Original Article

Malnutrition and Nosocomial Infection After Pediatric Cardiac Surgery

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ABSTRACT

Background: Malnutrition is common among children with cardiovascular diseases. A few studies have been conducted on the relationship between malnutrition and the incidence of postoperative infections among these children. This study sought to evaluate the relationship between malnutrition and nosocomial infections in pediatric patients undergoing cardiac surgery.

Methods: Totally, 129 children <15 years old who developed nosocomial infections after cardiac surgery were enrolled. According to weight for age, weight for height, and height for age, malnutrition was defined as mild, moderate, and severe. The association between some blood factors such as hemoglobin and hematocrit and malnutrition was also investigated.

Results: The prevalence of mild, moderate, and severe malnutrition based on weight for age was 19.5% (n=23), 16.9% (n=20), and 32.2% (n=38), respectively; according to height for age was 15.4% (n=19), 13.8% (n=17), and 20.3% (n=25), respectively; and according to weight for height was 19.4% (n=24), 18.5% (n=23), and 31.5% (n=39), respectively. Pneumonia was significantly associated with moderate and severe malnutrition (P=0.006). Among biochemical indices, only hemoglobin (P=0.007) and hematocrit (P=0.01) were associated with malnutrition in these children.

Conclusions: Pneumonia and anemia are associated with malnutrition in children undergoing cardiac surgery and it is necessary to resolve malnutrition before therapeutic processes. ***(Iranian Heart Journal 2019; 20(2): 21-27)***

KEYWORDS: Malnutrition, Nosocomial infection, Pediatric, Cardiac surgery

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Nosocomial infections occur 48–72 hours after hospitalization and the symptoms appear in the hospital or after discharge. Generally, the prevalence of these infections depends on several factors such as the severity of the underlying diseases such as the immune system deficiency.[1]

Nosocomial infections in pediatric patients are also the most important cause of comorbidity and mortality, leading to increased costs and prolonged periods of hospitalization. This problem is more serious among infants, preterm infants, and children with congenital anomalies.[1]

In this regard, malnutrition independently increases hospital mortality resulting from infection, pressure ulcers, and delayed wound healing, and all of these prolong the hospitalization period and the mortality rate of patients. Nutrition and infection greatly affect each other. Numerous studies confirm that the incidence of infection—nosocomial infections in particular—is among the problems resulting from malnutrition.[1,2]

On the other hand, some of the risk factors of nosocomial infections are malnutrition, diabetes, and obesity. The nutritional deficiencies result in weak immune system performance and susceptibility to infections.[1,2]

The nutritional status of patients is evaluated by various variables such as the amount of consumed food, body weight, weight loss, anthropometric data, liver proteins, and body mass analysis. The early diagnosis of malnutrition as an independent indicator and risk factor for the incidence of infection, in tandem with screening and the early diagnosis of patients at risk, is an appropriate way to reduce the high incidence of nosocomial infections.[2]

Malnutrition is common in children with congenital heart diseases. This is due to inadequate nutrition, increased need for energy, intestinal malabsorption, and reduced splanchnic blood flow.[3]

Inadequate nutrition is defined as low weight for age, which is associated with the increased rate of mortality in children and the incidence of many infections.[4] Some studies have reported that malnutrition defined as low weight for age or low serum albumin levels is associated with increased mortality and postoperative infections in children with cardiovascular diseases.[5,6]

A few studies have been performed on the relationship between nutrition status and the outcome of surgery, particularly the incidence of nosocomial infections in children with cardiovascular diseases. Therefore, in this study, the relationship between nutrition status and the incidence of nosocomial infections in children <15 years old and cardiovascular diseases was investigated.

METHODS

In this cross-sectional study, the height (cm), weight (kg), and age of 129 children <15 years old with congenital heart diseases undergoing surgery at Rajaie Cardiovascular, Medical, and Research Center in 2015, who developed nosocomial infections during ICU stay, were recorded.

