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Original article

The effectiveness of STRONGkids nutritional screening tool and C-reactive protein in identifying hospital-acquired malnutrition in children

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Abstract

Introduction: Hospital-acquired malnutrition remains high in children and is associated with poor prognoses, such as longer hospital stays and higher mortality. This study investigated the effectiveness of the Screening Tool for Risk on Nutritional status and Growth (STRONGkids) and C-reactive protein (CRP) in predicting hospital-acquired malnutrition in children.

Methods: This observational cohort study was performed in a single tertiary referral hospital between January and October 2020. Children who met the study criteria were recruited on admission and followed until hospital discharge. Their STRONGkids score and blood CRP levels were measured within 24 hours of admission. On discharge, hospital-acquired malnutrition was determined based on a weight loss of 2-5% over 1 week, 5-10% over 1 month, or > 10% over more than 1 month. The associations of STRONGkids scores and blood CRP levels with hospital-acquired malnutrition were assessed using the Chi-square test, considering a significance of $p < 0.05$.

Results: This study included 109 children, of which 55 (50.5%) were male and 54 (49.5%) were female, with a mean age of 6.1 years. Fifty-one of the 109 children (46.8%) were classified as having hospital-acquired malnutrition. The incidences of hospital-acquired malnutrition in subjects with high-, moderate-, and low-risk STRONGkids scores were 67.6%, 64.7%, and 29.3%, respectively. Subjects with high- and moderate-risk STRONGkids scores were twice as likely to have hospital-acquired malnutrition than subjects with low-risk STRONGkids scores (relative risk [RR] = 2.1; 95% confidence interval [CI]: 1.3-3.6, $p < 0.001$, and RR = 2.0, 95% CI = 1.0-3.8, $p = 0.008$, respectively). In addition,

the incidences of hospital-acquired malnutrition in children with high and low CRP levels were 68.3% and 33.8%, respectively. This study shows that children with high CRP levels are approximately twice as likely to have hospital-acquired malnutrition than children with low CRP levels (RR = 2.0, 95% CI: 1.3-2.9, $p < 0.001$). This study's multivariate analysis showed that CRP levels were better predictors of hospital-acquired malnutrition than STRONGkids scores.

Conclusion: The STRONGkids nutritional risk screening tool and blood CRP levels were effective in identifying children at risk of hospital-acquired malnutrition. We recommend that STRONGkids scores and blood CRP levels are routinely measured on admission. CRP levels were better at predicting hospital-acquired malnutrition in children than the STRONGkids nutritional risk screening tool.

Keywords

Malnutrition, screening, STRONGkids.

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Introduction

Hospital-acquired malnutrition in children remains high and has become a serious problem for pediatric hospitalists. It is associated with poor prognoses, including longer hospital stays, higher hospital expenses, greater need for additional nutrition support, higher infection risk, and higher mortality [1, 2]. Many nutritional screening tools for identifying those at risk of hospital-acquired malnutrition have been created and published [3-6]. They have been implemented in many countries [7-13], including in our hospital [14].

The Screening Tool for Risk on Nutritional status and Growth (STRONGkids) is one nutritional screening tool widely used to assess hospital-acquired malnutrition risk in children in many countries [15, 16]. A study in Brazil reported that the STRONGkids tool had greater sensitivity in predicting hospital-acquired malnutrition than the anthropometric measurement. However, it has low sensitivity and a high false positive rate when analyzing weight loss during hospitalization [15, 16]. Another study found that the STRONGkids tool showed good clinical performance in assessing malnutrition risk in hospitalized children [17]. Our hospital has used the STRONGkids tool for several years [14] since it is practical and easily used by nurses or dieticians.

The STRONGkids tool was created by Hulst et al. in 2010 and assessed 4 areas: (1) subjective global assessment, (2) high-risk disease, (3) nutritional intake and losses, and (4) weight loss or poor weight increase. Each item has a score of 1-2 points, with a maximum total score of 5 [4]. Patients are classified as having a high, moderate, and low malnutrition risk based on total scores of 4-5, 1-3, and 0 points, respectively.

All pediatric patients commonly have disease-related inflammatory processes. The inflammatory process, characterized by increased C-reactive protein (CRP) levels, is associated with poor prognoses [18]. High CRP levels are associated with high malnutrition risk and a poor prognosis for the underlying disease [19].

