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Characteristics of growth of ventricular septal defect patients post transcatheter closure in Dr. Soetomo general hospital Surabaya 2020-2023

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Abstract

Growth monitoring is important in children with congenital defects that may hinder development, such as ventricular septal defect (VSD). Although most VSD resolves by itself, some cases require closure to help protect growth and to relieve symptoms. This study aims to observe growth characteristics of children undergoing VSD closure by WHO guidelines. This descriptive analytical study evaluated the growth patterns of pediatric VSD patients undergoing transcatheter closure at Dr. Soetomo General Hospital from 2020–2023. Medical records of patients aged 1–10 years with complete anthropometric data were included. Collected variables consisted of age, sex, body weight, and body height. Inclusion criteria involved VSD patients aged 1-10 years old during the observation period with transcatheter closure who had a complete medical record. From the observation, it is observed that during the time of intervention, the total average of anthropometric Z-scores are normal: WAZ is -0.45SD, HAZ of 0.77SD, BAZ of -0.86SD (normal), and WHZ of -0.47SD. At 6 months post-closure, the average anthropometric characteristics remain normal: WAZ -0.71SD, HAZ -0.56SD, BAZ -0.44SD, WHZ -1.34SD. At the 1-year follow-up, the total averages are still within the normal limit: WAZ -0.76, HAZ -1.06, BAZ -0.25, and WHZ -0.71SD. This indicates that patients maintain normal growth after the procedure. In conclusion, although not always increasing, the average patients' growth post-closure still falls within normal limits. However, it is essential to note that external factors not observed in this study, may influence the outcome.

Keywords: Growth; Anthropometric Measurement; Congenital Heart Defect; Ventricular Septal Defect; Transcatheter Closure

1. Introduction

Growth disturbance is commonly found in children with congenital anomalies, one of them being a ventricular septal defect (VSD). VSD is a non-cyanotic CHD that typically appears as a cardiac structural defect resulting from the failure of interventricular fusion [1]. Complications that VSD may cause are, but are not limited to, failure to thrive and poor weight gain, recurring respiratory tract infection, and congestive heart failure in large VSD [2][1]. Generally, VSD closes by itself within a relatively early period of life. However, according to the Indonesian Heart Association's Clinical Guidelines and Clinical Pathway for Cardiovascular Disease, in large VSD or cases with complications such as congestive

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heart failure with unsuccessful medicamentosa, aortic valve prolapse, right ventricle infundibulum stenosis, and pulmonary hypertension with minimal lung vascular reactivity (<8 U/m2), closure is indicated. One of the available closure methods is transcatheter closure, a minimally invasive intervention that minimizes the risk posed by surgical closure.[1]

Considering how common it is for children with VSD to have growth abnormalities, growth in children with heart defects is a commonly studied subject of high importance. To measure anthropometric growth, Indonesia utilizes the WHO Child Growth Standards, which consists of length/height-for-age (HAZ), weight-for-age (WAZ), weight-for-length/height (WHZ), and body mass index (BMI)-for-age (BAZ). These measurements are later plotted on a growth chart, which is used to record a child's individual growth as they age. The graph created by the WHO presents a curve line representing the standard deviation (SD) [3]. This guideline also refers to a general consensus that children aged 5-10 years old are measured only with WAZ, HAZ, and BAZ. Later on, once they turn 11, growth is solely determined by BAZ and HAZ. The reason for this is due to the start of puberty, where children gain both weight and height at a different rate. Therefore, to make a fair comparison for each child, BMI along with HAZ is used simultaneously. BMI is used to determine the ideal body mass, while HAZ is used to reflect chronic nutritional status since the child was younger [4].

However, there are still limited works describing specifically patients' growth post-transcatheter closure. This study observes the growth progress of children aged 1-10 years old after transcatheter closure for VSD in Dr. Soetomo General Academic Hospital using the WHO growth chart. Observation is done to observe the patient's growth progress post-transcatheter closure.