The weight of the children was measured using a Seca (model 334) portable electronic scale (error rate <5 g), and Seca (model 786) mechanical column scale (error rate=0.5 kg). Their height was measured using the Seca (model 217 and model 207) stadiometer (error rate=1 mm) by a trained nurse.

The malnutrition degree in the children was determined by comparing weight for age, height for age, and weight for height of the children with the World Health Organization's standard tables, and the malnutrition level was assessed in 3 groups of mild (-1.1 to -2.0 SD), moderate (-2.1 to -3.0 SD), and severe (<-3 SD).[7]

The biochemical data of these children were checked on the first day of hospitalization—including Hg, Hct, serum albumin, and total protein. Albumin and total protein were measured by calorimetric, hemoglobin was measured by cyanmethemoglobin methods, and hematocrit was assessed based on hemoglobin.

The diagnosis of nosocomial infections was based on the Iranian Guideline to Nosocomial Infection Care System. For the diagnosis of clinical sepsis, the patient should have at least one of the following symptoms not resulted from another known cause: fever (temperature >38°C), hypotension (systolic pressure< 90 mm Hg), or oliguria (<20 cm^3/h) and no blood culture or no organism or antigen found in the blood, or no obvious infection in another location.[8]

Any of the following symptoms represents pneumonia: 1) dullness in the clinical examination, 2) radiography of the patient's chest and cavity or pleural effusion, and 3) maximum age of 1 having at least 2 of the following symptoms: apnea, tachycardia, bradycardia, wheezing, coughing, or rhonchi.[8]

Diagnosis of the urinary tract infection

The patient should have at least one of the following symptoms: temperature >38°C, frequent urination, dysuria, excessive suprapubic pain with local touch, and positive culture with $10^5 \leq$ microorganisms per cm^3 of urine provided, in which no more than 2 organisms are grown.[8]

Diagnosis of surgical site infection

The surface infection of the surgical site should have the following characteristics: infection has occurred within 30 days after the surgery and only affected the skin and subcutaneous tissue, with at least one of the following symptoms: 1) purulent discharge from surface incision, 2) organism aseptically separated from the liquid or tissue of the surface incision, and 3) the presence of at least one of these symptoms: pain, local swelling, redness, or heat, and the wound having been intentionally opened by the doctor.[8]

This study was approved by our institutional review board according to the Helsinki Declaration of the World Medical Association (2000).

Statistical Analysis

The statistical analyses were performed with the SPSS software, version 15, for Windows (SPSS Inc, Chicago, Illinois). The mean, the standard deviation (SD), and frequencies were used for the descriptive analysis. For the evaluation of the distribution of data, the one-sample Kolmogorov–Smirnov test was used. The mean variables between the 2 groups were tested using an independent *t*-test or the Mann–Whitney *U*-test. A multivariate analysis was used to test the variables that could predict postoperative nosocomial infections.

RESULTS

In total, 129 children with congenital heart diseases who underwent open-heart surgery were enrolled. The mean age of all the children was 20.78±38.82 months, ranging from newborn to 15 years old. Girls accounted for 44.2% of all the patients. The distribution of congenital heart diseases in the children is shown in Table 1.

Table 1. Distribution of congenital heart diseases

Congenital Heart Disease	N(%)
Tetralogy of fallot	25(19.37)
Transposition of great arteries	24(18.6)
Ventricular septal defect	46(35.65)
Single ventricle	4(3.1)
Complete A-V canal defects	9(6.97)
Arterial septal defect	20(15.5)
Coarctation of the aorta	4(3.1)
Double-outlet right ventricle	5(3.87)
Pulmonary atresia	5(3.87)
Patent ductus arteriosus	26(20.15)

All the included patients had documented significant postoperative infections—including bacteremia, sepsis, mediastinitis, urinary tract infections, and pneumonia—which were defined as culture-positive endotracheal tube aspirate with chest radiograph changes consistent with pneumonia and significant pleural effusions requiring the insertion of new chest tubes, positive urinary, and blood culture.

Distribution of nosocomial infections

As is shown in Table 2, among all the patients, 4 kinds of nosocomial infections were detected: surgical site infection, the bloodstream infection, the urinary tract infection, and pneumonia. Among all the isolates, pneumonia was the most prevalent pathogen (92, 71.3%).

