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Relationship between age at repair surgery and growth and development of children with acyanotic congenital heart disease: a cross-sectional study

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ABSTRACT

Background: The survival of children with congenital heart disease (CHD) has increased drastically in the last few decades. However, in children with the acyanotic type of CHD, it is often accompanied by symptoms of failure to thrive. This study aims to assess the correlation between age at repair surgery and the growth and development of children with acyanotic CHD.
Method: A cross-sectional study was conducted on eligible patients with acyanotic CHD who had undergone heart repair procedures. Age was taken when the patient was preoperatively repaired and categorized based on the age range of 3 months to 5 years. According to the WHO curve (weight/height), growth is assessed from nutritional status. Development was assessed from the category of height (cm) after surgery. Differences in growth and development before and after repair surgery were tested using the Wilcoxon method.
Results: Of the 40 samples analyzed, there were 20 males and 20 females, the majority aged 3-4 years (25%) followed by ages 2-3 years (10%). There was an effect of repair surgery on growth when surgery was performed at 2 to 3 years with a p-value of 0.016 (<0.05). In the development category, there was no effect of surgery on development in all age categories, with a p-value of 0.424 (>0.05).
Conclusion: Surgery at an early age has better growth outcomes, especially at 2-3 years, but is unrelated to developmental aspects.

Keywords: *acyanotic, cardiac repair, congenital heart diseases, development, growth*.
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INTRODUCTION

Congenital heart disease (CHD), a growth disorder of the heart and major blood vessels, is a common childhood problem. The worldwide incidence of CHD is estimated at 1.2 million cases out of 135 million live births annually. The incidence of CHD is estimated to be around 5 to 8 in 1000 births.[1] The incidence of CHD in Indonesia is estimated to be around 8 per 1000 births. If the population of Indonesia is 200 million and the birth rate is 2%, the number of CHD sufferers in Indonesia increases by 32,000 babies every year.[2] Echocardiography has been widely available recently and facilitates early CHD detection.[1]

Congenital heart disease consists of acyanotic and cyanotic types. Furthermore, the acyanotic type of CHD is divided into two types, namely tricuspid pre-valve lesions and tricuspid post-valve lesions. In patients with acyanotic CHD, the most common symptom is failure to thrive.[2,3] Research by Novatriyanto et al. found that the cyanotic CHD group most often experienced growth disorders, with the height of children with cyanotic CHD being more affected than children with acyanotic CHD. Shortness of breath is one of the symptoms of CHD that can be aggravated for the lactating baby. In addition, wasting (underweight) was found to be significant in the acyanotic CHD group due to acute malnutrition.[4]

Developmental disorders experienced by children with CHD are associated with the risk of malnutrition. Congenital heart disease causes hypermetabolic conditions, while the intake of nutrients tends to be less. Intestinal malabsorption conditions also often cause children to have no appetite. Because of this malnutrition, children with CHD tend to be sluggish and limited in their daily activities. This consequence ultimately hampers the development of their motor skills. In children with CHD, gross motor and fine motor development aspects are most often affected compared to speech-language and socialization aspects of independence. These motor disorders are more common in children with cyanotic CHD.[5] Therefore, the degree of hypoxia, developmental screening, and growth status assessment must be carried out regularly in children with CHD.[6]

Research on growth and development in postoperative patients with acyanotic CHD repair still needs to be carried out, particularly in Indonesia. Several studies have identified failure to thrive in postoperative patients due to inadequate nutrition. More research still needs to be done on the relationship between pre, peri, and post-cardiac repair surgery,

particularly based on age at surgery. This study aims to prove that the age factor during repair surgery in acyanotic CHD patients has a role in improving the growth and development of children.

