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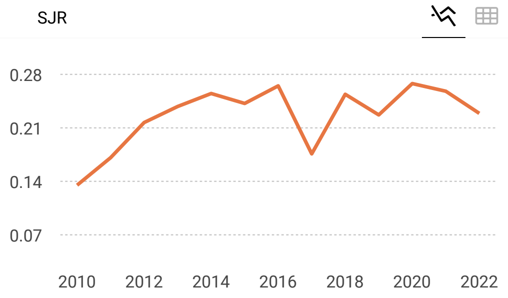
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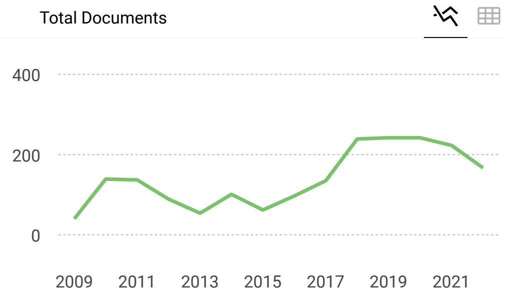
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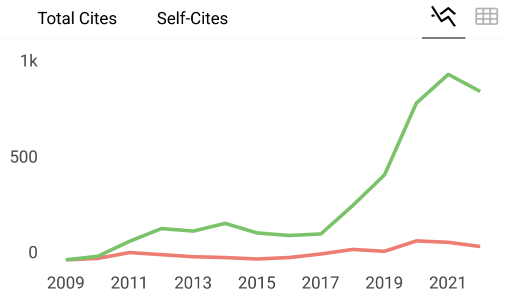
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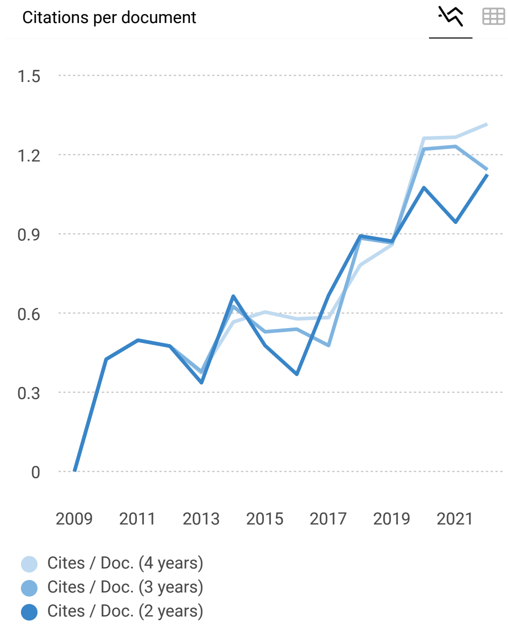
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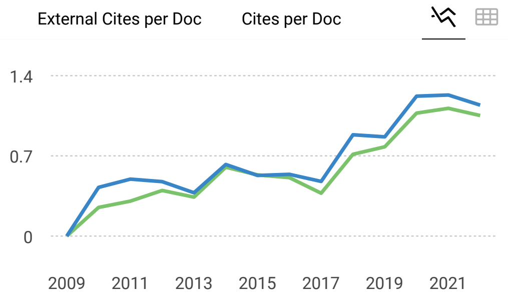
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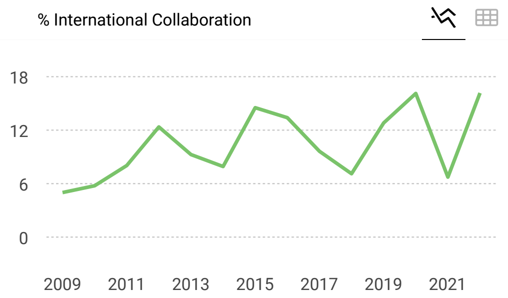
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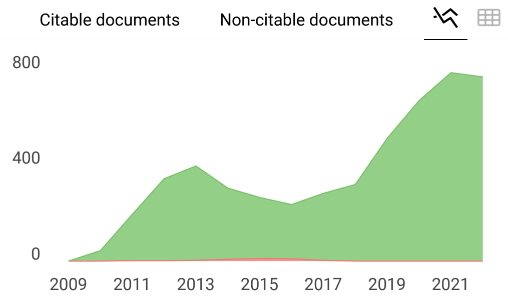
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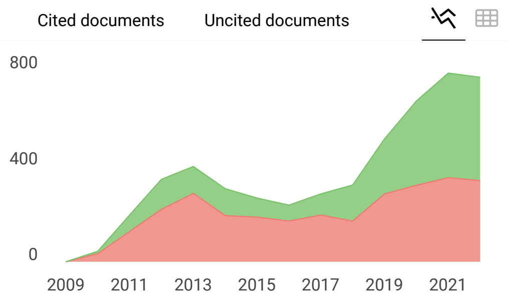
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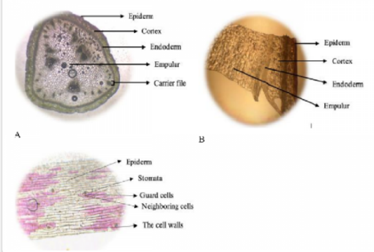