Therefore, we investigated the usefulness of the STRONGkids tool and CRP levels in predicting malnutrition risk during hospitalization in pediatric patients.

Patients and methods

This observational cohort study was conducted in a single tertiary referral hospital between January and October 2020. It included all children with non-surgical diseases admitted to the Paediatric Ward who met the inclusion criteria: (1) aged between 1 month and 18 years, (2) admitted to the hospital for ≥ 2 days, and (3) whose parents agreed to their participation in this study and signed in the informed consent form. The exclusion criteria were: (1) suffering from severe edema or severe dehydration, (2) admission to the Intensive Care Unit, and (3) death before hospital discharge. This study was approved by the Ethics Committee of Udayana University – Sanglah General Hospital (Bali, Indonesia; approval number: 1842/UN14.2.2.VII.14/LT/2020).

Within 24 hours of hospital admission, the STRONGkids score, blood CRP levels, and body weight of all children that met all inclusion criteria and no exclusion criteria were measured. Then, they were followed until hospital discharge. On their final day in

the hospital, their body weight was remeasured and compared to their body weight at admission. Hospital-acquired malnutrition was defined as a decrease in body weight during hospitalization of 2-5% over 1 week, 5-10% over 1 month, or > 10% over > 1 month [20]. Blood CRP levels were determined using a particle-enhanced immunoturbidimetric assay. In this assay, human CRP agglutinates with latex particles coated with monoclonal anti-CRP antibodies, and the precipitate is determined turbidimetrically. Blood CRP levels were classified as high or low based on CRP concentrations of ≥ 10 mg/L and < 10 mg/L, respectively. Nutritional status was determined by comparing their body mass index-for-age (BMIFA) z-score to the World Health Organization growth chart. Children were classified as malnourished if their BMIFA z-score was < -2 standard deviations (SDs) and obese if the BMIFA z-score was > +3 SDs in children aged < 5 years or > +2 SDs in children aged ≥ 5 years [21].

The STRONGkids nutritional risk screening tool used in this study was based on that of Hulst et al. [4]. It comprised 4 questionnaire items, each with a score of 1-2 points. The first item was subjective clinical assessment (1 point). The second item was high-risk disease (2 points). The third item was nutritional intake and losses (1 point). The fourth item was weight loss or poor weight gain (1 point). Trained nurses performed the STRONGkids assessment on all children within the first 24 hours of hospital admission. **Tab. 1** shows the STRONGkids nutritional risk screening tool.

The minimal sample size was 86 subjects to detect 20% differences between groups with an alpha of 0.05 and a power of 80%. Categorical data were presented as absolute values and percentages, and numerical values as means and standard errors. At the end of the study, the children were divided into hospital-acquired malnutrition and non-hospital-acquired malnutrition groups. A Chi-square test was used to assess differences in categorical variables between groups. An independent t-test was used to assess differences in numerical variables between groups. A $p < 0.05$ was considered statistically significant. Relative risks (RRs) and 95% confidence intervals (CIs) were also calculated. A logistic regression multivariable model was used to compare variables between groups. Data analyses were performed with the SPSS® software (version 20.0).

Results

During the study period, 109 children met all inclusion criteria and no exclusion criteria, of which 55 (50.5%) were male and 54 (49.5%) were female, with a mean age of 6.1 years. Hospital-acquired malnutrition was present in 51 (46.8%) children. Based on the STRONGkids score, 34 (31.2%) children were classified as at high risk, 17 (15.6%) as at moderate risk, and 58 (53.2%) as at low risk of malnutrition. In addition, 41 (37.6%) children had high CRP levels, and 68 (62.4%) children had low CRP levels. **Tab. 2** shows the basic characteristics of the children. **Tab. 3** presents the associations between hospital-acquired malnutrition and gender, age, nutritional status at admission, underlying diseases, and hospital stay length. No variable showed a statistically significant association ($p > 0.05$). **Tab. 4** presents the associations between hospital-acquired malnutrition and STRONGkids and blood CRP levels; both were statistically significant ($p < 0.05$). **Tab. 5** presents a multivariate analysis of the

Table 1. Screening Tool for Risk on Nutritional status and Growth (STRONGkids) [4].

