

Article

# Preoperative Nutritional Status of Infants with Non-Restricted Ventricular Septal Defect and Its Influence on Postoperative Recovery

Qu-Bo Huang<sup>1,†</sup>, Bi-Xia Shi<sup>2,†</sup>, Sheng-Huo Zhou<sup>1</sup>, Sai-Lan Li<sup>1</sup>, Yan-Juan Lin<sup>1,\*</sup>

<sup>1</sup>Department of Cardiovascular Surgery, Union Hospital, Fujian Medical University, 350001 Fuzhou, Fujian, China

<sup>2</sup>Rehabilitation Department, The Second Affiliate Hospital of Fujian University of Traditional Chinese Medicine, 350001 Fuzhou, Fujian, China

\*Correspondence: [xiehelyj@163.com](mailto:xiehelyj@163.com) (Yan-Juan Lin)

†These authors contributed equally.

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## Abstract

**Purpose:** This study described the preoperative nutritional status of infants with nonrestricted ventricular septal defects (VSDs) and evaluated its effect on postoperative recovery. **Methods:** We retrospectively collected data from infants with nonrestricted VSD who received surgical treatment in our hospital from January 2020 to December 2021 and analyzed their preoperative nutritional status and postoperative recovery. **Results:** Fifty (53.8%) patients were underweight (weight for age Z score (WAZ)  $\leq -1$ ), and 31 (33.3%) patients were malnourished (WAZ  $\leq -2$ ). The mechanical ventilation time, duration of intensive care unit stay and hospital stay time after surgery of patients with WAZ  $\leq -2$  were significantly longer than those of patients with WAZ  $> -2$  ( $p < 0.05$ ). The results of linear correlation analysis showed that age, WAZ and prealbumin were negatively correlated with mechanical ventilation time, duration of intensive care unit stay and hospital stay time after surgery, respectively. Multiple linear regression analysis showed that mechanical ventilation time =  $7.080 - 0.668 \text{ WAZ} - 0.013 \text{ prealbumin} - 0.618 \text{ age}$  ( $R^2: 0.729$ ,  $F: 79.773$ ,  $p: 0.001$ ); duration of intensive care unit admission =  $11.775 - 1.385 \text{ WAZ} - 0.018 \text{ prealbumin} - 0.102 \text{ age}$  ( $R^2: 0.714$ ,  $F: 74.072$ ,  $p: 0.001$ ); and hospital stay time =  $17.663 - 1.673 \text{ WAZ} - 0.017 \text{ prealbumin} - 1.07 \text{ age}$  ( $R^2: 0.711$ ,  $F: 72.842$ ,  $p: 0.001$ ). **Conclusion:** The incidence of malnutrition in infants with nonrestricted VSD was very high, and malnutrition had a significant adverse effect on postoperative recovery. Malnutrition significantly prolonged mechanical ventilation time, duration of intensive care unit stay and hospital stay after surgery.

## Keywords

non-restricted ventricular septal defect; malnutrition; postoperative recovery; infants; congenital heart disease

## Introduction

Congenital heart disease (CHD) is the most common type of congenital malformation, accounting for approximately 28%, and it is also the most common cause of death in children aged 0–5 years [1,2]. Surgery is the main method to treat CHD. A large number of studies have shown that malnutrition is very common in children with CHD, especially in cases with high-risk factors such as heart failure and pulmonary hypertension [3–7]. Malnutrition significantly worsens postoperative nutritional status; affects postoperative recovery; prolongs mechanical ventilation time, duration of intensive care unit and hospital stay time after surgery; and increases mortality [8–10]. Therefore, it is of great significance to provide preoperative nutritional support and improve preoperative nutritional status for malnourished infants with CHD [11]. It is of great guiding significance to perform nutritional support that clarifies the preoperative nutritional status and its influence on the postoperative recovery of CHD.

