Original Article

Association of nutritional status and clinical outcomes in pediatric cardiac surgery

Associação do estado nutricional e os desfechos clínicos em cirurgia cardíaca pediátrica

Relación del estado nutricional y los resultados clínicos en cirugía cardíaca pediátrica

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Abstract

Objective: To find the association of the biological personal factor 'nutritional status' of children undergoing cardiac surgery with the following behaviors: mortality/hospital discharge, length of stay in the Intensive Care Unit (ICU) and time in mechanical ventilation (MV).

Methods: Cross-sectional, retrospective study of 786 medical records of children under five years of age who underwent cardiac surgery. Nola J. Pender's model was used for data analysis. The Pearson's Chi-Square test was applied to find the association between the biological personal factor and the mortality/hospital discharge behavior. The Kruskal-Wallis test was used to assess the difference between medians of the biological personal factor and the behaviors of time in MV and ICU length of stay.

Results: The association between personal biological factors (poor nutritional status, acute malnutrition and chronic malnutrition) with mortality behavior was OR 2.18 (1.42 - 3.34), p=0.003, OR 0.75 (0.46 - 1.2), p=0.24 and OR 2.7 (1.77 - 4.12), p<0.0001, respectively. The median time in days of MV use and ICU length of stay in days was, respectively, 3 (p<0.0001) and 8 (p<0.0001) for poor nutritional status, two (p=0.041) and 6.5 (p=0.006) for acute malnutrition, 3 (p<0.0001) and 8 (p<0.0001) for chronic malnutrition.

Conclusion: The personal biological factors with a significant association with mortality behavior were poor nutritional status and acute malnutrition. Children with analyzed nutritional deficits had a higher median time of MV and time of ICU compared with children without nutritional deficits.

Resumo

Objetivo: Verificar a associação do fator pessoal biológico estado nutricional, das crianças submetidas à cirurgia cardíaca, com os seguintes comportamentos: mortalidade/alta hospitalar, tempo de internação na Unidade de Terapia Intensiva (UTI) e tempo de ventilação mecânica (VM).

Métodos: Estudo transversal, retrospectivo realizado com 786 prontuários de crianças menores de cinco anos, submetidas à cirurgia cardíaca. O modelo de Nola J. Pender foi usado para analisar os dados. Aplicou-se o teste Qui-Quadrado de Pearson para verificar associação entre o fator pessoal biológico e o comportamento mortalidade/alta hospitalar. O teste Kruskal-Wallis foi utilizado para verificar a diferença entre medianas do fator pessoal biológico e os comportamentos tempo de VM e de UTI.

Resultados: A associação entre os fatores pessoais biológicos (pobre estado nutricional, desnutrição aguda e desnutrição crônica) com o comportamento mortalidade foi de OR 2,18 (1,42 – 3,34), p=0,003, OR 0,75 (0,46 – 1,2), p=0,24 e OR 2,7 (1,77 – 4,12), p<0,0001, respectivamente. A mediana de tempo em dias de uso de VM e tempo em dias de UTI foi, respectivamente de 3 (p<0,0001) e 8 (p<0,0001) para o pobre estado nutricional, 2 (p=0,041) e 6,5 (p=0,006) para a desnutrição aguda, 3 (p<0,0001) e 8 (p<0,0001) para a desnutrição crônica.

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Conclusão: Os fatores pessoais biológicos que tiveram associação significativa com o comportamento mortalidade foram o pobre estado nutricional e desnutrição aguda. Foi verificado que as crianças com déficits nutricionais analisados tiveram uma superior mediana de tempo de VM e tempo de UTI quando comparadas com as crianças sem déficits nutricionais.

Resumen

Objetivo: Verificar la relación del factor personal biológico estado nutricional de niños sometidos a cirugía cardíaca, con los siguientes comportamientos: mortalidad/alta hospitalaria, tiempo de internación en Unidad de Cuidados Intensivos (UCI) y tiempo de ventilación mecánica (VM).

Métodos: Estudio transversal, retrospectivo realizado con 786 historias clínicas de niños menores de cinco años sometidos a cirugía cardíaca. Para analizar los datos se utilizó el modelo de Nola J. Pender. Se aplicó la prueba χ^2 de Pearson para verificar la relación entre el factor personal biológico y el comportamiento mortalidad/alta hospitalaria. La prueba de Kruskal-Wallis fue utilizada para verificar la diferencia entre medianas del factor personal biológico y los comportamientos tiempo de VM y de UCI.