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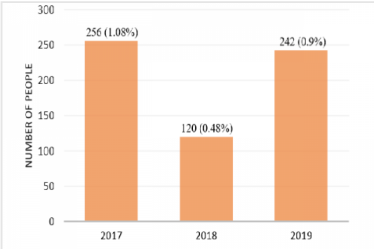

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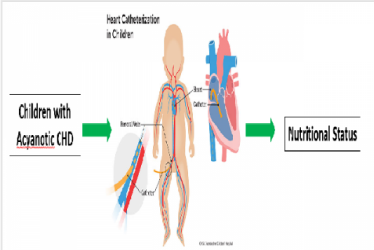

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Research Article

The Effect of Cardiac Catheterization Intervention on The Nutritional Status of Children with Acyanotic Congenital Heart Disease

Muqiemuddin Salim[1], I Ketut Alit Utamayasa[1,*], Roedi Irawan[1], Irwanto[1], Azwin Mengindra Putera[1], Meity Ardiana[2]

ABSTRACT

Background: Intervention is required since malnutrition in children with acyanotic congenital heart disease (CHD) will affect growth, development, and quality of life. Research on the impact of cardiac catheterization on the nutritional health of children with acyanotic CHD is limited, particularly in Indonesia. This study aims to analyze the effect of cardiac catheterization on the nutritional status of children with acyanotic CHD. **Methods**: A cross-sectional study was conducted between January 2019 and December 2021. The participants of this study were children aged 1-60 months with acyanotic CHD who had undergone cardiac catheterization. We compare the nutritional status of participants in three observation stages, including pre-intervention of catheterization and the 3rd and 6th months post-cardiac catheterization. The parameters of nutritional status are determined according to the mean of Z-scores of weight-for-age (WAZ), length-for-age (LAZ), and weight-for-length (WLZ) of participants. **Results:** A total of children with acyanotic CHD who underwent catheterization and 49 children were eligible participants. The mean age of children with acyanotic CHD patients who underwent catheterization was 31.51 months, and 89% of them were 1-5 years. Fifty-three percent of participants who underwent cardiac catheterization were male. The most common acyanotic CHD defects were the Patent Ductus Arteriosus (PDA) among 55.1% of participants. Significant differences were found in WAZ, LAZ, and WLZ in the measurement of three observation stages ($p<0.05$). **Conclusion:** Interventional cardiac catheterization affects and enhances the nutritional status of children with acyanotic CHD and may be suggested as an initial therapy to further evaluate the disease.

Keywords: Children, Congenital heart disease, Acyanotic CHD, Nutritional status, Interventional cardiac catheterization.

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INTRODUCTION

Acyanotic congenital heart disease (CHD) affects nutritional status related to decreased energy intake and increased energy requirements.[1-3] There are numerous cases of CHD patients' nutritional status improving following surgery.[4,5] However, there is a relatively high rate of surgical complications, particularly in those patients who have severe complications.[6] Moreover, the length of hospitalization and intensive care for surgery also take more time.[7] In terms of both the quantity and variety of treatments, the discipline of interventional cardiology has advanced quickly during the previous two to three decades. One of the procedures in pediatric cardiology is interventional cardiac catheterization, which is non-traumatic, does not cause scarring, and is relatively inexpensive.[2,8] Cardiac catheterization costs are relatively lower due to shorter or less length of stay in the intensive care unit.[9] Surgical and non-surgical cardiac correction interventions were reported to significantly improve nutritional status in CHD patients; of the 476 children with CHD, 132 underwent cardiac catheterization and showed increased Z-scores on 3 parameters compared to their initial Z-scores.[10] Research related to the effect of interventional catheterization on the nutritional status of children with acyanotic CHD is limited, particularly in Indonesia; thus it has to be investigated.

