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Evaluation of the relationship between preoperative nutritional status and postoperative outcome in children

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ABSTRACT

Background: To evaluate the relation between preoperative nutritional status and postoperative outcome in children.

Methods: Children aged between 6 months and 18 years, who underwent surgery were included. Preoperative anthropometric measurements (BMI: body mass index, HFA: Height for age, MUAC: mid upper arm circumference; z-scores) and serum albumin/prealbumin levels and STRONGkids Nutrition Screening Test were evaluated in preoperative assessment. Children with and without preoperative malnutrition were compared for postoperative complications and outcomes.

Results: Among 57 invited patients, 51 of them with complete preoperative nutritional assessment and postoperative follow-up were included. The median age was 6.8 years (IQR: 11.2). Male to female ratio was 1.4. According to BMI z-scores, 35.3% of the cases (n=18) had acute malnutrition and 29.4% of them (n=15) had chronic malnutrition. Prealbumin levels were not different between acute and/or chronic malnourished and non-malnourished patients (p=0.744) but albumin levels were lower in malnutrition group (p=0.025). Duration of hospitalization was significantly longer in cases with malnutrition (9.0 vs 4.0 days, p=0.025). There was a significant relationship between the frequency of medium-high risk patients according STRONGkids and the frequency of malnutrition according to z-scores of MUAC (68.4% vs 32.3%; p=0.013) and HFA (93.3% vs 27.8%; p<0.001).

Conclusion: Preoperative assessment of nutritional status should be considered as essential part of preoperative work-up in children. Malnutrition significantly increases the duration of hospitalization. STRONGkids is an easy and reliable screening tool to assess the nutritional status of children and help to define the surgical patients who are at risk for malnutrition.

Keywords: malnutrition, postoperative complication, duration of hospitalization, acute malnutrition, chronic malnutrition

Introduction

The surgical mortality has been significantly reduced by the understanding of perioperative physio-pathological changes in children and the identification of nutrition-related risk factors. Malnutrition is a common morbidity observed in hospitalized children and those undergoing planned surgical treatment.[1] Cooper et al have demonstrated that 54% of children undergoing surgery suffer from protein-energy malnutrition (PEM) and it might raise up to 63% in premature infants and children under three months of age.[2] Preoperative malnutrition in

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children has been shown to result in prolonged hospital stay, increased frequency of surgical site infections, and elevated healthcare-associated costs.[3] Moreover, malnutrition is considered a preventable risk factor for postoperative complications. Although several guidelines focus on the relation between nutritional status and surgical outcomes in adult patients, there is limited evidence-based data for preoperative assessment nutrition in children.[4]

Studies in adults have demonstrated a cause-and-effect relationship between nutritional status and outcomes of surgical treatment.[4] Preoperative assessment of nutrition allows not only the identification of risk factors, but also the development of appropriate nutritional strategies to prevent potential complications after surgery and shorten hospital stays. A comprehensive nutritional assessment requires the combined use of anthropometric and biochemical parameters as well as objective and subjective evaluation tools.[5] To date, there have been limited studies evaluating the relationship between nutrition and surgical complications in children and none of the existing studies examine all parameters including anthropometric measures, serum biomarkers and screening tools in children. Therefore, we aimed to evaluate the relationship between preoperative nutritional status and surgical outcomes and complications in children.

Patients and Methods

Between 2021-2023, children between 6 months to 18 years-of-age who were scheduled for elective surgery with complete preoperative nutrition assessment on admission and 1 to 3 days prior to surgery were included. In addition to demographic characteristics, medical reports and nursing care forms were investigated for anthropometric measurements [weight, height (or length for children under 2 years old), body mass index (BMI), mid-upper arm circumference (MUAC), triceps skinfold thickness (TSFT)] and biochemical markers (serum albumin/prealbumin levels) if obtained during routine evaluation.

The inclusion criteria of the patients were;

1. Patients aged between 6 months to 18 years-of-age
2. Patients who undergo surgical interventions that require hospitalization including abdominal, thoracic, genito-urinary and oncologic surgery.
3. Patients with complete preoperative nutritional assessment and postoperative follow-up.