Ventricular septal defect (VSD) is the most common CHD, and nonrestricted VSD is the most severe type. Due to the large number of left-to-right shunts, patients develop pulmonary hypertension early and even congestive heart failure, which requires surgery in young infants [12]. This study analyzed the preoperative nutritional status of infants with nonrestricted VSD in our hospital and further evaluated the influence of preoperative nutritional status on postoperative recovery.

## Methods

We conducted a retrospective study. We retrospectively collected data from infants with nonrestricted VSD who received surgical treatment in our hospital from January 2020 to December 2021 and analyzed their preoperative nutritional status and postoperative recovery. A total of 93 infants were included according to the criteria. All patients were treated with oral diuretics to reduce the burden on the heart after hospitalization. There was no significant difference in preoperative drug use (Fig. 1). Inclu-

sion criteria: infants with nonrestricted VSD who underwent surgery. The exclusion criteria were as follows: (1) patients with other serious malformations, such as anal atresia and esophageal atresia; (2) patients complicated with severe disease, such as severe hepatic or renal insufficiency or severe pneumonia before surgery; (3) patients with genetic syndrome; (4) patients who were premature infants; (5) patients who died postoperatively; and (6) patients with incomplete clinical data.

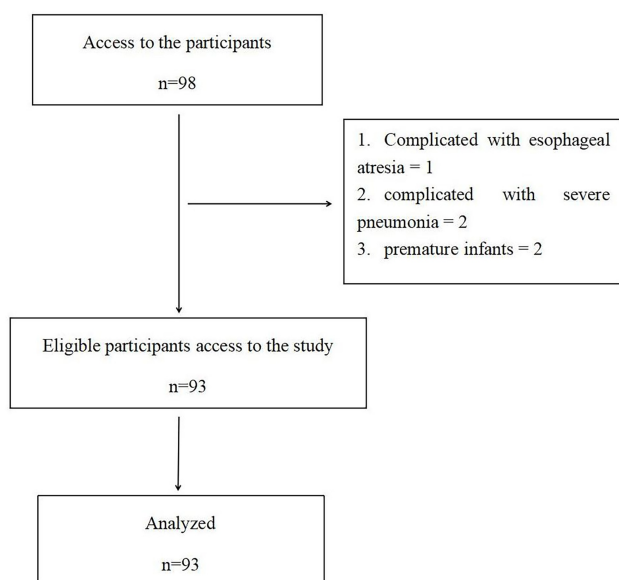


Fig. 1. The sequential diagram of the study.

### Data Collection

We searched and collected data from inpatient records. The data included birth weight, age, sex, preoperative weight, weight for age Z score (WAZ), albumin, prealbumin, size of VSD, pulmonary arterial hypertension, aortic occlusion time, extracorporeal circulation time, operation time, postoperative mechanical ventilation time, postoperative duration of intensive care unit and postoperative hospital stay time.

The weight for age Z score (WAZ) is a child growth indicator developed by the WHO and is widely used to evaluate the nutritional status of children. WAZ between  $-1$  and  $+2$  indicates normal body weight, and  $-2 < WAZ \leq -1$  indicates mild underweight.  $-3 < WAZ \leq -2$  indicates moderate underweight;  $WAZ \leq -3$  indicates severe underweight.  $WAZ \leq -2$  is generally considered to be malnourished.

Time of operation: We evaluated the time of operation on the basis of the patients' symptoms, chest X-ray results and echocardiographic results. Surgical treatment should be considered when patients have the following conditions: symptoms of cardiac insufficiency, such as shortness of breath and dyspnea, restricted growth and devel-

opment, chest X-ray showing heart shadow enlargement, echocardiography showing nonrestrictive ventricular septal defects, and obvious pulmonary hypertension.