CHD is one of the most common congenital malformations, with an incidence of 7-9 cases per 1000 live births.[11] CHD is also associated with an increased rate of fetal death,[12] with an incidence of up to 85% of deaths *via* necropsy in stillbirths, newborns, and infants.[13] Congenital heart disease is also the leading cause of cardiac arrest up to age 24, ranging from 84% in the first two years to 21% in the first two decades of life.[14] Research in India reported the prevalence of acyanotic CHD in as many as 290 cases (72.5%), with the most cases being 38% Ventricular Septal Defect (VSD), 20% Atrial Septal Defect (ASD), and 13% Patent Ductus Arteriosus (PDA).[15] Incidence of CHD in children aged 3 months – 5 years at Dr. Soetomo General Hospital for the period of November 2012 reported 66 cases of CHD consisting of 61% acyanotic CHD and 39% cyanotic CHD.[16] Between January and April 2018, there were 247 cases of acyanotic CHD at Dr. Soetomo General Hospital, with malnutrition accounting for 27.5% of the cases.[17]

Malnutrition will have a poor effect on growth, development, and quality of life in children with CHD, demanding intervention. The development of pediatric cardiology has allowed for the survival and extension of life in many CHD cases, particularly those that are acyanotic.[18] Vaidyanthan, *et al.* (2008) reported that of 476 patients, 72.3% underwent surgery, and 27.7% with an interventional catheter

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found a significant impact on improving nutritional status on short-term observation.[10] Nearly half of infants with univentricular heart defects require supplementation by nasogastric or gastrostomy prior to intervention.[19] Limited resources and delayed corrective intervention can lead to increased congestive heart failure and respiratory infections, as well as a high prevalence of malnutrition in pre-intervention CHD.[1,20] Cardiac catheterization as a therapeutic modality has increased very rapidly. After the era of the 90s, the concept and discourse on the function of the catheter as a therapeutic modality for CHD has become a reality and can be applied to newborns to adulthood. Interventions can be definitive, palliative, or adjunctive to surgery.[21,22,23] With technological advancements, it is believed that interventional cardiac catheterization would play a role, one that includes lowering the prevalence of malnutrition in CHD following intervention. The purpose of conducting this study was the shortage of existing research, particularly in Indonesia, on the impact of interventional cardiac catheterization on the nutritional status of children with CHD.

METHODS

A cross-sectional study was conducted to evaluate the effect of cardiac catheterization on nutritional status changes in acyanotic CHD patients before and after cardiac catheterization. This study involved pediatric patients with acyanotic CHD who underwent cardiac catheterization between January 2019 and December 2021 at the Integrated Health Service Center (IHSC), Pediatric Ward, Dr. Soetomo General Hospital. Additionally, we used the medical records of the pediatric patients with acyanotic CHD who underwent intervention that year and were monitored for 6 months following the intervention. This study evaluates nutritional status categories based on weight-for-age, length-for-age, and weight-for-height. Evaluation of nutritional status was carried out before cardiac catheterization intervention, then re-evaluated at the third month, and sixth month after the cardiac catheterization intervention. We also evaluated differences in Z scores for weight-for-age (WAZ), Z scores for length-for-age (LAZ), and Z scores for weight-for-length (WLZ) in pediatric patients with acyanotic CHD before cardiac catheterization, and the observation of the 3rd and 6th months of post-cardiac catheterization intervention.

The inclusion criteria for this study included children aged 1 – 60 months who had been diagnosed with acyanotic CHD with ASD, VSD, and/or PDA types, who came and were treated at IHSC, underwent cardiac catheterization, had complete medical record data, and parents or legal guardians signed informed consent. We excluded pediatric patients with acyanotic CHD who did not return for follow-up within 3 and 6 months after interventional cardiac catheterization and had incomplete medical records. This research has received ethical approval from the Hospital Ethics and Research Committee, Dr. Soetomo General Hospital, with exemption letter number: 1139/LOE/301.4.2/XI/2022.