Table 2. Nosocomial infection distribution

Nosocomial Infections	N (%)
Bloodstream infection	67(51)
Pneumonia	92(71)
Surgical site infection	7(5.4)
Urinary tract infection	4(3.1)

Nutritional status

Based on the z score, the prevalence of moderate and severe malnutrition according to height for age, weight for age, and weight for height was 20.3%, 32.3%, and 31.2, respectively. Nutrition status based on the z score is shown in Table 3.

Table 3. Severity of malnutrition based on the z score

Severity of Malnutrition	N (%)
Malnutrition based on WA	
No	37(31.4)
Mild	23(19.5)
Moderate	20(16.9)
Severe	38(32.2)
Malnutrition based on HA	62(50.4)
No	
Mild	19(15.4)
Moderate	17(13.8)
Severe	25(20.3)
Malnutrition based on WH	
No	38(30.6)
Mild	24(19.4)
Moderate	23(18.5)
Severe	39(31.5)

WA, Weight for age; HA, Height for age; WH, Weight for height

All the patients were divided into 2 groups: with malnutrition and without malnutrition, based on the z score. The patients with moderate and severe malnutrition were considered to be malnourished.

There was a significant relationship between malnutrition severity and pneumonia (*P*=0.006). Pneumonia diagnosis occurred more frequently in the patients with severe and moderate malnutrition according to weight for age, weight for height, and height for age scores (*P*=0.007, *P*=0.036, and *P*=0.01, respectively).

Laboratory findings

The association between some laboratory parameters and malnutrition is presented in Table 4. In a group composed of children with malnutrition, hemoglobin (Hb) and hematocrit (Hct) were significantly less than that in the children without malnutrition (Hb: 13.06±2.70 vs14.74±2.84; *P*= 0.007 and Hct: 39.06±7.96 vs 43.76±8.46; *P*=0.01). The other biochemical parameters had no association with malnutrition (*P*>0.05).

Multivariable analysis

Multivariable modeling is shown in Table 5. After the adjustment of the variables, the multivariable modeling revealed that the only factor associated with malnutrition was hemoglobin (*P*=0.008). No other laboratory factors were associated with malnutrition.

Table 4. Association between laboratory findings and malnutrition

	Without Malnutrition	With Malnutrition	*P* value
Hb (mg/dL)	14.74±2.84	13.06±2.70	0.007
Hct (mg/dL)	43.76±8.46	39.06±7.96	0.01
K	4.32±0.53	4.43±0.52	0.33
Ca	8.90±0.98	8.80±0.85	0.63
P	5.45±1.44	4.83±1.46	0.10
Na	137.27±5.23	135.91±10.61	0.92
Ca ion	1.66±0.41	1.71±0.46	0.62
Mg	1.92±0.37	1.83±0.39	0.26
FBS	93.51±14.43	87.93±21.63	0.08
D3	19.92±9.79	26.81±25.06	0.77
Albumin	34.95±7.76	35.27±7.45	0.75
Total protein	52.50±10.21	55.09±11.37	0.37

Table 5. Multivariable analysis of moderate-to-severe malnutrition

	B	Exp(B)	*P* value	95% CI for Exp(B)
Hb	-0.23	0.79	0.008	0.66-0.94
Ca	-0.30	0.87	0.23	0.42-1.29
FBS	-0.02	0.97	0.06	0.95-1.001
Age	-0.003	0.99	0.71	0.98-1.011
Gender	0.16	1.18	0.73	0.43-3.20
Total protein	0.04	1.04	0.11	0.99-1.09

DISCUSSION

Malnutrition is one of the causes of the immune system deficiency and sensitivity to infections in humans. Severe protein-energy malnutrition in children is defined as a weight for age <70% the ideal value, or presence of edema in the Marasmus and Kwashiorkor conditions.

Severe protein-energy malnutrition in children and infants causes thymus atrophy, reduced numbers of cells, and reduced antibody response to polysaccharide antigens of capsular bacteria such as *Streptococcus pneumonia*.