The exclusion criteria were;

1. Patients less than 6 months of age and older than 18 years-of-age.
2. Patients with surgical intervention that did not require hospitalization, outpatient surgical interventions.
3. Patients undergo cardiac, neurologic and orthopedic interventions and emergency operations.
4. Patients with incomplete nutritional assessment and postoperative follow-up.

Anthropometric measurements

The body weight, height/length and body mass index (BMI) were noted on admission. World health organization (WHO) Anthro and WHO AnthroPlus programs were used for the calculating the z scores.[6] In order to avoid missing data in patients older than 5 years old, the z scores for weight-for-age and height-for-weight parameters were not used in this study.

Although overweight and obesity (overnutrition) may theoretically be expressed under the definition of malnutrition,[7] since the aim of this study is to assess the association of undernutrition and surgical outcomes, we used the term of 'malnutrition' instead of protein-energy malnutrition (underweight, stunting and wasting) in line with previous articles.

The definitions of acute and chronic malnutrition were defined based on z scores of BMI and HFA, respectively.

Main Points

- Preoperative acute and/or chronic malnutrition was present in 49% of pediatric surgical patients.
- Malnutrition was associated with prolonged hospitalization (9.0 vs. 4.0 days, $p=0.025$), especially in chronically malnourished children.
- STRONGkids demonstrated 68% sensitivity and 73.1% specificity for detecting malnutrition risk in this cohort.
- Routine preoperative nutritional assessment combining anthropometric, biochemical, and screening parameters is essential in pediatric surgical practice.

According to WHO definitions, acute or chronic malnourished patients were classified under groups of moderate and severe malnutrition.[8] Mehta et al.[9] and Becker et al.[5] added -2 SD < BMI z-score ≤ -1 SD as mild malnutrition or 'at malnutrition risk' under the definition of acute malnutrition.[5,9] As in daily practice, children with mild malnutrition and related complications can easily be unnoticed, the morbidity and mortality risk increase. For that reason, to see the effect of any undernutrition conditions on surgery outcomes, the malnutrition group was enhanced as covering mild malnutrition/ at malnutrition risk group in order. Stunting reflecting chronic malnutrition is defined by WHO as HFA below -2SD: We also added -2SD< HFA z-score ≤ -1 SD to more robustly demonstrate the consequences of malnutrition and surgery in children at risk for chronic malnutrition. The nutritional definition of the study group was classified as shown in Table 1.

The MUAC was measured in millimeters using non-stretchable tape on the left arm. The midpoint of the distance between the tip of shoulder and the tip of elbow was determined while the arm was flexed at elbow. Afterwards, the arms were placed in a relaxed position and the tape was placed tightly and circularly around the arm, passing through this midpoint. The MUAC was recorded to the nearest 1mm. Z-scores for MUAC were assessed by using WHO Anthro program (< 5 years old)[6,10] and PediTools Electronic Growth Chart Calculators (≥5 years old).[11] Triceps skinfold thickness measurement was obtained by using caliper. Z-scores for TSFT were assessed by WHO Anthro program (< 5 years old)[6] and PediTools Electronic Growth Chart Calculators (≥5 years old).[11] Albumin (normal: 3.5-5.2 gr/dl) as well as prealbumin levels (normal: 18-38 mg/dL) were noted.

Table 1. Definitions used in the assessment of malnutrition severity[5,9,17]

Nutritional Assessment Tool	Malnutrition Severity
Z-scores for BMI:	
BMI z-score ≤ -3 SD	Severe Acute Malnutrition
-3SD ≤ BMI z-score < -2 SD	Moderate Acute Malnutrition
-2SD < BMI z-score ≤ -1 SD	Mild Acute Malnutrition
- 1SD < BMI z-score ≤ +1 SD	Normal
+1SD < BMI z-score ≤ +2 SD	Overweight
BMI z-score > +2 SD	Obese
Z-score for HFA:	
HFA z-score ≤ -3 SD	Severe Chronic Malnutrition
-3SD ≤ HFA z-score < -2 SD	Moderate Chronic Malnutrition
-2SD < HFA z-score ≤ -1 SD	Mild Chronic Malnutrition
- 1SD < HFA z-score ≤ +1 SD	Normal
HFA z-score > +1 SD	Tall Stature
Z-scores for Mid-upper Arm Circumference	
MUAC z-score ≤ -1 SD	Low MUAC z-score group
MUAC z-score > - 1 SD	Normal MUAC z-score group