Data analysis

IBM SPSS Statistics Version 25 and Microsoft Excel 2019 were both used in the data analysis for this investigation. We analyzed the differences in mean nutritional status before and after interventional cardiac catheterization using the one-way Anova test and Paired t-test if the data were normally distributed and the Wilcoxon signed-rank test if the data were not normally distributed. The data are shown as the mean and standard deviation (SD). The normality test used the Kolmogorof-Smirnov test. Analysis of differences in the nutritional status classification used the Chi-square test. All tests were carried out in a two-tailed test with a significance value of $p<0.05$.

RESULTS

There were 122 patients with acyanotic CHD who underwent cardiac interventional catheterization. A total of 73 patients were excluded because they did not have complete medical record data and did not return for follow-up within 3 and 6 months, therefore 49 children with acyanotic CHD were eligible participants. In this study, the mean age of pediatric patients with acyanotic CHD who underwent cardiac catheterization was 31.51 months, with the most common age category being 1-5 years, with 44 (89.8%), and 26 (53%) male children. Anthropometry of children with acyanotic CHD was obtained for weight-for-age which was included in the normal category of 18 (36.7%) patients, which included 12 (24.5%) underweight children, and 19 (38.8%) severely underweight children. The characteristics of children with acyanotic CHD are further summarized in Table 1.

At the three stages of observation, i.e., before cardiac catheterization, the third, and sixth months after a cardiac catheterization, Table 2 shows a significant difference in the mean weight-for-age evaluation. The same thing was shown in the WAZ category, where the scores for the evaluations conducted before catheterization were -2.44, at three months, -1.92, and at six months, 1.65 ($p<0.001$). In the LAZ category, the mean at the three observation stages -2.03, -1.89, and 1.51 also differed significantly.

However, there was no significant difference in the classification of LAZ nutritional status in children with acyanotic CHD ($p=0.893$) (Table 3).

The WLZ category in children with acyanotic CHD is shown in Table 4 with a value of -1.88 before catheterization and with values of -1.25 and 1.15 at the third- and sixth-month evaluations, respectively. The WLZ classification in children with acyanotic CHD also shows a significant difference with a *p*-value of 0.032. This is seen by the considerable decrease in severely wasted from 20.4% of children with acyanotic CHD before catheterization to 6.1% of children six months afterward.

Table 1: The characteristics of participants.

Characteristics	n (%)	p-value
Age (year)		
< 1	5 (10.2)	0.278[a]
1-5	44 (89.8)	
Sex		
Male	26 (53.1)	0.190[a]
Female	23 (46.9)	
Anthropometry		
Weight-for-age		
Overweight	-	
Normal	18 (36.7)	
Underweight	12 (24.5)	
Severely underweight	19 (38.8)	
Length-for-age		
Tall	-	
Normal	25 (51.0)	
Short	11 (22.4)	
Severely short	13 (26.5)	
Weight for height		
Obese	-	
Overweight	-	
Possible risk of overweight	-	
Normal	23 (46.9)	
Wasted	16 (32.7)	
Severely wasted	10 (20.4)	
Type of acyanotic CHD		
ASD	9 (18.4)	
VSD	13 (26.5)	
PDA	27 (55.1)	

Data was viewed as number (percentage); [a] Paired T-test was used to analyze the differences in WLZ pre-and-post-catheterization; ASD = Atrial Septal Defect; VSD = Ventricular Septal Defect; PDA = Patent Ductus Arteriosus.

Table 2: The difference based on weight-for-age before and after cardiac catheterization.

Variables	Before catheterization	After catheterization		p-value
		3rd month	6th month	
Weight	10.1 (± 2.69)	11.16 (± 2.77)	12.01 (± 3.00)	< 0.001[a]*
WAZ	-2.44 (± 1.53)	-1.92 (± 1.52)	1.65 (± 1.53)	< 0.001[a]*
WAZ classification				
Overweight	-	-	-	
Normal	18 (36.7)	23 (46.9)	27 (55.1)	< 0.357[b]
Underweight	12 (24.5)	13 (26.5)	11 (22.4)	
Severely underweight	19 (38.8)	13 (26.5)	11 (22.4)	

Data was presented as Mean ± SD, number (percentage); [a] Paired T-test was used; [b] Chi-square test was used; *a *p*-value < 0.05 was significant; WAZ = Z score for weight-for-age.