2. Material and methods

2.1. Materials

Data used for this research includes the patient's sex, birth date to determine age and observation period, body weight, body height, defect size, and defect type. Patient's identity, such as name, address, and date of birth, is not written in the study and therefore will be maintained confidential by the author. All information obtained is used only for research purposes.

2.2. Methods

This research is a descriptive study with a retrospective design, describing the anthropometric growth of patients with post-transcatheter closure of VSD. The study population is all of the VSD patients without any other congenital syndrome or defect aged 1-10 years old in Dr. Soetomo General Academic Hospital, Surabaya, receiving transcatheter closure from January 2020 to December 2023. This study has been approved by the Research Ethics Committee at Dr. Soetomo General Academic Hospital, Surabaya.

3. Results and discussion

3.1. Patient Characteristics

After filtering patients through the inclusion and exclusion criteria, the total sample of this research is 28 patients, with 14 boys and 14 girls. Most patients came with a perimembranous type of VSD (57.14%). 34.14% of the patients have a moderate-sized defect. Below are the defect characteristics of the patients.

Table 1 VSD Type Distribution

Type of Defect	Population
Perimembranous	16
Perimembranous inlet	1
Subaortic	3
SADC	2
Perimembranous extending to inlet	2
Muscular	2

Subarterial	1
Outlet	1

Most of the subjects who had their defect closed initially came with a perimembranous type VSD. A study regarding VSD closure in children also notes similar characteristic. It is commonly known that perimembranous defect is one of the most common form of VSD [5]. Not only is it the most common form, but perimembranous VSD is also the most favorable for a transcatheter closure approach. A study compared the long-term clinical outcome of the transcatheter closure approach for intracristal VSD and perimembranous VSD. It is later stated that perimembranous VSD transcatheter closure has a higher success rate than that of intracristal VSD, with a 96.3% success rate for perimembranous VSD and 84.6% for intracristal VSD. This is because there is a minimal distance between the aortic valve and intracristal defect, which may lead to aortic valve prolapse and regurgitation. This side effect is suggested to be caused by the device's placement against the aortic valve. Hence, technically, intracristal VSD transcatheter closure is more challenging to perform. Meanwhile, in perimembranous VSD, side effects and complications are usually minor, such as cardiac rhythm abnormalities, residual shunt, and valve regurgitation. These complications, as stated before, typically appear very minor and hence hardly need any intervention [6].

Table 2 VSD Size Distribution

Size	**Population**
Large	5
Moderate to large	2
Moderate	13
Small	2
Undetermined	6
Large	5
Moderate to large	2
Moderate	13

Table 3 Initial Anthropometric Status During Intervention

Baseline WAZ				**Baseline HAZ**			
Age	Category	N	(%)	Age	Category	N	(%)
1	Severely underweight	1	16.67	1	Normal	4	66.67
	Underweight	1	16.67		Tall	2	33.33
	Normal	4	66.67				
2	Underweight	1	20	2	Stunted	1	20
	Normal	4	80		Normal	4	80
3	Underweight	1	16.7	3	Severely stunted	1	16.67
	Normal	5	83.33		Normal	5	83.33
4	Normal	1	50	4	Normal	1	50
	Possible overweight	1	50		Tall	1	50
5	Severely underweight	1	25	5	Normal	3	75
	Underweight	1	25		Tall	1	25
	Normal	2	50				
6	Underweight	1	33.33	6	Normal	3	100

	Normal	2	66.67				
7	Normal	2	100	7	Normal	2	100

As mentioned above, most subjects had normal Z-scores (>-2SD) for the measured parameters (WAZ, WHZ, HAZ, and BAZ) during the closure procedure. However, observing from the average Z-score during the intervention, it is clear that despite the normal Z-score, most subjects fall at the lower limit of normalcy. A much earlier research also reported a similar result. That study noted that at the time of surgery, term and preterm infants with VSD generally have low height and weight Z-scores. The median WAZ value of patients born at term at surgery is -2,24 SD. In comparison, the median WAZ for preterm patients at the time of surgery is -3.07 SD. While the WAZ median generally falls between normal and low standards, the HAZ median is much worse. For preterm patients, during the same period, the median HAZ only reached -1.42 SD, while term patients reached -2.22 SD [7].

