted when the WHO length/height-for-age Z-score was below -2 SD from the median and severely stunted when the Z-score was below -3 SD. Children with weight-for-length/height less than -2 SD were categorized as malnutrition [12].

To evaluate the developmental status, the Denver Developmental Screening Test-II, suitable for children of 0–6 years old was administered. During this assessment, a total of 125 tasks were assessed which included four domains including social personal status (25 items), gross motor skills (32 items), fine motor skills (29 items), and language skills (39 items). If the child failed the task where the age line felt between 75 and 90 percentile, it was categorized as caution [13].

Data collection

The baseline characteristics of the patients were recorded during hospital admission. Echocardiography was then performed by pediatric cardiologists to assess the diagnosis to confirm the diagnosis. If the parents agreed to participate, the anthropometrics and development were measured using the WHO growth chart and Denver Developmental Screening Test-II.

Statistical analysis

Chi-squared test or Fisher's exact test was used to determine the association between the types of CHD and the growth and development status as appropriate. The Fisher's exact test was used when the expected frequency value in certain cells was <5. All statistical analyses were performed using SPSS version 22.0 (IBM, New York, USA) for Windows.

Results

Demographic and clinical characteristics

A total of 54 CHD patients were enrolled in this study. The patient's demographic and clinical characteristics are presented in **Table 1**. All of the participants were within the age group of 0–5 years, in which toddlers of 0–2 years old represented the highest percentage (48.1%) of all subjects. The majority of patients were girls with a total of 33 children (61.1%). There were more children in the acyanotic CHD group (74.1%) than in the cyanotic group (25.9%). Ventricular septal defect (VSD) was the most frequently diagnosed condition in the acyanotic CHD group, whereas tetralogy of Fallot (TOF) was the most commonly diagnosed condition in the cyanotic CHD group (**Table 1**).

Table 1. Demographic and clinical characteristics of patients with congenital heart disease (CHD) included in the study (n=54)

Patients' characteristic	Frequency (%)
Age (years)	
0–2	26 (48.1)
2–3	4 (7.4)
3–5	24 (44.4)
Gender	
Boy	21 (38.9)
Girl	33 (61.1)
Type of CHD	
Acyanotic	40 (74.1)
Cyanotic	14 (25.9)
Diagnosis	
Aortic stenosis	1 (1.9)
Atrial septal defect	7 (13)
Coarctation of the aorta	1 (1.9)

Patients' characteristic	Frequency (%)
Patent ductus arteriosus	14 (25.9)
Truncus arteriosus	1 (1.9)
Transposition of great arteries	1 (1.9)
Tetralogy of Fallot (TOF)	9 (16.7)
Ventricular septal defect (VSD)	16 (29.6)
Atrioventricular septal defect (AVSD)	3 (5.6)
Ventricular septal defect + patent ductus arteriosus	1 (1.9)

Child growth status

The growth statuses of the children are presented in **Table 2**. Based on the weight-for-age curve, the majority of children (47.5%) with acyanotic CHD were underweight, whereas 63.3% of those with cyanotic CHD were severely underweight. The length/height-for-age curve indicated that most of the children (45%) in acyanotic CHD group were normal, whereas those in the cyanotic CHD group were mostly stunted (64.3%). In terms of weight-for-length or weight-for-height assessment, the majority of the children with acyanotic CHD (72.5%) had a good nutritional status. In contrast, nearly 65.0% of the children in the cyanotic group suffered from malnutrition (**Table 2**). Furthermore, the result of the BMI-for-age curve analysis showed that more than half (55.0%) of acyanotic CHD children exhibited undernutrition status, while children with cyanotic CHD were malnutrition (71.4%). Statistical analyses suggested that the type of CHD was significantly associated with the growth status of the children (weight-for-age, weight-for-length or weight-for-height, and body mass index-for-age) with all had $p<0.05$ (**Table 2**).