BMI; body mass index, HFA: Height-for-Age, MUAC: mid-upper arm circumference, SD: standard deviation

Screening tools

The Screening Tool for Risk of Impaired Nutritional status and Growth (STRONGkids), which is an objective tool for nutritional assessment, was used for the assessment of malnutrition risk in patients, with its Turkish validation.[12] Table 2 demonstrates the parameters of STRONGkids and definitions for the risk assessment. Patients with '0' score was considered as 'low risk', whereas scores with 1-3 is 'moderate risk' and 4-5 points is 'high risk'. Outside the study, as a part of routine practice, patients with low risk underwent regular weight monitoring and no nutritional intervention is required. Moderate risk patients closely followed-up for weight monitoring and malnutrition assessment while high-risk patients consulted to nutrition support team as suggested in the STRONGkids.[12]

The demographic features, clinical findings, surgical treatments, surgical outcomes, perioperative and postoperative complications (surgical site infection, deep tissue infection, respiratory tract infection, bloodstream infection, catheter-related infection), and length of hospital stay were monitored and recorded for patients who underwent preoperative nutritional assessment. According to the nutritional status, patients were categorized as 'malnutrition group' and 'non-malnourished group'. Malnutrition group consists of patients with acute, chronic or acute plus chronic malnutrition. According to the aim of this study mentioned before, small number of overweight / obese patients or patients with tall stature included in 'non-malnourished group'. Demographic features, surgical outcomes and complications were compared between these two groups.

Statistical analysis and ethics

Statistical calculations were performed using SPSS 23.0 software (SPSS, Inc., Chicago, IL, USA). Descriptive statistics were presented as mean, standard deviation, median, minimum, and maximum values for continuous variables. Qualitative data were described using frequency and percentage values. Non-parametric independent numerical variables were compared using the Mann-Whitney U test, and parametric numerical variables were compared using the Student's t-test. The Pearson chi-square test and Fisher's exact test were used for the comparison of categorical variables. Sensitivity and specificity were calculated for each parameter. Results with a p-value less than 0.05 were considered statistically significant.

The Local Ethical Committee was approved the study (HU-GO-2022) and informed consent was obtained from the patients, parents and care-givers.

Results

Fifty-one patients who had complete preoperative assessment and follow-up were included. The median age of the patients was 6.8 years (IQR: 11.2 years, min: 6 months –max: 18 years). The male-to-female ratio was 1.4. Overall, 25 patients (49%) had acute and/or chronic malnutrition. Acute malnutrition, based on BMI z-scores, was observed in 35.3% (n=18) while chronic malnutrition, based on HFA z-scores, was detected in 29.4% (n=15) of the patients.

The demographic characteristics, nutritional status, and distribution of surgical procedures for the patients are presented in Table 3. Eighteen patients (35.3%) reported loss of appetite, whereas 7 patients (13.7%) reported vomiting±diarrhea and weight loss before surgery was noted in 8 patients (15.7%).

Table 2. STRONGkids Screening Tool for Malnutrition Risk in Children Under 18 years of age[12]

Malnutrition Risk Screening **(Once a week for children aged 1 month to 18 years, at the first visit)**		**Scoring**	
1	Does the patient at risk of malnutrition have an underlying illness or an expected major surgical intervention?	**NO**	**YES→2 points**
2	Does the patient show sign of poor nutrition based on subjective clinical evaluation? (decreased subcutaneous fat and/or muscle mass and/or vacant stare)	**NO**	**YES→1 point**
3	Is any of the following present? *Excessive diarrhea (>5 days) and/or vomiting (>3 days) *Decreased food intake in the past few days *Previous nutritional intervention *Inadequate food intake due to pain	**NO**	**YES→1 point**
4	Is there weight loss or lack of weight gain in the past week/month (<1 year of age)?	**NO**	**YES→1 point**

Malnutrition Risk and Treatment Needs

Score	**Risk**	**Treatment**
4-5 points	High Risk	*Consultation with the nutrition support team is requested from the primary doctor for a definitive diagnosis and individualized nutritional recommendations. *Weight monitoring is conducted twice a week, and nutritional recommendations are evaluated. *Weekly nutritional risk assessment is performed.
1-3 points	Moderate Risk	*Nutritional intervention is taken into consideration. *Weight monitoring should be conducted twice a week. *Weekly malnutrition risk assessment is performed.
0 Points	Low Risk	* Nutritional intervention is not required. *Regular weight monitoring is conducted according to hospital policy. *Weekly nutritional risk assessment is performed.