Similarly, in a study done in China, preoperative underweightness in children with CHD reached 36,1%, preoperative wasting 29,7%, and preoperative stunting 21,3%. It is also mentioned that children with severe CHD subtypes have a higher proportion of underweight in CHD children [7]. These findings in older studies indicate that, despite malnutrition being strongly associated with CHD, most patients reached the usual standard of growth. However, parallel to the result of this study, it is found that during the intervention period, although most patients had normal Z-score values across all criteria, nearly all in the normal category lie just above the lower limit of the normal cut-off number, -2 SD. Malnutrition is commonly found in any type of CHD due to increased metabolic demand or insufficient energy intake resulting from feeding difficulties. Another previous study showed how malnutrition occurred due to the decreased energy intake of children with CHD, only around 88% of the recommended energy intake for children, Aside from that, this same study mentioned that a possible venous drainage obstruction in cases with heart failure may cause the blood to pool in the children's intestinal system, which may lead to intestinal dysfunction that leads to a decrease of nutrient absorption [8]. This theory is supported by another study that found protein and fat malabsorption in children presenting with heart failure and cyanosis.

3.2. Growth Output Result

3.2.1. Weight-for-Age (WAZ) Result

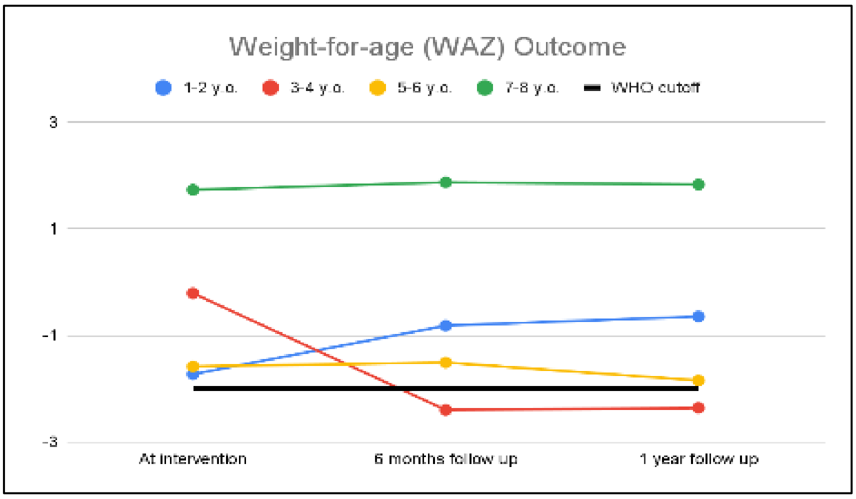

Figure 1 Mean WAZ across different age groups

Table 4 Average WAZ

	1-2 y.o.	3-4 y.o.	5-6 y.o.	7-8 y.o.	Total average
At intervention	-1.73	-0.21	-1.59	1.73	-0.45
6 months follow-up	-0.82	-2.4	-1.51	1.87	-0.71
1-year follow-up	-0.65	-2.36	-1.85	1.83	-0.76

The first, third, and fourth age group has a final outcome of normal WAZ (>-2SD).

During the intervention, across all age groups, the average WAZ falls into the normal category. However, these numbers are very close to the lower limit of the normal WAZ category, with the first age group average being -1.73 SD, the second being -0.21SD, the third being -1.59SD, and the fourth being 1.73SD. The total average is -0.45SD, which is within the normal range. At the six-month follow-up, the first and fourth age group has an increase in WAZ, where the first group's WAZ reaches -0.82SD and the fourth group reaches 1.87SD. However, the second age group, which has the best WAZ average during intervention, becomes the age group with the lowest WAZ average at -2.40SD. Similarly to the second group, the third group decreases until -1.51SD. The total average of the six-month follow-up is -0.71SD. At the one-year follow-up period, all age groups reached an increase. The first group's average is -0.65SD, the second is -2.36SD, the third is -1.85SD, and the fourth is 1.83SD, with the total average being -0.76SD, indicating an overall increase from the initial average during the intervention period. All three total averages on different follow-up periods show a normal WAZ score. Overall, three out of four groups maintain the WAZ above -2SD.