Resultados: La relación entre los factores personales biológicos (mal estado nutricional, desnutrición aguda y desnutrición crónica) y el comportamiento mortalidad fue de OR 2,18 (1,42 – 3,34), p=0,003, OR 0,75 (0,46 – 1,2), p=0,24 y OR 2,7 (1,77 – 4,12), p<0,0001, respectivamente. La mediana del tiempo en días de uso de VM y tiempo en días de UCI fue de 3 (p<0,0001) y 8 (p<0,0001) respectivamente para el mal estado nutricional, 2 (p=0,041) y 6,5 (p=0,006) para la desnutrición aguda, 3 (p<0,0001) y 8 (p<0,0001) para la desnutrición crónica.

Conclusión: Los factores personales biológicos que tuvieron relación significativa con el comportamiento mortalidad fueron el mal estado nutricional y la desnutrición aguda. Se verificó que los niños con deficiencias nutricionales estudiados tuvieron una mediana mayor de tiempo de VM y tiempo de UCI en comparación con niños sin deficiencias nutricionales.

Introduction

Nutritional status is often described in terms of anthropometric indices comparing weight and height with population standards, and is also the basis for the early identification of nutritional deficiencies, such as malnutrition.[1] In the context of children with congenital heart diseases, malnutrition is a constant phenomenon. The main factor responsible is the inadequate biological use of available nutrients because of the increase in energy expenditure resulting from clinical conditions inherent to cardiac changes.[2,3]

In a study of children with heart disease conducted in Southampton, United Kingdom, 28.2% of the sample were underweight for their age.[4] Corroborating this evidence, a study conducted in northeastern Brazil, found that 25% of children with heart disease had a low age-related height and weight, thereby indicating some degree of malnutrition.[5]

In addition to the nutritional changes inherent to congenital heart disease, about 80% of these children require surgical intervention, whether corrective or palliative, for greater chances of survival and to make cardiac function closer to normal.[6]

Hence the need for health-promoting actions related to the nutritional assessment of children with heart disease, even in the preoperative period. This nutritional assessment can establish and even prevent situations of postoperative risk, because the inadequate nutritional status in the period preceding surgery is often exacerbated in the postoperative period. The metabolic response in the postoperative period is manifested by altered energy demands, a complex inflammatory state and increased protein catabolism.[7,8]

Since the nutritional status is a relevant biological factor in the post-surgical prognosis of these children, it is convenient to adopt a theoretical model that identifies and specifies the factors influencing the health behaviors of children undergoing cardiac surgery. Thus, the health promotion nursing model developed by Nola J. Pender can help to understand how these factors influence such behaviors and how they increase the susceptibility to diseases.[9,10]

Pender et al. argued there are three determinants of healthy behavior, namely: individual characteristics and experiences, specific behavioral cognitions and affects, and situational/interpersonal influences. Individual characteristics and experiences include past behaviors and personal factors (biological, psychological, sociocultural).[9]

In this model, the nutritional status is classified as a variable of the biological personal factor, in which the relevant characteristics of each individual can predict or explain a certain behavior.[9] Health promotion behaviors in the postoperative period of children undergoing cardiac surgery rep-

resent the shortest period of use of hard technologies such as mechanical ventilatory support, short hospital stay and, consequently, the return to home, thereby decreasing the deleterious effects caused by hospitalization.

The aim of this study was to find the association of the biological personal factor 'nutritional status' of children undergoing cardiac surgery with the following behaviors: mortality/hospital discharge, length of stay in the Intensive Care Unit (ICU) and time in mechanical ventilation (MV).

Methods

This is a cross-sectional, retrospective study. It was developed in a state tertiary hospital that is a reference in the treatment of congenital heart diseases in the northeast of Brazil.

Inclusion criteria were the following: medical records of patients with congenital heart disease younger than five years old, who underwent cardiovascular surgery (corrective or palliative) in the period between January 2014 and December 2016. This age group was selected because it is the top age for the performance of Z score calculations by the selected software. The exclusion criteria were pediatric patients transferred to another service before hospital discharge and incomplete data in medical records without possibility of knowing the final outcome.

During the evaluated period, 802 palliative and corrective surgeries were performed in children aged five years or less. Of these, 16 medical records of children were excluded because their data were incomplete, thus totaling a sample of 786 medical records of children who met the proposed inclusion criteria.

Data collection was performed from September 2017 to April 2018 through search in the medical records of subjects targeted by the study, according to the inclusion and exclusion criteria.