Table 3. Demographic characteristics, surgical interventions and anthropometric assessment of patients

Characteristics of the Patients	n, %
Gender	
Female	21 (41.2%)
Male	30 (58.8%)
Age	
<6 years	22 (43.1%)
6-12 years	11 (21.6%)
>12 years	18 (35.3%)
Localization of surgical interventions	
Thoracic Surgery	4 (7.8%)
Abdominal Surgery	17 (33.3%)
Urological Surgery	10 (19.6%)
Oncological Surgery	10 (19.6%)
Other	10 (19.6%)
History of previous surgical procedure	
Yes	24 (47.1%)
No	27 (52.9%)
Duration of surgical procedure	
0-60 minutes	12 (23.5%)
61-90 minutes	15 (29.4%)
91-120 minutes	13 (25.5%)
121-150 minutes	6 (11.8%)
151 minutes and above	5 (9.8%)
Duration of hospital stay	
0-5 days	9 (17.6%)
6-10 days	31 (60.8%)
>10 days	11 (21.6%)
Body Mass Index Z-scores	
Severe Acute Malnutrition	4 (7.8%)
Moderate Acute Malnutrition	5 (9.8%)
Mild Acute Malnutrition	9 (17.6%)
Normal	19 (37.3%)
Overweight or Obese	14 (27.5%)

SD: standard deviation, TSFT: Triceps skinfold thickness.

Table 3. Continued

Characteristics of the Patients	n, %
Height-for-Age Z-scores	
Severe Chronic Malnutrition	2 (3.9%)
Moderate Chronic Malnutrition	4 (7.8%)
Mild Chronic Malnutrition	9 (17,7%)
Normal	26 (51%)
Tall Stature	10 (19.6%)
Mid-upper Arm Circumference Z-scores	
Malnutrition	19 (37.3%)
No Malnutrition	32 (62.7%)
Triceps skinfold thickness Z-scores	
TSFT z-score ≤ -1 SD	6 (11.8%)
TSFT z-score > - 1 SD	45 (88.2%)
Malnutrition Risk According to the STRONGkids[11]	
Low Risk	27 (52.9%)
Moderate Risk	19 (37.3%)
High Risk	5 (9.8%)

SD: standard deviation, TSFT: Triceps skinfold thickness.

Patients were grouped under the 'malnutrition group' (acute, chronic, acute plus chronic malnutrition) and the 'non-malnourished group' (normal, overweight/obese and tall stature). There were no significant differences between these groups in terms of gender distribution and previous surgical history (p=0.332 and p=0.322, respectively). The ratio of malnutrition was similar in abdominal and non-abdominal surgeries (p=0.322). However, when patients with acute and chronic malnutrition were evaluated separately, acute malnutrition was more frequent in the abdominal surgery group (n=13/27, 48.1% vs. n=5/24, 20.8%) (p=0.042). Chronic malnutrition ratio was not different between abdominal (8/27, 29.6%) and non-abdominal surgery group (n=7/24, 29.2%). The ratios of abdominal and non-abdominal surgeries were also similar in groups of low MUAC z-score (≤ -1 SD) and normal MUAC z-score (> -1 SD) (p=0.514). Besides, the ratio of normal and low TSFT z-score (≤ -1 SD) patients did not show any difference in abdominal and non-abdominal surgery groups (p=1.0). According to the STRONGkids risk classification, 16 out of 27 patients (59.3%) having abdominal surgery were

Table 4. Comparison of demographic features, surgical complications and duration of hospitalization in patients with malnutrition and non-malnourished ones (*p values less than 0.05 is considered as statistically significant)