3.2.2. Height-for-Age (WAZ) Result

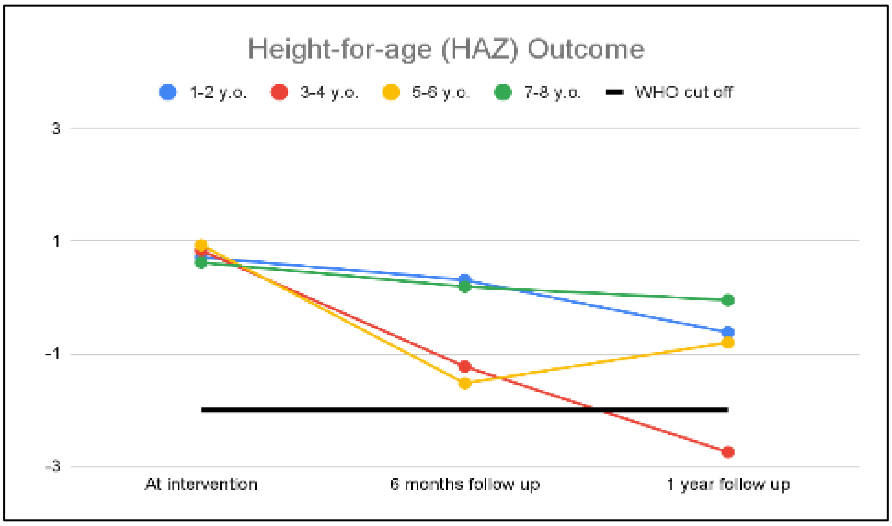

Figure 2 Mean HAZ across different age groups

Table 5 Average HAZ

	1-2 y.o.	3-4 y.o.	5-6 y.o.	7-8 y.o.	Total average
At intervention	0.71	0.83	0.93	0.62	0.77
6 months follow-up	0.31	-1.23	-1.53	0.19	-0.56
1-year follow-up	-0.62	-2.75	-0.80	-0.05	-1.06

The first, third, and fourth age group has a final outcome of normal WAZ (>-2SD).

Despite most patients having normal HAZ at intervention, all groups show a decreasing trend at the 6-month follow-up, but the average Z-score later increases at the 1-month follow-up. During the intervention, all age groups presented with normal HAZ values. The first age group's average was 0.71SD, the second 0.83SD, the third 0.93SD, and the fourth, 0.62SD. However, a decrease in HAZ is observed over the period of six months across all age groups. The first age group falls into an average HAZ of 0.31SD, the second group -1.23 SD, for the third age group, the average is -1.53SD, and 0.19 for the fourth age group. The total average of HAZ at six months is -0.56, which is lower than at the intervention period, despite retaining its place within the normal range. At the final observational period, the first age group rose into 0.31SD, the third into -0.80SD, the fourth into -0.05SD, while the second group regained the normal category at -2.75SD. The total average for 1-year follow-up is -1.06SD. Overall, three out of four age groups maintain a HAZ above -2SD.

Malnutrition is commonly found in any type of CHD due to increased metabolic demand or insufficient energy intake resulting from feeding difficulties. In a study where the postoperative outcome of VSD patients is observed, it is found that each moderate and severe wasting, underweight, and stunting becomes an independent predictor of adverse outcome.