Table 3: The difference based on length-for-age before and after cardiac catheterization.

Variables	Before catheterization	After catheterization		p-value
		3rd month	6th month	
Height	85.05 (± 11.02)	87.47 (± 10.81)	90.61 (± 10.59)	< 0.001[a]*
LAZ	-2.03 (± 1.93)	-1.89 (± 1.83)	1.51 (± 1.71)	0.008[a]*
LAZ classification				
Tall	-	-	-	
Normal	25 (51)	26 (53.1)	27 (55.1)	0.893[b]
Short	11 (22.4)	13 (26.5)	13 (26.5)	
Severely short	13 (26.5)	10 (20.4)	9 (18.4)	

Data was presented as Mean ± SD, number (percentage); [a] Paired T-test was used; [b] Chi-square test was used; *a *p*-value < 0.05 was significant; LAZ = Z score for length-for-age.

Table 4: The difference based on weight-for-length before and after cardiac catheterization.

Variables	Before catheterization	After catheterization		p-value
		3rd month	6th month	
WLZ	-1.88 (± 1.48)	-1.25 (± 1.28)	1.15 (± 1.24)	0.001[a]*
WLZ classification				
Obese	-	-	-	
Overweight	-	-	-	
Possible risk of overweight	-	-	-	
Normal	23 (46.9)	36 (73.5)	34 (69.4)	0.032[b]*
Wasted	16 (32.7)	7 (14.3)	12 (24.5)	
Severely wasted	10 (20.4)	6 (12.2)	3 (6.1)	
WLZ based on the acyanotic CHD type				
ASD	-1.72 (± 1.00)	-1.03 (± 1.13)	-0.89 (± 1.03)	0.454[c]
VSD	-1.72 (± 1.49)	-1.11 (± 1.23)	-0.90 (± 1.27)	
PDA	-2.02 (± 1.63)	-1.40 (± 1.38)	-1.35 (± 1.29)	

Data was presented as Mean ± SD, number (percentage); [a] Paired T-test was used; [b] Chi-square test was used; [c] One-way Anova test was used; *a *p*-value < 0.05 was significant; WLZ = Z score for weight-for- height; ASD = Atrial Septal Defect; VSD = Ventricular Septal Defect; PDA = Patent Ductus Arteriosus.

DISCUSSION

Many children with acyanotic CHD did not undergo routine control or follow-up visits after cardiac catheterization, causing 59% of patients to be excluded. The decreased number of outpatient visits was due to the fear of patients and their families about the risk of exposure to the coronavirus disease 2019 (COVID-19) infection, transportation limitations, and the regulation of activity restrictions by the government during this period.[24,25] Even though there is no significant difference in the classification of the nutritional status of the two parameters WAZ and LAZ, on average there is a significant increase from the average of these parameters at each observation stage.

Weight-for-age before and after cardiac catheterization

The average increase in weight-for-age can be seen before catheterization it was 10.1 kg, the third month's evaluation weight-for-age after catheterization was 11.16 kg, and the sixth month's weight-for-age evaluation after catheterization was 12.01 kg. We got the same thing in the WAZ category, with a score of before catheterization -2.44, third-month evaluation -1.92 and sixth-month evaluation 1.65. Hartati *et al.* (2016) also reported a comparison of WAZ before and after catheterization showed an increase and statistically significant differences in each measurement period. An increase in the mean of the Z-score has been obtained since one month after the catheterization, from the time before the catheterization the mean WAZ was -2.63 to -2.41 in the first month, -1.92 in the sixth month and reached -1.56 in the 12th month (> -2.00).[26] Another study also reported that there was an increase in z score classification, 20% of children with normal WAZ before catheterization increased to 63% six months after catheterization, while for WAZ children with underweight and severely underweight each 40% decreased to 33% for WAZ children with underweight and the Z-score for severely underweight dropped to 3% after six months post-catheterization.[27]

Corrective action for CHD can improve nutritional status because, after repairing the defect, children with CHD will require more energy, return to normal, and achieve energy balance. This energy balance will enhance nutritional status, and a few months after the treatment, increasing body weight will be associated with successful defect closure. The improvement in hemodynamics following the closure of the defect also contributed to the improvement in nutritional status. The nutritional condition will also improve as a result of reduced intake caused by heart failure and recurring respiratory infections, which will become better after defect closure.[28]