Patient Characteristics	Malnutrition (n=25)	Non-malnourished (n=26)	p-value
Gender			
Female	12 (48%)	9 (34.6%)	0.332
Male	13 (52%)	17 (65.4%)	
Surgical site			
Abdominal Surgery	15 (60%)	12 (46.2%)	0.322
Non-abdominal Surgeries	10 (40%)	14 (53.8%)	
Previous surgical procedure			
Yes	10 (40%)	14 (53.8%)	0.322
No	15 (60%)	12 (46.2%)	
Serum albumin level (g/dL)			
Mean ± SD	4.15±0.39	4.42±0.40	**0.025***
Minimum-maximum	3.37-4.69	3.76-5.71	
Serum prealbumin level (mg/dL)			
Median (IQR)	16,5(3.5)	16.9 (7.8)	0.744
Minimum-maximum	9-21.1	15.1-35.3	
Median hospital stay (days)			
Median (IQR)	9 (6)	4 (6)	**0.025***
Minimum-maximum	3-32	3-15	
STRONGkids classification[11]			
Low Risk	8 (%32)	19 (%73.1)	**0.003***
Moderate-high Risk	17 (%68)	7 (%26.9)	

IQR: interquartile range, SD: standard deviation.

in the moderate/high malnutrition risk group. The ratio was 33.3% (n=8/24) in the non-abdominal surgery group and no statistical significance was shown (p=0.064) (Table 4). The number of patients with moderate/high risk according to STRONGkids was higher in 'malnutrition group' compared to 'non-malnourished group' (68% vs 26.9%; p=0.003). In the chronic malnutrition group, moderate/high malnutrition risk was more frequent than low risk (93.3% vs. 27.8%, p<0.001). However, acute malnutrition group did not show any difference (61.1% vs. 39.4%, p=0.138). Based on MUAC z scores classification, there were significantly more patients at moderate/high risk in low MUAC z-score group (68.4%) than patients with normal MUAC (32.3%) (p=0.013). The sensitivity of STRONGkids (moderate to high risk) to detect malnutrition was 68% and specificity was 73.1%.

The mean albumin and median prealbumin preoperative values for the study population were 4.29 ± 0.42 g/dL (minimum: 3.37 and maximum: 5.71) and 16.9 mg/dL (IQR: 3.9, minimum: 9, maximum: 35.5), respectively. Only one case in the study group had an albumin level <3.5 g/dL. Prealbumin levels were evaluated in 19 patients, and 13 of them (68.4%) had low levels than normal limits (Table 3). Despite clinical insignificance, the albumin levels were lower in 'malnutrition' group (4.15±0.39 vs. 4.42±0.4; p=0.025), but prealbumin levels were similar (p=0.744) (Table 4).

Patients in malnutrition group showed a longer hospital stay (9.0 vs. 4.0 days) (p=0.025) (Table 4). While duration of hospital stay in patients with acute malnutrition and non-malnourished group was similar (p=0.238), chronic malnutrition was associated with a slightly longer hospital stays (9.0 vs 7.5 days) (p=0.05). The ratio of patients stayed in the hospital longer than 10 days was higher in the malnutrition group than the non-malnourished group (36% vs 7.7%, p=0.014). There was no difference in abdominal surgery and non-abdominal surgery group based on hospital stay duration (p=1.0).

Forty-two patients (82.4%) were given prophylactic antibiotics before surgery. Only 2 patients (3.9%) showed bloodstream infection but no catheter related infection. Postoperative complications and Clavien-Dindo classification grades for each complication is listed in Table 5. At least one postoperative complication was seen in 12 patients (23.5%); surgical site infections (SSI) (n=9, 17.6%), pulmonary complications (n=3, 5.9%), late enterocutaneous fistula (n=1, 2.0%), late anastomotic stricture (n=1, 2.0%), and urethrocutaneous fistula after hypospadias repair (n=2, 3.9%). Despite the rate of postoperative complication was higher in the malnutrition group (72,7% vs. 27.2%), there were no significant difference between the malnutrition and non-malnourished group (p=0.076). The acute malnutrition group did not show higher complication rate than patients with BMI >-1 SD (p=0.726). The postoperative complications were higher but not statistically significant in chronic malnutrition group with HFA≤ -1 SD (54.5% vs. 22.5%, p=0.061). Among the cases with complications, a patient with enterocutaneous fistula had acute malnutrition and a patient with anastomotic stricture had chronic malnutrition, while the nutritional status of the other cases with complications was normal. While 66.7% (n=6) of patients with SSI had acute and/or chronic malnutrition (chronic malnutrition in 5 patients and acute malnutrition in 1 patient), 45.2% of patients with no SSI showed malnutrition (p=0.291). Six of nine patients with SSI had TSFT z-score ≤ -1SD, but MUAC z-score were lower than normal limits in 3 patients. There was no significant difference between malnutrition and non-malnourished groups based on MUAC z -score and TSFT z-scores. (p=0.446, p=0.576, respectively). The site of the operation was not different in patients with SSI (p=0.464).