3.2.3. Weight-for-Height (WHZ) Result

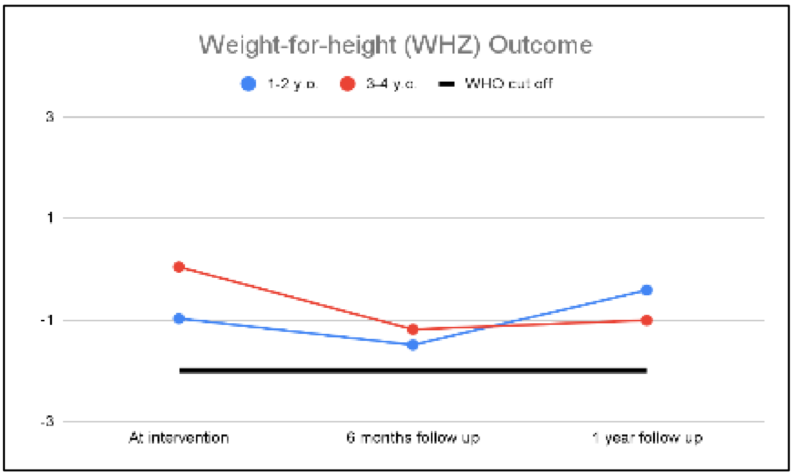

Figure 3 Mean WHZ across different age groups

Table 6 Average WHZ

	1-2 y.o.	3-4 y.o.	Total average
At intervention	-0.98	0.04	-0.47
6 months follow-up	-1.49	-1.19	-1.34
1-year follow-up	-0.42	-1.01	-0.71

The first and second age group has a final outcome of normal WAZ (>-2SD).

As explained before, the sample that WHZ observes is only 1-2 years old and 3-4 years old. Even though 5-year-olds still can be measured by WHZ, the observational period will be finished once they are 6, which makes the WHZ determinant invalid for this age group. The average initial WHZ is -0.98SD for the first age group and 0.04SD for the second age group. The complete average is -0.47SD, as explained before, which is categorized as wasting. However, at 6-month follow-up period, the trend changes, as the first age group undergoes a decrease (into -1.49SD) while the second age group reaches an increase up to -1.19SD. At one year post closure, the first group has the average of -0.42, while the second age group decreased to -1.01. Overall, WHZ is still within the normal range of >-2SD for both age groups.

3.2.4. BMI-for-Age (WHZ) Result

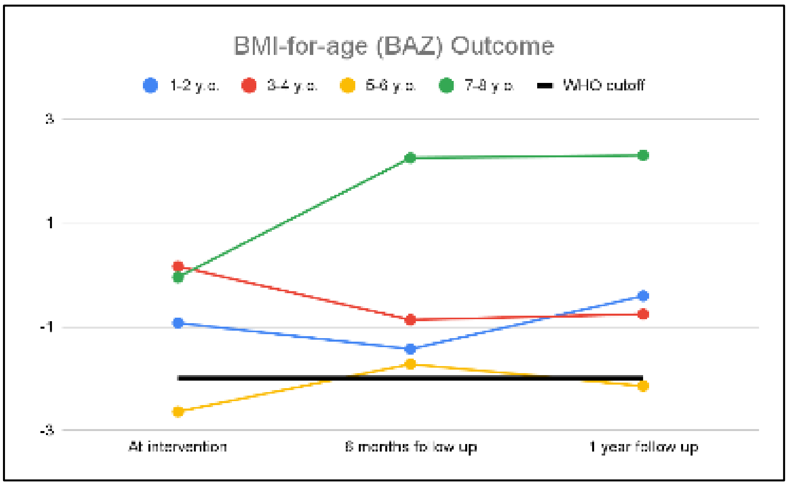

Figure 4 Mean BAZ across different age groups

Table 7 Average BAZ

	1-2 y.o.	3-4 y.o.	5-6 y.o.	7-8 y.o.	Total average
At intervention	-0.93	0.16	-2.64	-0.05	-0.86
6 months follow-up	-1.43	-0.87	-1.72	2.25	-0.44
1-year follow-up	-0.41	-0.76	-2.15	2.30	-0.25

All groups have a final outcome of normal WAZ (>-2SD).