Table 2. Association between types of congenital heart disease (CHD) and child growth status

Growth status	Types of CHD		*p*-value*
	Acyanotic (n=40) Frequency (%)	Cyanotic (n=14) Frequency (%)	
Weight-for-age			0.034*
Severely underweight	11 (27.5)	9 (63.3)	
Underweight	19 (47.5)	2 (14.3)	
Normal	10 (25.0)	3 (21.4)	
Length or height-for-age			0.054
Severely stunted	10 (25.0)	3 (21.4)	
Stunted	12 (30.0)	9 (64.3)	
Normal	18 (45.0)	2 (14.3)	
Weight-for-length or weight-for-height			0.014*
Malnutrition	11 (27.5)	9 (64.3)	
Good nutrition	29 (72.5)	5 (35.7)	
Body mass index-for-age			0.008*
Malnutrition	10 (25.0)	10 (71.4)	
Undernutrition	22 (55.0)	3 (21.4)	
Good nutrition	8 (20.0)	1 (7.4)	

*Statistically significant at $p=0.05$

Child development status

We analyzed the children's developmental status based on four factors: social personal status, gross motor skill, fine motor skill, and language skill (**Table 3**). The majority of children with both acyanotic and cyanotic CHD had normal personal-social (acyanotic 82.5%; cyanotic 64.3%), gross motor (acyanotic 87.5%; cyanotic 78.6%), fine motor (acyanotic 85.0%; cyanotic 71.4%), and language (acyanotic 75.0%; cyanotic 50.0%) skills (**Table 3**). These data suggested an overall normal development status in children with CHD. In addition, statistical analyses suggested that there was no significant association between CHD and the development status of the children for all components with $p>0.05$.

Discussions

CHD may be diagnosed at any age from birth to any age. It has contributed to a relatively high mortality rate among children, especially in those less than one year of age [14]. In the current study, the majority of the subjects aged between 0–2 years old, which was similar to the age ranges reported in a previous investigation (1–5 years) [15]. Aligned with that suggested by previous studies [15,16], our study found a higher percentage of acyanotic CHD than cyanotic

CHD cases, with VSD was most common type of CHD and TOF was the most common diagnosis of cyanotic CHD among the subjects.

Table 3. Association between types of congenital heart disease (CHD) and child growth status

Development status	Types of CHD		*p*-value*
	Acyanotic (n=40) Frequency (%)	Cyanotic (n=14) Frequency (%)	
Personal-social			0.261
Normal	33 (82.5)	9 (64.3)	
Caution	7 (18.5)	5 (35.7)	
Gross motor			0.413
Normal	33 (87.5)	9 (78.6)	
Caution	5 (12.5)	3 (21.4)	
Fine motor			0.424
Normal	33 (85.0)	10 (71.4)	
Caution	6 (15.0)	4 (28.6)	
Language			0.103
Normal	30 (75.0)	7 (50.0)	
Caution	10 (25.0)	7 (50.0)	

*Statistically significant at p=0.05

Our findings suggested a significant association between the type of CHD and the growth status of the children based on weight-for-age, weight-for-length or weight-for-height and BMI-for-age (**Table 2**). Most of the children with acyanotic CHD were underweight, whereas those with cyanotic were severely underweight based on the weight-for-age curve. In addition to being severely underweight, children with cyanotic CHD also tended to suffer from stunting, whereas children with acyanotic CHD were more likely to have a normal length or height-for-age curve. These results were in accordance with the findings of a previous investigation conducted at Sanglah Hospital, Denpasar, Indonesia, which suggested a higher prevalence of stunting in cyanotic CHD compared to acyanotic CHD groups [17]. The cause of stunting in children with CHD has been linked to chronic hypoxia that possesses a direct or indirect effect on decreasing the insulin-like growth factor I (IGF-I) hormone [18]. The disruption of the IGF-I mechanism will affect bone growth in children. Children with cyanotic CHD often present with abnormal length/height [17]. In addition, a lack of nutritional intake, high energy needs, and pulmonary hypertension are among other suggested factors influencing the incidence of growth failure in children with CHD [19,20].

The weight-for-length or weight-for-height curves interpretation of our data indicated that the vast majority of the children (72.5) with acyanotic CHD were well-nourished. On the other hand, more than half of children (64.3%) with cyanotic CHD presented with malnutrition status. In terms of BMI-per-age, children with acyanotic CHD were mostly (55.0%) undernourished, whereas those with cyanotic CHD were predominantly (71.4%) malnourished. Based on these two growth-associated aspects, our analyses suggested a significant association between CHD and children's growth status (**Table 2**). These results are in line with that reported in a previous study, justifying a significant difference in the nutritional status of children with cyanotic CHD and acyanotic CHD [21]. Many factors have been proposed to influence nutritional disorders in CHD children, including hemodynamic factors, low growth potential such as low birth weight (LBW), lower anthropometric status of parents, and the presence of other congenital abnormalities [16]. The etiology of malnutrition in children with CHD is divided into several groups, including inadequate nutritional intake, inefficient absorption mechanisms, and/or increased energy requirements. Infants with CHD often have increased energy expenditure due to the extra effort required for the heart to pump blood effectively [16,22].