### Statistical Analysis

SPSS 25 (IBM SPSS statistics, Chicago, IL, USA) was used for statistical analysis. Continuous and categorical variables are expressed as medians with interquartile ranges (IQRs) and frequencies with percentages, respectively. Patients were divided into  $WAZ \leq -2$  and  $WAZ > -2$  groups according to whether they were malnourished. Kruskal-Wallis and chi-square tests were used for statistical analysis of continuous data and classified data, respectively. Multiple linear regression analysis was used to analyze the relationship between WAZ, prealbumin and postoperative mechanical ventilation time, postoperative duration of intensive care unit and postoperative hospital stay time.

### Results

A total of 93 patients were included in the study, with 60 males and 33 females. The median age was 2.1 (IQR: 1.5, 2.5) months, the median size of VSD was 6.8 (IQR: 6.2, 7.4) mm, and the median pulmonary arterial hypertension was 54 (IQR: 49.5, 63) mmHg. Nutritional status indicators included birth weight, preoperative weight, WAZ, albumin and prealbumin. The median birth weight was 3.2 (IQR: 3.0, 3.5) kg, the median preoperative weight was 4.5 (IQR: 3.8, 5.1) kg, the median WAZ was  $-1.21$  (IQR:  $-2.07$ ,  $-0.31$ ), the median albumin was 35 (32, 38.5) g/L, and the median prealbumin was 175 (132.5, 199) mg/L. The postoperative recovery index included postoperative mechanical ventilation time, postoperative duration of intensive care unit stay and postoperative hospital stay time. The median postoperative mechanical ventilation time was 4.3 (IQR: 3.35, 5.4) days, the postoperative duration in the intensive care unit was 8 (IQR: 6, 10) days, and the postoperative hospital stay time was 14 (12.5, 17) days.

Patient characteristics and postoperative outcomes categorized by WAZ are shown in Table 1. There were no significant differences in age, sex, VSD size, pulmonary arterial hypertension, aortic occlusion time, extracorporeal circulation time, or operation time between the  $WAZ \leq -2$  and  $WAZ > -2$  groups.

The postoperative mechanical ventilation time, postoperative duration of intensive care unit stay and postoperative hospital stay time of patients with  $WAZ \leq -2$  were significantly longer than those of patients with  $WAZ > -2$ .

Linear correlation analysis showed that age was negatively correlated with postoperative mechanical ventilation time ( $r: -0.387$ ,  $p: 0.001$ ), postoperative duration of intensive care unit ( $r: -0.360$ ,  $p: 0.001$ ) and postoperative hospital stay time ( $r: -0.322$ ,  $p: 0.002$ ). WAZ was negatively

**Table 1. Patient characteristics and postoperative outcomes categorized by WAZ.**

	WAZ $\leq -2$	WAZ $> -2$	<i>p</i>
Number	31	62	
Age (month)	2 (1.3, 2.3)	2.1 (1.5, 2.6)	0.440
Male/female	23/8	41/21	0.429
Size of ventricular septal defect (mm)	6.8 (6.5, 7.8)	6.5 (6.1, 7.2)	0.113
Pulmonary arterial hypertension (mmHg)	56 (50, 68)	52 (49, 60)	0.185
Operation time (minute)	176 (168, 189)	170 (165, 182)	0.186
Extracorporeal circulation time (minute)	65 (67, 70)	66 (61, 70)	0.213
Aortic occlusion time (minute)	35 (33, 37)	35 (32, 37)	0.446
Postoperative mechanical ventilation time (day)	5.6 (5, 6.7)	3.8 (3, 4.4)	0.001
Postoperative duration of intensive care unit (day)	11 (9, 12)	7 (6, 8)	0.001
Postoperative hospital stay time (day)	17 (16, 19)	13 (12, 15)	0.001

WAZ, weight for age Z score.