Nola J. Pender's Health Promotion Model was used as a theoretical framework for data analysis in this study. This model enables the assessment of the behavior conducive to health promotion by studying the interrelationship of three main points: 1. individual characteristics and experiences, 2. feelings and knowledge about the behavior that one wants to achieve, and 3. desirable health promotion behavior. In this study, the analysis of the interrelation was only between individual characteristics (personal biological factors) and health behavior.[9]

In the studied hospital context, the preoperative nutritional status was assessed as a relevant individual characteristic with the belief that desirable health behaviors are directly related to factors that contribute to positive results focused on health after the performance of cardiac surgery. Thus, health behavior was considered as the shortest period of use of mechanical ventilator, the shortest length of stay in the ICU, with consequent early hospital discharge for minimization of the harmful effects of hospitalization and possible complications, seeking to achieve an acceptable personal balance.

We chose to evaluate the following: age, sex, weight and height of children undergoing cardiac surgery, recorded in the preoperative period, representing Pender's personal biological factors and clinical outcomes, the representation of Pender's behaviors recorded in the postoperative period (type of cardiac surgery classified by complexity and defined by the risk score adjusted for surgery in congenital heart diseases - in English, Risk Adjustment for Congenital Heart Surgery 1/RACHS-1), hospital discharge/death, length of stay in the ICU and MV time.[11] These data were compiled in a Microsoft Excel for Mac®2011 spreadsheet.

The biological personal factors were used to obtain anthropometric measurements by calculating the Z scores with support of the Anthro 2007 software provided by the WHO. Z scores related to the following indices were calculated: weight/age, weight/length, length/age.

Values resulting from the calculation of Z scores were used to classify the nutritional status of children undergoing cardiac surgery. In all cases, a Z score of less than -2 and the type of malnutrition were considered as the cutoff point for malnutrition, classified as: poor nutritional status (weight/

age index less than -2), acute malnutrition (weight/height index less than -2) and chronic malnutrition (height/age index less than -2).[12] Note that the same child can present the three types of malnutrition analyzed in this study.

The following behaviors were analyzed (outcomes): mortality/hospital discharge after cardiac surgery during hospitalization, length of stay in the ICU and time in mechanical ventilation. Risk factors included Z score of weight/age, weight/height, height/age <-2, that is, poor nutritional status, acute malnutrition and chronic malnutrition, respectively. The additional risk factor was defined by the RACHS-1 score, a marker of complexity in pediatric cardiac surgery, greater than or equal to 4.[11] Note that 24 patients who underwent cardiac surgery could not be categorized by the RACHS-1 score because they did not belong to any group of surgeries associated with the score used.

The health promotion behaviors, that is, positive health results, were considered according to the model proposed by Pender: hospital discharge, short period of use of mechanical ventilatory support and short length of ICU stay.

Statistical analysis was performed using the SPSS© software. The continuous variables of the study were assessed for normality using the Komolgorov - Smirnov test. The Pearson's Chi-Square test was applied to verify the association between poor nutritional status, acute malnutrition, chronic malnutrition and the additional risk factor with the mortality outcome. The strength of the association between the variables was assessed using the OR (Odds Ratio) with the respective Confidence Interval (CI). The nutritional deficits mentioned in relation to the outcomes, ICU length of stay and MV time, were analyzed based on the difference between medians by using the Kruskal-Wallis test. A significance level of p <0.05 and a 95% confidence interval (CI) were considered.

The ethical requirements established in Resolution 466/2012 of the National Health Council were followed, and the research was approved by the Research Ethics Committee of the institution where the study was conducted under opinion number 406,229.

Results

Of the evaluated patients, 399 (50.8%) were female. The mean age at the time of surgery was 12.47 months (SD ± 14.85). Regarding weight and height at the time of surgery, the average was 7.22 kg (SD ± 4.48), 67.94 cm (SD ± 18.14), respectively. The means of the Z scores for the weight/age indices were -1.866 (SD ± 3.15), weight/height of -1.066 (SD ± 4.32) and height/age of - 1.600 (SD ± 3.3). In total, 48.68% of children had poor nutritional status (weight/age Z score <–2), 31.9% had acute malnutrition (weight/height Z score <–2) and 41.47% had chronic malnutrition (height/age Z score <–2). Using the RACHS-1 score, the total number of patients with the lowest additional risk factor, that is, 1-3 scores was 637 (81%), being the most prevalent population and 125 (15.9%) were classified as greater additional risk factor (scores 4-6). Regarding the mortality outcome, 681 (86.6%) were discharged from hospital and 105 (13.3%) patients died. Of the nutritional deficits studied (biological personal factor), poor nutritional status and chronic malnutrition were significantly associated with the outcome of death, and increased children's chance of death by 2.18 and 2.7 times when undergoing cardiac surgery, respectively (Table 1).