METHODS

This study used a cross-sectional design based on medical records of acyanotic CHD patients who had been operated on at RSUD Dr. Soetomo Surabaya for January 2017 - December 2019. Data on children's growth and development was obtained through interviews and filling out online questionnaires in the period January-March 2022. Patients with a diagnosis of acyanotic CHD who had undergone heart repair procedures, patients who were still alive during the study with a maximum age of 6 years, and a minimum of six months of follow-up were the inclusion criteria in this study. Patients with repair surgery without using CPB or Aortic Cross clamp, patients with repair surgery without opening the heart chambers (patent ductus arteriosus ligation), patients with other congenital diseases (down syndrome, hydrocephalus, cerebral palsy, etc.), patients who are being treated or in critical condition (patients in an ill/unstable state who require hospital or intensive care at the time of sampling) that making it impossible to participate in the study, patients who are unwilling to participate or difficult to contact, or incomplete medical record data will be excluded from this study. All samples were taken using the total sampling method and comprised a minimum of 36 subjects based on the Lemeshow formula.

Age is an independent variable in this study. The age taken was when the patient was in preoperative repair. Age was categorized into three groups: age less than 12 months, age 12 to 36 months, and age more than 36 months.

Samples were taken at least six months after the repair operation. The growth was measured by taking preoperative height, and weight data, then compared postoperatively, then matched with the WHO curve. Growth is defined as the patient's weight and height data measured postoperatively using the WHO Curve. It shows the nutritional status of children with five categories: severely wasted, wasted, normal, possibly overweight, and obese. The development variable was measured using an interview in which the questions are based on the maternal and child health (MCH) book, which was revised in 2020 by comparing the child's abilities before surgery with when the questionnaire was given. If one word "no" is in the completed questionnaire, the development is considered deviant.

Descriptive statistics supplied in tabular form were used to examine the patient data's characteristics. Data were examined using the Wilcoxon test for growth and the Fisher Exact test for development to ascertain the association between age at the time of surgery and the growth or development of children in acyanotic CHD patients. If the P value is less than 0.05, the data are considered to be significantly different. Software called SPSS 26.0 was used for data analysis.

RESULTS

Baseline Characteristics

This study involved 40 children with demographic characteristics, pre and post-op nutritional status, and pre-and post-op developmental status, which can be seen in Table 1. This study found equal numbers of boys and girls (male n=20; female n=20). Most subjects were between 2-3 years and 3-4 years (n=10, 25%). The most nutritional status before surgery (pre) was in the normal category (45%), followed by wasted (27.5%) and severely wasted (22.5%) categories. One child was in the possible overweight and obese category (each 2.5%). After surgery, the nutritional status was reassessed in the subjects of this study, and it was found that 25 study participants (62.5%) were in normal nutritional status. In the category

Table 1. Characteristics of study participant.

Characteristics	(n)	%
Gender		
Boys	20	50.0
Girls	20	50.0
Age prior to surgery		
3-6 months	2	5.0
6-9 months	2	5.0
9-12 months	2	5.0
12-18 months	7	17.5
18-24 months	3	7.5
2-3 years	10	25.0
3-4 years	10	25.0
4-5 years	4	10.0
Pre-op nutritional status		
Severely wasted	9	22.5
Wasted	11	27.5
Normal	18	45.0
Possible overweight	1	2.5
Obese	1	2.5
Post-op nutritional status		
Severely wasted	3	7.5
Wasted	2	5.0
Normal	25	62.5
Possible overweight	3	7.5
Overweight	2	5.0
Obese	5	12.5
Pre-op developmental status		
No deviation	12	30.0
Deviation	28	70.0
Post-op developmental status		
No deviation	17	42.5
Deviation	23	57.7

Table 2. **Comparative analysis of changes in nutritional status before and after repair surgery.**

Age	Pre-op nutritional status					Post-op nutritional status					P-value*
	SW	W	N	PO	O	SW	W	N	PO	O	SW
3-6 months	0	2	0	0	0	0	0	1	1	0	0	0.180
6-9 months	1	1	0	0	0	1	0	1	0	0	0	0.317
9-12 months	1	0	1	0	0	1	0	1	0	0	0	1.000
12-18 months	1	1	5	0	0	1	0	6	0	0	0	0.655
18-24 months	2	1	0	0	0	0	1	2	0	0	0	0.157
2-3 years	2	3	5	0	0	0	0	5	2	2	1	0.016
3-4 years	1	3	5	0	1	0	1	7	0	0	2	0.066
4-5 years	1	0	2	1	0	0	0	2	0	0	2	0.141