**Table 2. Linear correlation analysis of patient characteristics and postoperative outcomes.**

	Postoperative mechanical ventilation time	Postoperative duration of intensive care unit	Postoperative hospital stay time
Age	r: -0.387, <i>p</i> : 0.001	r: -0.360, <i>p</i> : 0.001	r: -0.322, <i>p</i> : 0.002
Size of ventricular septal defect	r: 0.165, <i>p</i> : 0.115	r: 0.177, <i>p</i> : 0.089	r: 0.127, <i>p</i> : 0.227
Pulmonary arterial hypertension	r: 0.167, <i>p</i> : 0.111	r: 0.163, <i>p</i> : 0.120	r: 0.160, <i>p</i> : 0.126
WAZ	r: -0.777, <i>p</i> : 0.001	r: -0.776, <i>p</i> : 0.001	r: -0.799, <i>p</i> : 0.001
Albumin	r: -0.184, <i>p</i> : 0.077	r: -0.147, <i>p</i> : 0.161	r: -0.191, <i>p</i> : 0.067
Pre-albumin	r: -0.710, <i>p</i> : 0.001	r: -0.697, <i>p</i> : 0.001	r: -0.696, <i>p</i> : 0.001
Extracorporeal circulation time	r: 0.150, <i>p</i> : 0.152	r: 0.174, <i>p</i> : 0.096	r: 0.135, <i>p</i> : 0.199

correlated with postoperative mechanical ventilation time (r: -0.777, *p*: 0.001), postoperative duration of intensive care unit (r: -0.776, *p*: 0.001) and postoperative hospital stay time (r: -0.799, *p*: 0.001). Prealbumin was also negatively correlated with postoperative mechanical ventilation time (r: -0.710, *p*: 0.001), postoperative duration of intensive care unit (r: -0.697, *p*: 0.001) and postoperative hospital stay time (r: -0.696, *p*: 0.001) (Table 2).

The relationship between mechanical ventilation time and WAZ, prealbumin and age could be expressed by the following regression equation: mechanical ventilation time = 7.080 - 0.668 WAZ - 0.013 prealbumin - 0.618 age ( $R^2$ : 0.729, F: 79.773, *p*: 0.001). The higher the value of WAZ, prealbumin and age, the lower the mechanical ventilation time, and the total effect of the three independent variables on mechanical ventilation time reached 72.9%. The relationship between duration of intensive care unit stay and WAZ, prealbumin and age could be expressed by the following regression equation: duration of intensive care unit stay = 11.775 - 1.385 WAZ - 0.018 prealbumin - 0.102 age ( $R^2$ : 0.714, F: 74.072, *p*: 0.001). The meaning was that the higher the values of WAZ, prealbumin and age were, the lower the duration of intensive care unit stay, and the total effect of the three independent variables on the duration of intensive care unit stay reached 71.4%. The relationship between hospital stay time and WAZ, prealbumin and age could be expressed by the following regression equation:

hospital stay time = 17.663 - 1.673 WAZ - 0.017 prealbumin - 1.07 age ( $R^2$ : 0.711, F: 72.842, *p*: 0.001). The meaning was that the higher the values of WAZ, prealbumin and age were, the lower the duration of hospital stay time, and the total effect of the three independent variables on the duration of intensive care unit stay reached 71.1%.

## Discussion

Malnutrition negatively affects growth and neurocognitive development, especially in patients with CHD [13, 14]. Patients with CHD are prone to cardiac insufficiency due to abnormal hemodynamics, which increases energy consumption, and combined with insufficient caloric intake, malnutrition in patients with CHD is very common [15,16]. Inadequate protein and energy intake can also lead to loss of skeletal and cardiac muscle, which would worsen cardiac compensatory dysfunction and failure [17]. Surgery for CHD has a positive effect on weight gain [18,19]. However, preoperative malnutrition increases the risk of cardiac surgery, impairs recovery and even increases mortality after cardiac surgery [20,21]. Nutritional status is a potentially modifiable risk factor [11]. Therefore, optimizing the preoperative nutritional status of patients with CHD will improve postoperative outcomes. However, there is no consensus on the optimal nutrition support strategy for patients

with CHD, especially the nutrition management of patients with severe CHD. The analysis of the preoperative nutritional status of patients with nonrestricted VSD and the influence of preoperative nutritional status on postoperative recovery had important reference significance for developing the optimal preoperative nutritional management strategy.