Discussion

Malnutrition is considered as a preventable risk factor for the development of postoperative complications in surgical patients.[4] Several studies showed that malnutrition has a negative impact on surgical outcomes in adult patients and is associated with longer hospital stays and increased healthcare costs.[4] Nutrition health is an important factor not only for preparing but also for recovery from the surgery.[13] Since children who require surgical intervention are exposed to physiological stress, their nutritional needs may change during the pre and postoperative period. Hence, providing optimal nutritional support is an integral part surgical care to minimize surgical morbidity. In children, malnutrition not only causes imbalance of weight and height but also impairs the cognitive and neurodevelopment of a child. The nutritional guidelines for surgical patients are mostly based on adult data and include recommendations for adult population. There is insufficient information about the relationship between nutritional status and surgical outcomes in children. Moreover, there is no consensus on how and when to assess the preoperative nutrition in children and which treatment strategies can be apply in the presence of malnutrition. In this study, we aimed to evaluate the role of preoperative nutrition status on surgical outcomes and complications in children who underwent surgical intervention. In this context, we evaluated the relationship between nutritional status

Table 5. Postoperative complications and Clavien-Dindo classification grades for each type of surgical interventions.

Type of surgical intervention	Surgical site infection (n, Grade)	Pulmonary complications (n, Grade)	Postoperative complications (n, Grade)
Thoracic	1, II	1, II	-
Abdominal	2, II	1, II	Enterocutaneous fistula (n=1), IIIb Anastomotic stricture (n=1), IIIb
Urologic	5, II	-	Uretrocutenous fistula (n=2), IIIb
Oncological	-	-	-
Others	1, II	1, II	Blood stream infections (n=2), II

Clavien-Dindo Grade II; Complication requires pharmacological treatment; Clavien- Dindo Grade IIIb; Complication requires surgical treatment under general anesthesia.

and surgery outcome by using a wide spectrum of preoperative nutritional assessment tools including anthropometric measures, biochemical markers, and screen tools.

Malnutrition can be observed in children who require hospitalization for various reasons. In the pediatric surgery practice, gastrointestinal (GI) tract anomalies may cause decreased appetite, refusal to eat, and also the GI tract surgery may worsen the nutritional status. Although current pediatric data concentrated in patients undergoing cardiac surgery, abdominal and oncologic surgery may have obvious impact on nutrition in children.[14] Firstly, Durakbaşa et al reported that the overall malnutrition was 13.4% in pediatric surgical patients.[15] The American and European Societies for Pediatric Gastroenterology, Hepatology, and Nutrition have emphasized that identifying the risk of malnutrition in pediatric patients is a preventive measure against malnutrition-related complications and prolonged hospital stays, recommending its routine implementation.[5] For this reason, the nutritional status of all patients should be evaluated preoperatively and patients with malnutrition should be defined and treated before surgery. In our study, we used both anthropometric measurements and biochemical investigations. As recommended in previous consensus reports anthropometric measurements such as body weight for height (BWH) and BMI were used to define acute malnutrition, while HFA is considered as an indicator of chronic malnutrition.[16] In our study, only BMI z-scores were used to assess acute malnutrition as BWH z-scores cannot be calculated for children over 5 years old. In the preoperative assessment 49 % of our patients had acute and/or chronic malnutrition. In subgroups, acute and chronic malnutrition was determined in 35.3% and 29.4%, respectively. However, we could not make subgroup analysis for mild, moderate and severe malnutrition due to small sample size in each group. We also evaluated other anthropometric parameters such as z-scores of MUAC and TSFT. An indirect method for malnutrition assessment, the MUAC z-scores, which can be determined by a non-stretchable tape has the advantages of being correlated with BMI, high sensitivity of catching mild and moderate malnutrition, detecting malnutrition in non-ambulatory children.[17] We found that 37.3% of the patients showed low MUAC z-scores (≤ -1 SD) that was compatible with malnutrition. Triceps skinfold thickness measurement is recommended to detect fat stores in children.[18] To reveal the relationship of decreased fat stores and malnutrition, we evaluated TSFT z-scores and found that 11.8% patients had TSFT z-scores ≤ -1 SD.