**Wilcoxon Signed Rank Test. Abbreviation: W, Wasted; SW, Severely Wasted; PO, Possible Overweight; O, Obese; N, Normal*

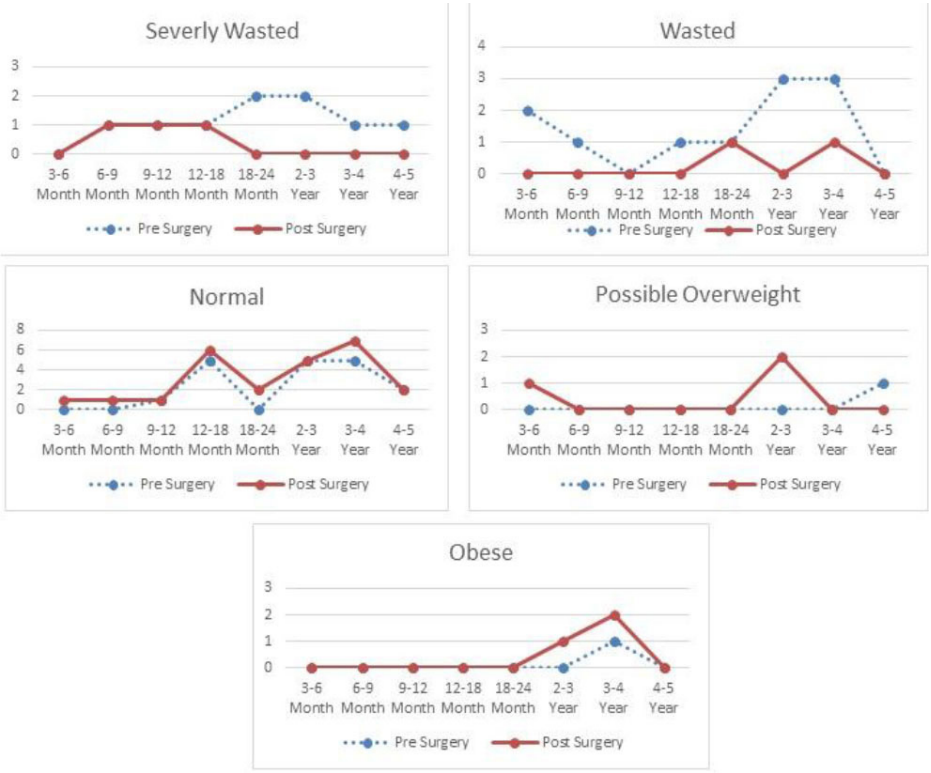

Figure 1. Comparison of the level of nutritional status pre-and post-cardiac repair based on age categories.

of normal nutritional status, there was an increase from the period before surgery compared to the period after surgery (62.5% vs. 45%). Moreover, there appears to be an increase in the number of overweight and obese subjects in patients after surgery, namely two overweight subjects (5.0%) and five subjects with obese status (12.5%). The developmental status of the subjects was also observed, and it was found that developmental deviation was more predominant both before surgery and after surgery (n=28, 70% vs. n=12, 30%; n=23, 57% vs. n=17, 42%). However, there was a decrease in the number of subjects who experienced developmental deviations in the postoperative period (n=28, 70% vs. n=23, 57%).