We retrospectively analyzed the preoperative nutritional status of patients with nonrestricted VSD in our hospital and further evaluated the influence of preoperative nutritional status on postoperative recovery. Our results showed that patients with nonrestricted VSD had serious nutritional problems, with 53.8% underweight ( $WAZ \leq -1$ ) and 33.3% malnourished ( $WAZ \leq -2$ ). Marino *et al.* [22] reported that 28.2% of infants were malnourished before surgery. In an Australian study, 23% of infants were malnourished before surgery [8]. Our study also found that infants with nonrestricted VSD had serious nutritional problems, with 53.8% being underweight ( $WAZ \leq -1$ ) and 33.3% being malnourished ( $WAZ \leq -2$ ). Since the patients in our study had nonrestricted VSD with relatively severe cardiac malformation, the incidence of malnutrition was higher than that in other studies. It can also be inferred that severe CHD is associated with a higher risk of malnutrition and needs more attention.

Many studies have shown that low WAZ was associated with longer postoperative mechanical ventilation time, postoperative duration of intensive care unit and postoperative hospital stay time [23–25]. The same results were found in this study. The postoperative mechanical ventilation time, postoperative duration of intensive care unit stay and postoperative hospital stay time of patients with  $WAZ \leq -2$  were significantly longer than those of patients with  $WAZ > -2$ . Further linear analysis results also showed that WAZ was significantly negatively correlated with postoperative mechanical ventilation time, postoperative duration of intensive care unit stay and postoperative hospital stay time. With decreasing WAZ, postoperative mechanical ventilation time, postoperative duration of intensive care unit and postoperative hospital stay time were significantly extended. Although WAZ can provide an assessment of nutritional status, it lacks the ability to differentiate muscle reserves. Leite *et al.* [26] found that low protein and low muscle reserve were not conducive to postoperative recovery and prolonged the time of postoperative mechanical ventilation, postoperative intensive care unit stay and postoperative hospital stay. We further analyzed the effect of prealbumin on postoperative recovery, and the results showed that prealbumin was also significantly negatively correlated with mechanical ventilation time, postoperative intensive care unit stay and postoperative hospital stay time. Pulmonary hypertension and congestive heart failure occur early in nonrestricted VSD. Surgery is needed as early as in young infants, and the physiological energy, protein and muscle reserves of these patients are poor. Therefore, we

should strengthen the protein and muscle reserve of infants with nonrestricted VSD before surgery, with the introduction of high-calorie milk formula, micronutrient, calorie or protein additives.

Multiple linear regression analysis showed that WAZ, prealbumin and age significantly affected the postoperative recovery of patients with nonrestricted VSD, and they contributed 72.9%, 71.4% and 71.1% to the extension of mechanical ventilation time, postoperative intensive care unit stay and postoperative hospital stay time, respectively. Early operation is beneficial to improve the nutritional status of infants with CHD. Therefore, early surgery can be a protective factor for improving nutrition. This seems to contradict this study. Due to the serious condition of nonrestricted VSD, surgery is needed in the early infant period, and nutrition and energy reserves are often poor. As a result, early surgery will have a greater impact on postoperative recovery. Therefore, for patients with nonrestricted VSD, pulmonary artery pressure, cardiac function, and growth should be closely evaluated, and surgery should be performed as early as possible when circumstances permit. Nutritional support and protein and muscle reserve should also be enhanced during feeding.

There were some limitations in this study. First, this study was a single-center retrospective study. Second, the sample size of this study was small. Third, we only evaluated the effect of preoperative nutritional status on postoperative short-term outcomes, and it would be interesting to evaluate the effect of nutritional status on long-term outcomes. However, no such data were collected in this study. We will continue this research in the future.