The epithelial defense system is also disturbed for intestinal mucous structural changes and reduces the IgA secretion.[1,2]

Nutritional deficiency impairs the immune system competence and increases the frequency and severity of infection; in addition, it reduces muscle mass, physical energy, postoperative recovery, and wound healing.[3]

The association between the nutritional status and the immune system has been a research subject for several decades and numerous studies have shown that the protein-calorie malnutrition causes damage to the immune system, including cellular immunity and the secretion of immunoglobulin A. The protein-calorie malnutrition is one of the most important secondary causes of the immune system deficiency in the world.

Several mechanisms have been proposed to explain the relationship between malnutrition and susceptibility to infectious diseases. For example, it causes a disorder in the normal development of the immune system. Stimulating the immune system by infection increases the demand for energy and results in a defective nutritional cycle and increased susceptibility to the infection. This infection by itself leads to a loss of protein, energy, minerals, and vitamin reserves of the body. During the immune response, energy consumption is increased, while food intake is decreased in the body of the infected person.

Metabolic responses to infections include hypermetabolism, negative nitrogen balance, increased gluconeogenesis, and increased fat oxidation; such responses occur by the secretion of hormones, cytokines, and other proinflammatory mediators.[9]

In this study, the prevalence of malnutrition in the children was evaluated according to weight for age, weight for height, and height for age. The results showed that incidence of mild, moderate, and severe malnutrition, according to weight for age was 19.5% (n=23), 16.9% (n=20), and 32.2% (n=38); according to height for age was 15.4% (n=19), 13.8% (n=17), 20.3% (n=25); and according to weight for height was 19.4% (n=24), 18.5% (n=23), and 31.5% (n=39), respectively.

Mehrizi and Drash[10] reported that the prevalence of acute malnutrition and chronic malnutrition in their study was 55% and 52% in children, respectively. In Turkey, the incidence of acute malnutrition and chronic malnutrition was 65% and 42%, respectively, in children with congenital heart diseases.[11] Because children with malnutrition are at risk for infectious diseases, in this work, the relationship between 4 types of infections (urinary tract, blood, surgical site, and pneumonia) was evaluated with malnutrition in children and the results demonstrated that pneumonia generally had a significant association with moderate and severe malnutrition (*P*=0.006). Additionally, there was a significant relationship with pneumonia according to weight for age (*P*=0.007), height for age (*P*=0.01), and weight for height (*P*=0.036).

Anderson et al[12] showed that malnutrition, according to weight for age, in 19% of their patients with single ventricle (age=18–72 mon) was below -2 SD and these children were more susceptible to postoperative infection (*P*=0.006). Moreover, the only predictive factor for a prolonged hospital stay was the development of nosocomial infections in these children.

In another research performed in 2004, the prevalence of surgical site infection in children undergoing cardiac surgery was estimated at approximately 3.4% and the risk factor of such an infection was the duration of surgery in these children.[13]

In the present study, the relationship between some biochemical factors such as hemoglobin, hematocrit, albumin, and total protein was also investigated with the incidence of infection. In the studied biochemical indicators, only hemoglobin (*P*=0.007) and hematocrit (*P*=0.01) were significantly associated with malnutrition in these children.

The relationship between anemia and pneumonia was specified in 1925. In a study conducted in 2014, malnutrition and anemia were introduced as pneumonia risk factors.[14]

The blood hemoglobin level is the most reliable anemia index among all individuals. Anemia is one of the major problems of society, which can affect any individual at any stage of life, but its prevalence is higher among women and children. Anemia is also proposed as one of the risk factors of lower respiratory tract infection among children.[15-16] Iron is an essential nutrient for both humans and microbes. There are many assumptions about increased susceptibility to infectious diseases as the result of iron deficiency and iron deficiency anemia.[15-17]