Comparison of nutritional status between pre and post-surgery based on age category

Nutritional status is an indicator of growth in this study. A comparison of nutritional status between pre and post-surgery by age category can be seen in Table 2. There was no significant difference between the pre and post-operation nutritional status levels in various age categories (all p values > 0.05). However, in the 2-3 year age category, nutritional status was significantly different between pre- and postoperative repair conditions (p-value = 0.016). Five children were under normal nutritional status during the pre-surgery period, and no children were under normal nutritional status during the postoperative period. There has been an increase in the accumulation of children with nutritional status above normal after surgery (n=5 vs. n=0). As shown in Figure 1, an analysis of differences in the levels of pre-and postoperative repair nutritional status by age category shows that in the 2-3 year age range, there is a significant change in the proportion of nutritional status, both in the normal category, below normal, and above normal. Changes in the proportion of nutritional status are not seen at the age of under two years.

Comparison of developmental status between pre and post-surgery based on age category

A comparison of the development between pre and post-operation repair based on age category can be seen in Table 3. The total number of patients at pre-surgery was nine in the severely wested category, and at the time of post-surgery, there were 9 cases of severely wested. At pre-surgery, two patients remained severely wasted, while six became normal and one possibly overweight. Meanwhile, there was no significant difference between the development of pre-and post-operation repair in various age categories (all p values > 0.05), but in the 12-18 month age group and the 2-3 years age group, there is an increase in the number of children who have appropriate normal development in their respective age categories.

Table 3. Comparative analysis of changes in developmental status before and after repair surgery.

Age	Pre-op developmental status		Post-op developmental status		*P-value**
	Deviation	No deviation	Deviation	No deviation	
3-6 months	2	0	1	1	1.000
6-9 months	1	1	2	0	1.000
9-12 months	0	2	2	0	0.50
12-18 months	6	1	1	6	0.063
18-24 months	2	1	3	0	1.000
2-3 years	9	1	4	6	0.125
3-4 years	6	4	7	3	1.000
4-5 years	2	2	3	1	1.000
Total	**28 (70.0%)**	**12 (30.0%)**	**23(57.5%)**	**17(42.5%)**	

Fisher Exact test

DISCUSSION

Children with CHD are significantly at risk of experiencing delays and developmental disorders. Most children diagnosed with congenital heart disease do not experience many problems early in life. However, in the second year of life, they often experience problems due to the increasing severity of the disease, which makes it difficult to gain weight and hinders their intelligence in various aspects of development. The severity of the disease exacerbated the condition so that it interfered with his weight gain, while the lack of weight eventually also interfered with improving his illness. This condition is not well known and understood by parents of children with congenital heart disease, even by medical personnel.[7]

The availability of diagnostic tools such as echocardiography, fetal scanning, surgical technique development, and comprehensive postoperative care can significantly increase the life expectancy of children with the disease. Today earlier diagnosis and calculated treatment are becoming more feasible in acyanotic congenital heart disease so that these infants can live into their teens with nearly normal health status.[8]

Growth retardation is frequently observed in infants with congenital heart disease (CHD). Growth charts should reflect height and weight in absolute values and percentiles. Plotting an accurate and following growth curve is essential to the initial evaluation and follow-up of a child with significant cardiac problems. In overweight children, acanthosis nigricans should be examined in the neck, armpits, and abdomen.[9]

Along with the development of pediatric heart surgery medicine, currently, there is an increase in life expectancy for children with CHD. About 50 years ago, before the advent of pediatric cardiac surgery, only about 30% of children with CHD lived to enter adulthood. In countries that can provide adequate health services, it is estimated that around 85% of children with CHD can live to adulthood.[8,10]

Acyanotic heart surgery now has a relatively low mortality and morbidity rate, so this study aims to see the effect of congenital heart surgery in catching up on growth and development and provide additional insights. Handling congenital heart disease should be done as early as possible. Definitive correction done at a young age will prevent distortion of cardiac growth. Therefore, efforts and research continue to be carried out so that heart surgery can be performed on neonates more safely. The trend for the future is for definitive correction to be performed in the neonate.[11]