## Conclusion

The incidence of malnutrition in infants with nonrestricted VSD was very high, and malnutrition had a significant adverse effect on postoperative recovery. Malnutrition significantly prolonged mechanical ventilation time, duration of intensive care unit stay and duration of hospital stay after surgery. Preoperative nutritional support should be actively performed to improve preoperative nutritional status and increase protein and muscle reserve.

## Abbreviations

VSD, ventricular septal defect; IQR, interquartile range; WAZ, weight for age Z score; CHD, Congenital heart disease.

## Availability of Data and Materials

The data for this study are available from the authors upon reasonable request with permission from the corresponding author.

## Author Contributions

QBH designed the study, acquired and interpreted the data and drafted the manuscript. BXS has made substantial contributions to conception, design and analysed the data. SHZ and SLL acquired and analysed the data. YJL involved in designing the work, revising the manuscript and confirmed the final authorship for this manuscript. All authors read and approved the publication this manuscript. All authors contributed to editorial changes in the manuscript. All authors read and approved the final manuscript. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

## Ethics Approval and Consent to Participate

This study was approved by the ethics committee of our hospital (the ethics approval number: 2021KY133) and strictly adhered to the tenets of the Declaration of Helsinki. Parents of the patient signed the informed consent form before study.

## Acknowledgment

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## Conflict of Interest

The authors declare no conflict of interest.

## References

[1] da Silva VM, de Oliveira Lopes MV, de Araujo TL. Growth and nutritional status of children with congenital heart disease. *The Journal of Cardiovascular Nursing*. 2007; 22: 390–396.

- [2] Hinton RB, Ware SM. Heart Failure in Pediatric Patients with Congenital Heart Disease. *Circulation Research*. 2017; 120: 978–994.
- [3] Cameron JW, Rosenthal A, Olson AD. Malnutrition in hospitalized children with congenital heart disease. *Archives of Pediatrics & Adolescent Medicine*. 1995; 149: 1098–1102.
- [4] Hehir DA, Easley RB, Byrnes J. Noncardiac Challenges in the Cardiac ICU: Feeding, Growth and Gastrointestinal Complications, Anticoagulation, and Analgesia. *World Journal for Pediatric & Congenital Heart Surgery*. 2016; 7: 199–209.
- [5] Kogon BE, Ramaswamy V, Todd K, Plattner C, Kirshbom PM, Kanter KR, *et al*. Feeding difficulty in newborns following congenital heart surgery. *Congenital Heart Disease*. 2007; 2: 332–337.
- [6] Nydegger A, Bines JE. Energy metabolism in infants with congenital heart disease. *Nutrition*. 2006; 22: 697–704.
- [7] Argent AC, Balachandran R, Vaidyanathan B, Khan A, Kumar RK. Management of undernutrition and failure to thrive in children with congenital heart disease in low- and middle-income countries. *Cardiology in the Young*. 2017; 27: S22–S30.
- [8] Costello CL, Gellatly M, Daniel J, Justo RN, Weir K. Growth Restriction in Infants and Young Children with Congenital Heart Disease. *Congenital Heart Disease*. 2015; 10: 447–456.
- [9] Hassan BA, Albanna EA, Morsy SM, Siam AG, Al Shafie MM, Elsaadany HF, *et al*. Nutritional Status in Children with Un-Operated Congenital Heart Disease: An Egyptian Center Experience. *Frontiers in Pediatrics*. 2015; 3: 53.
- [10] Gongwer RC, Gauvreau K, Huh SY, Sztam KA, Jenkins KJ. Impact of a Standardized Clinical Assessment and Management Plan (SCAMP®) on growth in infants with CHD. *Cardiology in the Young*. 2018; 28: 1093–1098.
- [11] Li C, Carli F, Lee L, Charlebois P, Stein B, Liberman AS, *et al*. Impact of a trimodal prehabilitation program on functional recovery after colorectal cancer surgery: a pilot study. *Surgical Endoscopy*. 2013; 27: 1072–1082.
- [12] Hu Z, Xie B, Zhai X, Liu J, Gu J, Wang X, *et al*. Midterm results of “treat and repair” for adults with non-restrictive ventricular septal defect and severe pulmonary hypertension. *Journal of Thoracic Disease*. 2015; 7: 1165–1173.
- [13] Nyaradi A, Li J, Hickling S, Foster J, Oddy WH. The role of nutrition in children’s neurocognitive development, from pregnancy through childhood. *Frontiers in Human Neuroscience*. 2013; 7: 97.
- [14] Daymont C, Neal A, Prosnitz A, Cohen MS. Growth in children with congenital heart disease. *Pediatrics*. 2013; 131: e236–e242.
- [15] van der Kuip M, Hoos MB, Forget PP, Westerterp KR, Gemke RBJ, de Meer K. Energy expenditure in infants with congenital heart disease, including a meta-analysis. *Acta Paediatrica*. 2003; 92: 921–927.
- [16] Monteiro FPM, de Araujo TL, Lopes MVDO, Chaves DBR, Beltrão BA, Costa AGDS. Nutritional status of children with congenital heart disease. *Revista Latino-americana De Enfermagem*. 2012; 20: 1024–1032.
- [17] Agudo de Blas P, Conthe Gutiérrez P, Alvarez de Frutos V, García Peris P, Gil López M, Torres Segovia FJ. Heart failure, malnutrition and inflammation. Prevalence and relevant aspects in its assessment. *Revista Clínica Española*. 2006; 206: 122–128. (In Spanish)
- [18] Cheung MMH, Davis AM, Wilkinson JL, Weintraub RG. Long term somatic growth after repair of tetralogy of Fallot: evidence for restoration of genetic growth potential. *Heart*. 2003; 89: 1340–1343.
- [19] Ratanachu-Ek S, Pongdara A. Nutritional status of pediatric patients with congenital heart disease: pre- and post cardiac surgery. *Journal of the Medical Association of Thailand*. 2011; 94: S133–S137.