Length-for-age before and after cardiac catheterization

In this study, there was a significant difference between height-for-age and LAZ before catheterization, and the third- and sixth-months post-catheterization. Vaidyanathan *et al* (2008) reported similar things in children who underwent intervention corrections that experienced an increase in LAZ in the evaluation period of the first 3 months after the intervention correction was carried out with LAZ -1.2 to -0.9. In a study in India also reported, children who had corrected interventions after being followed-up for 2 years experienced catch-up growth in weight but not in height.[10, 19] A study showed that the mean WAZ, LAZ, and WLZ values were significantly higher in post-catheterization control patients than before catheterization. Weight-for-age and weight-for-length are better than before the intervention correction but length-for-age is not too influential. Corrective cardiac intervention is associated with weight improvement within a few months after the procedure, but it may take up to one year for the height to return to normal.[20,29] Similar to the previous study, in China, it was reported that significant improvements were found in three parameters in one year's observation after intervention correction. This may indicate that growth is less affected by the condition of the heart itself in a certain period after correction interventions, while environmental, dietary, and genetic factors may be more favorable after the heart condition is corrected.[30]

Weight-for-length before and after cardiac catheterization

We also found significant differences in the mean weight-for-length and WLZ across the three stages of observation. Vaidyanathan *et al*. (2009) also reported a significant increase in WLZ values.[28] Another study also reporting the WLZ evaluation six months after the intervention correction found a significant difference, 89% showed catch-up growth after the intervention correction whereas 50% of them achieved catch-up growth six months after the procedure.[31] In this study, we found no significant difference in nutritional status between ASD, VSD, and PDA before and after interventional cardiac catheterization.

In developing countries, corrective interventions carried out at an early age also affect nutritional recovery. This might have occurred because if the defect has been resolved with corrective intervention, it will reduce nutritional needs, better nutrient absorption, and reduce the incidence of lower respiratory tract infections.[32] If the defect is resolved early, it is hoped that the child will be able to grow and develop to reach his genetic potential.[33] In children with persistent lesions or those accompanied by genetic disorders and other congenital abnormalities that affect growth are at risk of missing the window of opportunity to grow optimally. This results in a reduction in the number of cells (including adipose cells, muscle, and bone) so that they cannot reach their proper body size. Children with CHD, fewer of these cells can also result in a 30% loss in brain tissue. In addition to resulting in poor bone maturation and growth, cell reduction also has an impact on motor and oromotor development.[33]

CONCLUSION

Interventional cardiac catheterization affects nutritional status in children with acyanotic CHD aged 1 – 60 months. Significant differences and good development were found for the three parameters, including WAZ, LAZ, and WLZ, in children with acyanotic CHD after cardiac catheterization. In developing countries, this therapy can be used as an alternative treatment to open-heart surgery. In addition, catheterization has been shown to improve nutritional status in children with acyanotic CHD. However, further studies are still needed with a longer observation period to be able to assess nutritional status as a whole with more varied variables.

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CONFLICTS OF INTEREST

The authors have no conflict of interest to disclose.

ETHICS APPROVAL

This research has obtained ethical approval and an ethical certificate issued by the Research Ethics Commission of Dr. Sutomo Hospital Surabaya, Indonesia (1139/LOE/301.4.2/XI/2022).

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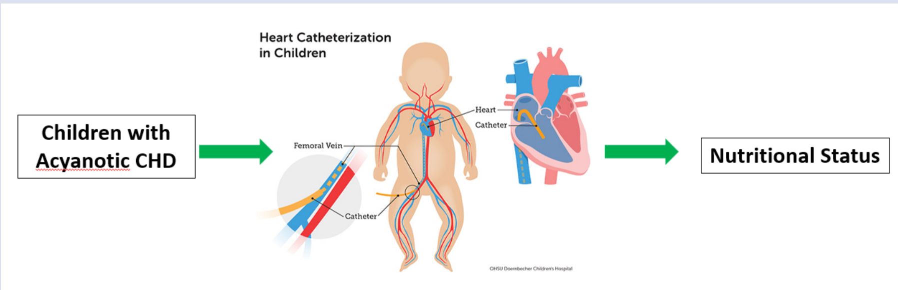
GRAPHICAL ABSTRACT



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