Cellular and humoral immunity is disturbed by iron deficiency anemia. For example, the phagocytic activity of monocytes is reduced in patients with iron deficiency anemia and bacteria-killing enzymes are not generated sufficiently in the individual with iron deficiency anemia. The generation of interleukin in children with iron deficiency anemia is also disturbed. Iron is required for the proliferation of high-speed tissues such as intestinal epithelial surface, which is among the protective organs against infections.[16]

According to the results of the current research, since pneumonia and anemia are associated with malnutrition in children undergoing cardiac surgery, it is necessary to resolve them before therapeutic processes. Thus, it is recommended that these children be evaluated in terms of nutrition before undergoing therapeutic processes and the possible deficiencies be compensated for using nutritional supplements, proper nutrition techniques, increasing calorie intake, modifying the nutrition pattern, and using suitable nutritional supplements.

Conflict of Interest: There was no conflict of interest.

REFERENCES

1. Cavalcante SS, Mota E, Silva LR, et al. Risk factors for developing nosocomial infections among pediatric patients. Pediatr Infect Dis J. 2006 May;25(5):438-45.

2. Schneider SM, Veyres P, Pivot X, et al .Malnutrition is an independent factor associated with nosocomial infection. Br J Nutr. 2004 Jul;92(1):105-11.

3. Anderson JB, Beekman RH, Border WL, et al. Lower weight –for-age z score adversely affects hospital length of stay after the bidirectional Glenn procedure in 100 infants with a single ventricle. J Thorac Cardiovasc Surg. 2009 Aug;138(2):397-404.e1.

4. Caulfield LE, deOnis M, Blossner M, et al. Undernutrition as an underlying cause of child deaths associated with diarrhea, pneumonia, malaria, and measles. Am J Clin Nutr. 2004 Jul;80(1):193-8.

5. Hussain SQ, Ashraf M, Wani JG, et al. Low hemoglobin level a risk factor for acute lower respiratory tract infections in children. J Clin Diagn Res. 2014 Apr;8(4):PC01-3.

6. Algra SO, Driessen MM, Schadenberg AW, et al. Bedside prediction rule for infections after pediatric cardiac surgery. Intensive Care Med. 2012 Mar;38(3):474-81.

7. WHO Multicentre Growth Reference Study Group. WHO child growth standards based on length/height, weight and age. Acta Paediatr Suppl. 2006 Apr;450:76-85.

8. Brown KH.. Diarrhea and malnutrition. J Nutr. 2003 Jan;133(1):328S-332S.

9. Rodríguez L, Cervantes E and OrtizInt R. Malnutrition and Gastrointestinal and Respiratory Infections in Children: A Public Health Problem. Int J Environ Res Public Health. 2011 Apr;8(4):1174-205.

10. Mehrizi A, Drash A. Growth disturbance in congenital heart disease. J Pediatr. 1962 Sep;61:418-29.

11. Anderson JB, Kalkwarf HF, Kehl JE, et al. Low weight-for-age z-score and infection risk after the Fontan procedure. Ann ThoracSurg. 2011;91:1460-1466.

12. Nateghian A, Taylor G, Robinson J. Risk factors for surgical site infection s following open-heart surgery in a Canadian pediatric population. Am J Infect Control. 2004;32:397-401.

13. Sopena N, Heras E, Gasas I, et al. Risk factors for hospital-acquired pneumonia outside the intensive care unit: A case –control study. American Journal of Infection Control. 2014;42:38-42.

14. Malla T, Pathak OK, Malla KK. Is low hemoglobin level a risk factor for acute lower respiratory tract infections? Journal of Nepal pediatric society. 2010; 30:1-7.

15. Tansarli GS, Karageorgopoulos DE, Kapaskelis A. Iron deficiency and susceptibility to infection: evaluation of the clinical evidence. Eur J Clin Microbial Infect Dis. 2013; 32: 1253-1258.

16. Kumar V, Choudhry VP. Iron deficiency and infection. Indian Journal of peadiatrics. 2010; 77: 789-793.

17. Levy A, Fraser D, Rosen SD, et al. Anemia as a risk factor for infectious disease in infants and toddlers: results from a prospective study. Eur J Epidemiol. 2005; 20(3):277-284.