Table 1. Analysis of the biological personal factor 'nutritional status' with mortality behavior

Biological personal factor	Behavior		*p-value*	OR (95%CI)
	Discharge n(%)	Death n(%)		
Poor nutritional status			0.003	2.18
Yes	304 (44.64)	67 (63.8)		(1.42– 3.34)
No	377 (55.36)	38 (36.2)		
Acute malnutrition			0.24	0.75
Yes	207 (30.4)	26 (24.76)		(0.46 – 1.2)
No	474 (69.6)	79 (75.24)		
Chronic malnutrition			<0.0001	2.7
Yes	249(36.57)	64(60.95)		(1.77 – 4.12)
No	432(63.43)	41(39.05)		

* Pearson's Chi-square test

When analyzing children with poor nutritional status classified with the additional risk factor RACHS score ≥ 4, an association with the outcome of death was found, which leads to a 6.07 times higher chance of children's death when undergoing

cardiac surgery. The same occurred in the analysis of children with chronic malnutrition assessed with RACHS ≥ 4 and the lowest percentage, who had a 3.82 times higher chance of death (Table 2). Note that in table 2, out of the total of 371 children classified as poor nutritional status, 19 children could not be assessed, because they did not fit into any RACHS category. The same occurred for chronic malnutrition, where out of a total of 313 children classified as this type of malnutrition, 16 children did not fit into any RACHS category.

Table 2. Analysis of the additional risk factor with mortality behavior only for children with poor nutritional status (n=352) and chronic malnutrition (n=297)

Poor nutritional status				
Rachs-1	Death n(%)	Discharge n(%)	*p-value*	OR (95%CI)
(1-3)	31 (50.81)	251 (86.25)	<0.0001	6.07
(4-6)	30 (49.19)	40 (13.75)		(3.32 – 11.09)
Chronic malnutrition				
Rachs-1	Death n(%)	Discharge n(%)	*p-value*	OR (95%CI)
(1-3)	42(62.68)	199 (86.52)	<0.0001	3.82
(4-6)	25(37.32)	31(13.48)		(2.04 – 7.12)

* Pearson's Chi-squared test

The median obtained for the ICU stay and time in ventilation was 6 days (95% CI 3-13) and 1 day (95% CI 0-7), respectively. Children with poor nutritional status, acute malnutrition and chronic malnutrition were more likely to need more days in invasive respiratory support, and consequently more days in the ICU compared to children without nutritional deficits (Table 3).

There was a significant difference in the distribution of MV time and ICU length of stay between groups with poor nutritional status, acute malnutrition and chronic malnutrition (p <0.05).

Discussion

The limitations of the results of this study were related to the age restriction of the sample, since this decreases the generalization of results. There was also a sample loss due to insufficient or inadequate record of data in medical records. Finally, as classification systems were originally developed for global populations, they were less applicable to hospitalized children with heart disease whose nutritional disorder may not fit into the classic categories.

According to Nola J. Pender, personal biological factors are part of individual characteristics that directly or indirectly influence the health promotion behavior. For a better understanding of health promotion behaviors, Pender suggests examining a limited number of these factors at the same time.[9] In the present study, we chose to examine the influence of the nutritional status of children undergoing heart surgery on the health behaviors selected, namely mortality/postoperative hospital discharge, length of stay in the ICU and time in MV.

In the health promotion model, one of the main determinants of healthy behavior is good nutritional status, which means balance between the individual's intake and his/her need for nutrients.[9]

However, in the present study, higher rates of nutritional deficiencies were found in children undergoing cardiac surgery, when compared with other scientific findings from developed countries. This finding may be related to the peculiar characteristics of the biotype of children in northeastern Brazil, a region where nutritional deficiencies predominate, the population has different physical characteristics, height and weight are relatively smaller than values obtained in children from other localities in the country, such as the south and southeast, and,

Table 3. Analysis of the biological personal factor 'nutritional status' of children undergoing cardiac surgery with the behaviors of ICU time and MV time

Behavior	Biological personal factor								
	Poor nutritional status			Acute malnutrition			Chronic malnutrition		
	Yes	No	*p-value***	Yes	No	*p-value***	Yes	No	*p-value***
ICU time (days)	8 † (3.5- 17) §	4 † (2-10) §	0.000	6.5 † (3-14) §	5 † (3-12) §	0.006	8† (3-18) §	5 † (3-11) §	0.000
MV time (days)	3 † (1-10) §	1 † (0-5) §	0.000	2† (1-7) §	1† (0-7) §	0.041	3 † (1-11) §	1† (0-5) §	0.000