Patients grouped under the malnutrition and non-malnourished groups according to BMI and/or HFA z-scores were compared. Gender and previous surgery history were similar in two groups. The abdominal surgery was higher in only acute malnutrition group (48.1%) when compared to patients with normal nutritional status (20.8%), but not in chronic malnutrition. Therefore, we conclude that patients, especially those undergoing abdominal surgery, may require more comprehensive evaluation of nutritional status before surgery to avoid missing acute malnutrition which may resolve in a relatively short time if the surgery is elective.

Serum albumin level, which has a half-life of 18-20 days compared to the 2-day half-life of prealbumin, can be used for evaluating nutritional status over a longer period. Low albumin levels are associated with chronic loss, while low prealbumin levels shows acute protein loss.[19] However, albumin levels are commonly used in some of the screening tools, albumin and prealbumin levels cannot be considered as only indicator for malnutrition. Although, hypoalbuminemia is considered as an independent risk factor for surgical site infections, serum protein levels should be evaluated together with the other parameters.[2] In our study, only one of the patients had low albumin levels whereas 13 of 19 patients (68.4%) had low prealbumin levels. Also, while evaluating the serum proteins, it should be kept in mind that serum levels of albumin and prealbumin might be affected by inflammation and metabolic disorders and prolonged hospitalization is an important risk factor for low albumin levels.[2] In our study group despite clinically insignificant differences, patients with malnutrition showed statistically lower albumin levels. Prealbumin levels were similar in two groups, but the sample number is small. Since prealbumin levels is not the sole criteria for assessing the preoperative malnutrition, we suggest that they did not affect our results. Furthermore, due to the retrospective design of the study, prealbumin levels may have been assessed in a selected group of patients with short-term insufficient preoperative nutrition. Although its use in pediatric surgical population is not clear, it can be monitored in patients with evident preoperative malnutrition.

Up to now, various screening tools have been identified to determine the risk of malnutrition in children. Subjective Global Nutritional Assessment (SGNA) and Screening Tool for Risk on Nutritional Status and Growth (STRONGkids) are common tools used in children to have a standardized assessment of nutrition.[15,20,21] STRONGkids is a nutritional risk screening tool for hospitalized children and it is different from SGNA in purpose, methodology, complexity and time to administer. It is an easy and simply applicable tool and does not require training and physical examination like SGNA.[20,21] STRONGkids provides a structured, standardized screening framework, which reduces variability in nutritional risk recognition between clinicians. Many hospitals adopt a ≥1 point threshold for at least a dietitian review, since even "moderate risk" can progress quickly in hospitalized children. It is particularly useful in toddlers younger than 3 years-of age, children with chronic disease and surgical treatment.[22] Omar et al reported that STRONGkids exhibited the best accuracy in detecting acute and chronic malnutrition in children when compared to other tools.[23] It has also been utilized as a reliable assessment tool in pediatric surgery patients.[15] We used the Turkish version of STRONGkids in our study.[12] The sensitivity and specificity of the STRONGkids to define malnutrition in our study was 68% vs 73.1%, respectively. Chronic malnutrition group showed significantly high number of patients in moderate/high malnutrition risk than lower risk. Therefore, we suggest that STRONGkids can be used to define malnutrition risk, especially in chronic malnourished surgical patients and it can easily be applied preoperatively in surgical clinics and can be used repeatedly during hospitalization in children. Although there was no significant difference, the higher ratio moderate/high STRONGkids risk scores (59.3% vs. 33.3%) in patients undergone abdominal surgery may support the need for clinicians to focus on nutrition before elective abdominal surgery. Moreover, presence of moderate/high risk score was more frequent in the low MUAC z-score group. Hence, an easy tool to detect for malnutrition (MUAC) can be used even in the absence of scale and stadiometer in a surgery department.