During the intervention period, all age groups had a normal BAZ, with the first age group being -0.93SD, the second age group being 0.16SD, the third age group being -2.64SD, and the fourth age group being -0.05SD. The total average for this period is around -0.86SD. At the six-month follow-up period, the first age group reaches -1.43SD. The second age group reaches -0.87SD, the third group is -1.72SD and the fourth 2.25SD, which is already entering the overweight category. The overall average for the sixth-month follow-up is -0.46SD. At a one year follow-up period, the first group average is -0.41SD. The second group is -0.76SD, the third age group is -2.15SD, and the last group is 2.3SD. Overall, three out of four age groups are still within the normal cutoff value of -2SD.

3.3. Growth Output Discussion

As observed in graphs 5.1-5.5, by the end of the observation period, most of the patients had the Z-score of above -2SD, which indicates normal growth. Therefore, it can be said that this result is also supported by the research conducted earlier [7], which shows that patients generally have increased Z-scores and become more noticeable during the third-month follow-up period. This increase continues to occur at 6 months post-surgery, even though the mean Z-score is slightly lower than the reference population. Most subjects have already reached the normal range, indicating complete catch-up growth. Also in line with this study's findings, a previous study in India observing infants who receive a VSD closure procedure in infancy shows that a growth catch-up is indeed achieved. Across all categories, WAZ shows the most significant improvement after the shunt closure. Additionally, improvement in anthropological measurement is most visible in patients receiving closure at an age below 8 months [10].

However, according to Martins' research [7], at 12 to 24 months post-surgery, a significant number of patients showed a negative variation in Z-scores for height and weight. This indicates that aside from dealing with the preexisting birth defect, in this case, being VSD, environmental and genetic growth potential still play an essential role in a child's growth. A parallel finding is also stated by Ruan [8], in which CHD is not only tied to the defect itself. Many external factors may contribute to undernutrition, including the parents' economic status, environmental conditions, maternal nutrition status, and more. This study also mentioned their findings on how mothers with a BMI of <18,5 before the pregnancy were more likely to have underweight CHD children. In addition to that, family dietary habits may also contribute to the child's overall growth. Although not statistically significant, this study also demonstrated a positive association between healthy maternal dietary habits and children's nutrition [8].

Therefore, it is recommended that caregivers be educated on monitoring the child's growth and development by providing proper nutrition and age-appropriate developmental stimuli. This is especially important for children with a history of any CHD, including but not limited to VSD, even after the defect closure.

4. Conclusion

28 of the VSD patients who received transcatheter closure at Dr. Soetomo General Hospital in Surabaya, who fit the inclusion and exclusion criteria, are aged 1-7 years, and are equally distributed between males and females. The most common VSD type is perimembranous VSD (46.34%), with varying locations.

At the time of intervention, the average anthropometric characteristics of the patients are as observed: WAZ of -0.45SD (normal), HAZ of 0.77SD (normal), BAZ of -0.86SD (normal), and WHZ of -0.47SD (normal). At 6 months post-closure, the average anthropometric characteristics of the patients are as observed: WAZ -0.71SD (normal), total HAZ average is -0.56SD (normal), total average of BAZ is -0.44SD (normal), total average of WHZ at this period is -1.34SD (normal). At the 1-year post-closure follow-up, the total averages are as follows: WAZ -0.76 (normal), HAZ -1.06 (normal), BAZ -0.25 (normal), and WHZ -0.71SD (normal).

Although not always increasing, the average patients' growth post-closure still falls within normal limits. However, it is essential to note that external factors not observed in this study, such as upbringing, economic status, diet, etc. may influence the outcome.

Compliance with ethical standards

Disclosure of Conflict of interest

There is no conflict of interests in this study.

Statement of ethical approval

The ethical clearance for this study was issued by Dr. Soetomo General Hospital Surabaya, Indonesia. The author has obtained the permission to obtain necessary data from the patient's medical record. The patient's identity such as name, birth date, and address is not published.

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