From the present study, repair surgery on CHD showed an effect on growth following the surgery at 2 to 3 years (p-value of 0.016). This finding follows the results of a previous study by Li et al., who found that growth improved immediately after successful surgery, but the age of the studied patients was less than 12 months.[12] Meanwhile, for the development category, there was no effect of surgery on development in all age categories. This finding follows the results of a study by L. Catherine et al. in 2002, which examined 98 patients using the Griffith Mental Development Scale (GMDS). They found that 41% experienced abnormal neurological examinations, 42% experienced gross or subtle disturbances, and 23% indicated a delay in global developments.[13]

Other studies look at postoperative mortality associated with birth weight and gestational age. Research conducted by Steurer et al. in San Francisco found 25,244 patients who were included in the inclusion category by grouping patients who had a gestational age below 44 weeks, then dividing them based on weight at birth using a z-score calculation. The study results found that even with a Z-score that was included in the mild deviated category, it was still an independent risk factor for postoperative mortality and morbidity.[14]

A study was conducted using a prospective cohort study by Hui Shi et al. in Guangzhou, China, by comparing the growth at birth to 6 months postoperatively between the simple CHD group and the complex CHD group in 801 patients. The result is an influence between the type of CHD and postoperative growth through the Z-score measurement, where the complex group has an increased postoperative growth delay rate.[15]

Growth and development disorders are one of the characteristics of CHD patients, and surgery is one of the therapies expected to catch up or improve growth and development. According to some literature, the best operation time is at preschool age. However, it needs to be explained whether that age also affects the achievement of targets to catch up with growth and development.[11]

A comparable finding was found by Atmaja et al. 2018. The study was conducted on 40 people (20 postoperatively and 20 healthy people) using the PedQL Generic Core Scale aged 2 to 18 years, where the study found no significant differences in the parameters of social, emotional, and school functioning.[14] Poor growth in children with mild heart defects or failure to catch up with weight gain after cardiac repair can also be caused by failure to

recognize specific syndromes, inadequate caloric intake, or underlying genetic predispositions.[9]

Fuller et al., 2010 examined DHCA (Deep Hypothermic Circulatory Arrest) as a heart surgery technique and found that development was increasingly hampered after four years after surgery. However, using DHCA made it easier for operators to perform operations. On the contrary, it could improve acute brain injury and have long-term adverse developmental outcomes.[15]

A retrospective study was conducted on patients undergoing ASD closure surgery in the first two years of life. Of the 31 symptomatic ASD patients, 22 had persistent respiratory symptoms, 24 failed to thrive, and 9 had pulmonary hypertension. Overall, 26 patients (84.0%) showed clinical improvement after ASD closure, including improvement in respiratory status (17/22; 77.3%), return to normal growth (15/24; 62.5%), and resolution of hypertension. pulmonary (7/7). ; 100%, two patients unable to assess postoperatively).[6]

The main limitation of this study is that the research design used is a cross-sectional study taken from 40 samples, which may explain a temporal relationship between age and child growth and development. This sample size is still relatively small, so further research is needed with a more significant number and multicenter to increase the external validity of the results of this study. In addition, it is necessary to add other factors that can be analyzed, such as parents' education and economic level, to developmental biomarkers to truly ascertain the effect of age on the growth and development of children with acyanotic CHD after repair surgery.

CONCLUSION

Acyanotic CHD repair surgery at an early age has better growth outcomes, particularly at 2-3 years, but not in child development outcomes. This finding may be caused by several factors that need further investigation. Therefore, cardiac repair surgery can be used to catch up on growth in acyanotic CHD patients.

RESEARCH ETHICS

All research protocol used in this study has been reviewed and approved by the Health Research Ethics Committee of the Faculty of Medicine, Airlangga University in Surabaya (No. 0876/110/3/VIII/2021).

CONFLICT OF INTEREST

There is no conflict of interest in writing this research report.

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AUTHOR CONTRIBUTION

M. Zulfadli Nuralim and Heroe Soebroto conceived and designed the analysis, collected the data, contributed data or analysis tools, performed the analysis, and wrote the paper. Irwanto and Ito Puruhito conceived and designed the analysis and ascertained the quality of the manuscript.

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