- [20] Wong JJM, Cheifetz IM, Ong C, Nakao M, Lee JH. Nutrition Support for Children Undergoing Congenital Heart Surgeries: A Narrative Review. *World Journal for Pediatric & Congenital Heart Surgery*. 2015; 6: 443–454.
- [21] Mitting R, Marino L, Macrae D, Shastri N, Meyer R, Pathan N. Nutritional status and clinical outcome in postterm neonates undergoing surgery for congenital heart disease. *Pediatric Critical Care Medicine*. 2015; 16: 448–452.
- [22] Marino LV, Magee A. A cross-sectional audit of the prevalence of stunting in children attending a regional paediatric cardiology service. *Cardiology in the Young*. 2016; 26: 787–789.
- [23] Kelleher DK, Laussen P, Teixeira-Pinto A, Duggan C. Growth and correlates of nutritional status among infants with hypoplastic left heart syndrome (HLHS) after stage 1 Norwood procedure. *Nutrition*. 2006; 22: 237–244.
- [24] Marino LV, Johnson MJ, Davies NJ, Kidd CS, Fienberg J, Richens T, *et al*. Improving growth of infants with congenital heart disease using a consensus-based nutritional pathway. *Clinical Nutrition*. 2020; 39: 2455–2462.
- [25] Toole BJ, Toole LE, Kyle UG, Cabrera AG, Orellana RA, Coss-Bu JA. Perioperative nutritional support and malnutrition in infants and children with congenital heart disease. *Congenital Heart Disease*. 2014; 9: 15–25.
- [26] Leite HP, Fisberg M, de Carvalho WB, de Camargo Carvalho AC. Serum albumin and clinical outcome in pediatric cardiac surgery. *Nutrition*. 2005; 21: 553–558.