Item	Points	
	Yes	No
Subjective clinical assessment: **Is the patient in a poor nutritional status judged by subjective clinical assessment (diminished subcutaneous fat and/or muscle mass and/or hollow face)?**	1	0
High-risk disease: **Is there are underlying illness with a risk of malnutrition or expected major surgery (list below [a])?**	2	0
Nutritional intake and losses: **Are one of the following items present? Excessive diarrhea (> 5 per day) and/or vomiting (> 3 times/day) during the last few days? Reduced food intake during the last few days before admission (not including fasting for an elective procedure or surgery)? Pre-existing dietetically advised nutritional intervention? Inability to consume adequate intake because of pain?**	1	0
Weight loss or poor weight gain: **Is there weight loss or no weight gain (infants < 1 year) during the last few weeks/months?**	1	0

[a] List of the high-risk diseases: anorexia nervosa, burns, bronchopulmonary dysplasia (maximum age 2 years), celiac disease, cystic fibrosis, dysmaturity/prematurity (corrected age 6 months), cardiac disease, chronic infectious disease (AIDS), inflammatory bowel disease, cancer, liver disease, chronic kidney disease, chronic pancreatitis, short bowel syndrome, muscle disease, metabolic disease, trauma, mental handicap/retardation, expected major surgery, not specified (classified by doctor).
Classification risk score: high risk, 4-5; moderate risk, 1-3; and low risk, 0.

Table 2. General characteristics of subjects.

Characteristic		Number	Percentage
Gender	Male	55	50.5
	Female	54	49.5
Age (year), mean ± SE		6.1 ± 0.5	
Nutritional status at admission	Malnourished	23	21.1
	Well-nourished	76	69.7
	Obese	10	9.2
Diagnosis	Acute infection	47	43.1
	Chronic infection	12	11.0
	Chronic non-infection	50	45.9
Body weight on discharge	Decreased	58	53.2
	Not changed	47	43.1
	Increased	4	3.7
Hospital-acquired malnutrition	Yes	51	46.8
	No	58	53.2
STRONGkids classification risk	High risk	34	31.2
	Moderate risk	17	15.6
	Low risk	58	53.2
CRP levels	High (≥ 10 mg/L)	41	37.6
	Low (< 10 mg/L)	68	62.4

CRP: C-reactive protein; SE: standard error; STRONGkids: Screening Tool for Risk on Nutritional status and Growth.

Table 3. Association between hospital-acquired malnutrition and some variables.

Variable		Hospital-acquired malnutrition		p
		Yes	No	
Gender	Male, n (%)	25 (45.5)	30 (54.5)	0.778 [a]
	Female, n (%)	26 (48.1)	28 (51.9)	
Age (year), mean ± SE		5.2 ± 0.7	6.7 ± 0.7	0.162 [b]
Length of hospital stay, mean ± SE		8.2 ± 0.9	7.1 ± 0.6	0.377 [b]
Nutritional status at admission	Malnourished, n (%)	12 (52.2)	11 (47.8)	0.494 [a]
	Well-nourished, n (%)	36 (47.4)	40 (52.6)	
	Obese, n (%)	3 (30.0)	7 (70.0)	
Diagnosis	Acute infection, n (%)	25 (53.2)	22 (46.8)	0.417 [a]
	Chronic infection, n (%)	6 (50.0)	6 (50.0)	
	Chronic non-infection, n (%)	20 (40.0)	30 (60.0)	

[a] Chi-square test; [b] independent t-test.
SE: standard error.

Table 4. Bivariate analysis between hospital-acquired malnutrition, the Screening Tool for Risk on Nutritional status and Growth (STRONGkids) and C-reactive protein (CRP) levels.

Variable		Hospital-acquired malnutrition		RR (95% CI)	p [a]
		Yes	No		
STRONGkids classification risk	High risk, n (%)	23 (67.6)	11 (32.4)	2.1 (1.3-3.6)	**< 0.001**
	Moderate risk, n (%)	11 (64.7)	6 (35.3)	2.0 (1.0-3.8)	**0.008**
	Low risk, n (%)	17 (29.3)	41 (70.7)	1	-
CRP levels	High (≥ 10 mg/L), n (%)	28 (68.3)	13 (31.7)	2.0 (1.3-2.9)	**< 0.001**
	Low (< 10 mg/L), n (%)	23 (33.8)	45 (66.2)	1	-

[a] Chi-square test.
CRP: C-reactive protein; RR: relative risk (to compare the risk of hospital-acquired malnutrition in one group with another group); STRONGkids: Screening Tool for Risk on Nutritional status and Growth.