Children undergoing surgical intervention also face surgical stress and cause metabolic response similar to that in adults. However, they are more fragile and due to their limited energy sources, development of acute and chronic malnutrition is more likely. This risk is reported to be particularly high after prolonged and serious surgeries and during long hospital stays.[2] Similar to our results, Secker et al. demonstrate a significant relationship between height-for-age and prolonged hospital stay.[20] Also, El-Regibi et al found higher complication rates and prolonged hospital stays in children who underwent hepatobiliary and GI surgery.[24] However, Toole et al. found similar results in children who underwent cardiac surgery, they did not define a similar relation between prolonged hospital stay and acute malnutrition.[14] In our study, we found that patients with malnutrition, especially chronic malnutrition had slightly longer hospital stay than normal nourished children but not in children with acute malnutrition. These results suggest that having a malnutrition associated with longer hospital stays and worse outcomes. Therefore, we suggest that patients with malnutrition, especially chronic malnutrition, requires a comprehensive preoperative assessment and special attention for postoperative complications.

In our study, 9 of 12 patients (75%) with postoperative complications had malnutrition. While the complication rate was high in the chronic malnutrition group (54.5% vs. 22.5%), the difference was not significantly significant due to limited number of patients. Malnutrition is considered as a risk factor for development of surgical site infections (SSI).[25] In a meta-analysis, it has been shown that undernutrition is predictive for postoperative infectious complications in children.[26] However, authors reported no high-quality data confirming a relation between undernutrition and SSI.[25] Since, development of SSI is multifactorial, malnutrition can be considered as one of the risk factors for developing postoperative infections. In our study group 17.6% of cases (n=9) develop SSI in the postoperative period and six of them had either acute or chronic malnutrition. The rate of SSI was similar in malnutrition and non-malnourished group. Interestingly, a recent and a big cohort study from Saxena et al, showed that even in younger ages, there were no relationship between anthropometric measurements and surgical complications.[27] Prolonged surgery was only risk factor in patients with complications.[27] The variation in different studies may be related to the use of different tools to assess nutrition and to the characteristics of the patient groups selected in each study.

The nutritional guidelines on surgery recommend assessment of nutritional status in all surgical patients preoperatively.[4] Although the aim of preoperative assessment is to define patients who are at risk for complications, the prevention of these complications with appropriate nutritional treatment is also recommended. In elective surgical procedures, 7 to 10 days enteral or parenteral nutritional treatment is recommended prior surgery.[28] In pediatric population, the optimum time of nutritional treatment and the best formula to overcome acute nutrition is not clear. Therefore, nutritional treatment strategy should be developed in pediatric surgical patients.

Our study has limitations such as small sample size and heterogenous group of patients with different surgical interventions. The effect of different types of surgery could not be evaluated because of small amount of data in subgroup analysis. Larger cohort of studies are needed to define the role of preoperative malnutrition on surgical outcomes and complications in different surgical interventions. Although it is difficult to have a firm conclusion about a strong correlation between malnutrition and postoperative complications / outcomes, we suggest patients with chronic malnutrition at higher risk for developing complications and associated with longer hospital stays. Despite these limitations, we firstly used all preoperative nutritional assessment tools to define malnutrition in children before surgery and showed that STRONGkids is easy and reliable screening tool in children. Studies including large cohort of pediatric surgical patients are needed to define the best assessment method and principles of nutrition treatment to prevent malnutrition related complications. High quality evidence-based data in pediatric population may contribute to publish pediatric guidelines instead of following recommendations adapted from adult results.

In conclusion, preoperative assessment of nutritional status should be considered as integral part of preoperative work-up in children undergoing surgical treatment. STRONGkids is an easy and reliable screening tool to assess the nutritional status of children and help to define the surgical patients who are at risk for malnutrition. Chronic malnutrition significantly increases the duration of hospitalization. Nutritional treatment and optimizing the nutritional status are mainstay of preventive measures for malnutrition related postoperative complications in children.

Ethical approval

The study was approved by Hacettepe University Ethics Committee (date: 01.01.2024, number: HU-GO-2022). Written informed consent was obtained from the participants.

Author contribution

The authors declare contribution to the paper as follows: Study conception and design: TS, OB; data collection: TT, DY; analysis and interpretation of results: TT, TS, HHG; draft manuscript preparation: TT, TS, HHG. All authors reviewed the results and approved the final version of the article.

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Conflict of interest

The authors declare that there is no conflict of interest.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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