Impaired growth is linked to adverse consequences such as increased mortality, extended hospital stays, delayed cardiac surgery and postoperative complications [23]. A study reported that underweight and stunting increased mortality with an odds ratio (OR) of 3.54 and 3.31, respectively [23]. Another study identified a correlation between low height-for-age and weight-for-age z-scores and post-surgery mortality in CHD patients [24]. Low height-for-age or weight-for-age was also associated with mortality risk; low height-for-age was associated with increased risk of infection, cardiac arrest, mechanical ventilation use, and longer hospital stays [24].

The management of nutrition in these infants varies significantly in clinical practice, encompassing diverse strategies for initiating, advancing and discontinuing enteral feeding. Despite the existence of numerous practice guidelines aimed at guiding nutritional care in recent years, this variability persists. The implementation of standardized feeding protocols has been proven to reduce this problem and improve outcomes for CHD patients [25].

In terms of development status, our analysis suggested no significant association between CHD with the children's developmental status. The Denver Developmental Screening Test-II test in the current study showed that the majority of children, both with acyanotic (75.0%–87.5%) and cyanotic CHD (50.0%–78.6%), exhibited normal development status determined based on their personal social, gross motor, fine motor, and language skills; only a few subjects in both CHD groups were observably indicative of possessing developmental disorders (12.5%–50.0%) (**Table 3**). Our findings, except those related to language skills, were contrary to those reported earlier, suggesting that almost 58.0% of children with cyanotic CHD were suspected of experiencing delays, and personal social impairment was only evidenced in CHD children with comorbidities [26]. Further, gross motor skill development in acyanotic CHD children was more frequently inaccessible compared to the cyanotic CDH group, and around 38.4% of the subjects in both groups exhibited below-average gross motor skill scores [6]. A study also indicated that the majority (54%) of one-year-old children with CHD experienced gross motor skill development disorders [27]. Such impairment in gross motor skill development has been reportedly linked to the severity of the disease. In a normal fetal brain, adequacy of oxygen and substrate requirements, which are strongly influenced by the anatomical structure of the heart and the function of the myocardium, affects children's gross motor skill development [6]. In terms of fine motor skills, which were also in contrast to our findings, some previous studies suggested that more than 60% of both acyanotic and cyanotic CHD subjects were suspected of having delays [26]; however, children having fine motor skill scores below the average was more prevalent in acyanotic compared to cyanotic CHD group [6].

Children with CHD face the potential for developmental issues stemming from events that occurred in intrauterine life, at the surgery, or throughout their growth years e.g., acid-base disturbances, hypoxia and failure to thrive [28,29]. Development failure in this aspect has been suggestively associated with poor or inadequate nutritional status in the majority of CHD children [26]. As to language skills, our result showed normal language skill development in most acyanotic and cyanotic CHD children, which was aligned with the previous study [26].

Delayed development carries lifelong implications but when recognized and intervened early, many children can be spared from disabilities. Treatment programs tailored for severe acute malnutrition should also incorporate a robust early recognition and intervention protocol to prevent neurodevelopmental disabilities [30,31]. A study conducted in Indonesia revealed that the primary cause for delayed diagnosis of CHD is caused by doctors followed by midwives, financial considerations, delays in referral and social factors [32].

This study has some limitations. Firstly, it was a single-center study H. Adam Malik General Hospital is a tertiary hospital, meaning that it serves as the last referral hospital for North Sumatra and Aceh Province. Findings from a single center may not be representative of a broader population, as patients' demographics, practices and conditions vary across locations. Secondly, this study had a relatively small sample in this study. A small sample size may limit the statistical power of a study.

Conclusion

We evaluated the association between the type of CHD with the growth and development status among 54 CHD children. Our data suggested that the type of CHD was associated with the growth status of the children based on the weight-for-age, weight-for-length/height, and BMI-for-age curves analysis. In contrast, there was no significant association between the type of CHD with the development status of the children in terms of social personal, gross motor, fine motor, and language skills.

Ethics approval

This research was approved by Research Ethics Committee of the Faculty of Medicine, Universitas Sumatera Utara, Medan, prior to conducting the study (No 751/KEPK/USU/2022).

Competing interests

The authors declare that there is no conflict of interest.

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Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

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