† median; § Interquartile range; ** Kruskal-Wallis test

especially, when comparing with children born in developed countries.[5]

A study conducted in Seattle, United States, identified that only 31% of the sample were underweight, that is, with poor nutritional status, 32% had height deficit (chronic malnutrition) and 15% had weight loss (acute malnutrition).[13] Another study conducted in London, United Kingdom, showed that 39.1% of the sample had poor nutritional status.[14]

Although several factors contribute to these frequent nutritional disorders in children with heart disease, modifiable factors are noteworthy, such as the quality of nutrients offered, the clinical treatment performed and the waiting period for the surgical intervention.[15] Thus, health professionals must intervene in such factors that can be changed, aiming at an adequate nutritional support that offers better conditions for children facing surgical stress.

The higher chances of risky behavior, such as postoperative mortality among those with risk factors, poor nutritional status and chronic malnutrition was consistent with other studies that showed a correlation between these nutritional deficits and higher death rates in the postoperative period of children undergoing cardiac surgery.[13,16-21,24] Thus, when scheduling a surgical intervention, the nutritional status of children should be considered relevant, nutritional guidance and surveillance should be intensified in the preoperative period, and surgical risks clarified to parents.

The impact of acute malnutrition and poor nutritional status in children with congenital heart disease is still not well established in the literature when compared to the effects of chronic malnutrition. It is difficult to interpret if a child is short with an adequate weight or is tall with an inadequate weight in a population where edema, a common symptom in this pathology, may confuse the weight variable. Unlike chronic malnutrition, where the inadequate linear growth is directly related to energy deficits that cause a significant pathophysiological impact during post-surgical recovery.[13]

The association of mortality behavior increased even more when added to the complexity of the surgical procedure performed, RACHS risk factor ≥ 4. Similarly, in a study conducted in southern India, in addition to the preoperative nutritional deficit, the elevated RACHS had a significant influence on postoperative mortality.[22] In Brazil, a study conducted in the state of Ceará showed that postoperative mortality increased by approximately 135% with each increase in the RACHS category without making any association with nutritional status.[23] Diverging from the findings in this study, in a study conducted in Southampton, United Kingdom, was not found a higher association of mortality when associated with the RACHS score.[4]

All personal biological factors analyzed (poor nutritional status, acute malnutrition and chronic malnutrition) of children undergoing cardiac surgery also contributed to the following behaviors: long time in mechanical ventilation and, consequently, longer length of stay in the intensive care unit. Scientific evidence corroborates the same finding in Intensive Care Units in Seattle, San Francisco and Houston, United States.[14,24]

These findings are justified by the exacerbation of nutritional deficit in the postoperative period, either for the correction or palliation of congenital heart disease, as the child with any type of nutritional deficit has few nutritional substrates available to respond to the greater catabolic effects of injuries resulting from surgery.[25]

The use of Nola J. Pender's Health Promotion Model allows nurses' assessment of factors and behaviors that help determine interventions, such as the monitoring of nutritional status and educational activities according to the real needs of the clientele.[9] This will contribute to the early identification of biological personal factors that favor the planning of hospital discharge and implementation of educational interventions in the pre- and postoperative period of this clientele in order to maximize the positive health results in these children, thereby contributing to what Pender calls great health. In addition, the author argues that by knowing the factors that pose as a risk, individuals can change themselves and assume a lifestyle that promotes health.[9]

In view of the challenges faced by congenital heart disease and the complexity of its treatment,

health promotion must be done through comprehensive nursing care, where nurses show the completeness of their interventions and multidisciplinary coordination for promoting specialized and individualized care. In the context of children with heart disease undergoing surgery and hospitalization, biological, socio-cultural and psychological factors must be considered for promoting healthy nutrition and achieving the expected health-promoting behavior in this population.

Conclusion

The biological personal factors significantly associated with the mortality behavior in children with congenital heart disease undergoing cardiac surgery were poor nutritional status and acute malnutrition. In addition, all nutritional deficits analyzed had a higher median time in MV and a longer length of stay in the ICU in the postoperative period, compared to children without nutritional deficits.

Collaborations

Souza NMG, Andrade GV, Bastos LF, Dantas AVVC, Cavalcante CTMB, Barbosa LP, Guedes NG and Silva VM collaborated with the study design, analysis and interpretation of data, relevant critical review of the intellectual content and approval of the final version to be published.

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