Table 5. Multivariate analysis of variables.

Variable	aOR	95% CI	p [a]
High CRP levels	3.8	1.1-13.5	**0.033**
High-risk STRONGkids scores	2.0	1.0-4.0	**0.040**
Male gender	0.8	0.3-2.2	0.784
Aged	1.1	1.0-1.2	**0.032**
Length of hospital stay	1.0	0.9-1.1	0.726
Nutritional status at admission	1.2	0.8-1.9	0.234
Diagnosis	1.6	0.9-2.7	0.054

[a] Logistic regression test.
aOR: adjusted odds ratio; CI: confidence interval; CRP: C-reactive protein; STRONGkids: Screening Tool for Risk on Nutritional status and Growth.

variables, simultaneously considering all variables in **Tab. 3** and **Tab. 4**. Hospital-acquired malnutrition was significantly associated with high CRP levels, high-risk STRONGkids scores, and age ($p < 0.05$).

Discussion

This study found that hospital-acquired malnutrition was present in 51 of 109 hospitalized children (46.8%), higher than the reported incidences of 24% and 17% in 2010 and 2012, respectively [20, 22]. Therefore, hospital-acquired malnutrition incidence has almost doubled at our hospital within the past 10 years. Several factors possibly influence the complexity of the underlying diseases and the severity of the inflammatory process related to them in our study subjects. Approximately 56.9% of our subjects suffered from chronic diseases, such as human immunodeficiency virus (HIV) infection, tuberculosis, congenital heart disease, malignancy, cerebral palsy, and epilepsy. Chronic diseases are related to the severe inflammatory process and poor prognosis, including an increased risk of hospital-acquired malnutrition [23].

According to the STRONGkids nutritional screening tool classification, 31.2% of children were at high malnutrition risk, 15.6% at moderate risk, and 53.2% at low risk. Our previous study found that 12.4% were at high risk and 87.6% were at moderate risk; no low-risk classification was considered [14]. In this study, most children were at lower malnutrition risk, potentially reflecting that most of our subjects were well-nourished and had a low inflammation status, as indicated by their low CRP levels. The incidences of hospital-acquired malnutrition in subjects with high-, moderate-, and low-risk STRONGkids scores were 67.6%, 64.7%, and 29.3%, respectively. Subjects with high- and moderate-risk scores were twice as likely to have hospital-acquired malnutrition than low-risk subjects. Other studies reported that the STRONGkids nutritional screening tool showed good clinical performance in predicting hospital-acquired malnutrition in children [14-17].

Inflammation is characterized by high CRP levels and is associated with a high risk of hospital-acquired malnutrition [24]. Disease-related malnutrition mechanisms are poor food intake, food malabsorption, and increased energy requirement, which cause weight loss during hospitalization. This study shows that children with high CRP levels are approximately 4 times more likely to have hospital-acquired malnutrition than children with low CRP levels. The incidences of hospital-acquired malnutrition in children with high and low CRP levels were 68.3% and 33.8%, respectively. A previous study reported that children with high CRP levels in hospitals had a high malnutrition risk and poor prognosis for their underlying diseases [18, 19]. This study's multivariate analysis showed that CRP levels were better predictors of hospital-acquired malnutrition than STRONGkids scores. Therefore, we recommend routinely measuring CRP levels in hospitalized children at initial admission. In addition, age was associated with hospital-acquired malnutrition risk, especially in younger children.

Future studies on predicting hospital-acquired malnutrition need to evaluate combining inflammatory markers such as CRP with nutritional risk screening tools such as STRONGkids.

Conclusions

The STRONGkids nutritional risk screening tool and blood CRP levels effectively predicted hospital-acquired malnutrition risk in children. We recommend routinely measuring the STRONGkids score and blood CRP levels at initial admission. CRP levels were better at predicting hospital-acquired malnutrition in children than the STRONGkids nutritional risk screening tool.

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Ethics approval

The current study was approved by the Ethics Committee of Udayana University – Sanglah General Hospital (Bali, Indonesia) with approval number: 1842/UN14.2.2.VII.14/LT/2020.

Declaration of interest

The Authors declare that there is no conflict of interest.

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