STRONGKIDS Nutritional risk score and Body Mass Index in Malnourishment Risk assessment in Critically Ill Children

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ABSTRACT

Introduction: Recently malnutrition is considered one of the major problems nowadays in our community. Critically ill children have metabolic alterations and a catabolic state. Malnutrition is one of the factors that affect the outcome of critically ill children.**Objectives:** This study aimed to assess the accuracy of BMI and NRS (STRONGKIDS) in the assessment of malnutrition risk and the relation of malnutrition to the outcome of mechanically ventilated critically ill children. **Methods:** nutritional status using STRONGKIDs score and BMI of 101 mechanically ventilated children in pediatric intensive care units at Cairo University Pediatric Hospital was assessed. Outcome (mortality, hospital-acquired infections, and length of PICU stay and ventilation) was followed up to detect its correlation with malnutrition.**Results:** percentage of malnutrition depending on BMI Z-score was 39.6%, nutritional status depending on STRONG KIDS score showed a low risk of malnutrition 17.8%, moderate risk of malnutrition 65.4% and high risk of malnutrition was 16.8%. There was a significant correlation between STRONG KIDS score with BMI z –score with p-value 0.007. Also, there was a significant correlation between malnutrition (assessed by BMI and STRONGKIDS score) and HAI with p-value 0.05 and 0.035 respectively. There was also an inversely significant correlation between malnutrition (assessed by BMI) and a period of ventilation P-value 0.02.**Conclusion:** STRONG KIDS score is an easy method for assessment of nutritional status and can be used with BMI to avoid missing malnourished critically ill children as malnutrition is associated with prolonged mechanical ventilation and increase risk of HAI.

Key Words: *BMI - STRONG KIDS score - Critically ill children - Malnutrition.*

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INTRODUCTION

Critical illness greatly influences one’s nutritional status; therefore, assessment of nutritional status should be an integral part of patient care. During a child’s intensive care stay, however, attention is mostly focused on the primary medical problem, e.g., hemodynamic instability, serious infection, congenital anomaly, and nutritional status is often neglected.

Malnutrition can be defined as a deficiency (or excess) of energy, protein, and other nutrition which results in the measurable adverse effects on the body and growth (in children), and may have an impact clinical outcome [1]**.**

Malnutrition and low body weight are found mainly in developing countries [2].

Vitamin A and calcium deficiencies are among the most frequent reasons for childhood malnutrition [3].

In addition to presenting with poor nutrition at the time of admission, children often suffer worsening of their nutritional status during hospitalization. Pediatric

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hospitalists have a role in diagnosing and treating this common comorbid condition [4].

Malnutrition also affects growth. Growth depends on a permanent increase in fat and lean body mass, which requires positive energy and nitrogen balance [5].

High nutritional is needed due to illness or injury compete with these specific needs of growth. Infancy and adolescence are high-risk periods that can be affected if and when nutrition is low during illness and this may inhibit growth. Initially, children may not gain weight, have weight loss. And over time, their height will be affected as well. Early on, height is an important way to diagnose chronic malnutrition [1].

In practice, assessment of hospitalized patients' nutritional status is difficult, and often, even when they are assessed properly, it serves to identify patients who are already malnourished. Several authors nake emphasis on the assessment of nutritional risk because that allows intervention such as early and timely nutritional support to prevent the short- and long-term consequences of malnutrition on clinical outcomes, growth, and development [6].

With this objective, different screening methods of malnutrition with different targets have been developed [7]. The method that is used should be simple, understandable, reliable, not time consuming and can be used for a wide range of diseases. It should determine patients with moderate and severe malnutrition for the required support to be provided and also, be sensitive and specific. Anthropometric measures are used by the World Health Organization (WHO) as a screening method for the diagnosis of malnutrition.

Several nutritional scores were developed as easy methods of diagnosis of malnutrition in the pediatric population.

These scores included: Nutritional Risk Score (NRS) [8],Pediatric Nutritional Risk Score (PNRS) [9],Subjective Global Nutritional Assessment (SGNA) [10],Screening Tool for the Assessment of Malnutrition in Pediatrics (STAMP) [11], Pediatric Yorkhill Malnutrition Score (PYMS) [12],Screening Tool for Risk of Impaired Nutritional Status and Growth (STRONg-kids) [13]and Pediatric Nutrition Screening Tool (PNST) [14].

PATIENTS AND METHODS

Study Design:

A Cross-sectional, observational study was carried out on all mechanically ventilated children admitted in pediatric intensive care units at Cairo University Pediatric Hospital during six months period from December 2017 to May 2018 with a minimum number of 100 cases.

Ethics

Informed consent was taken from patients' guardians before enrollment with an explanation of the type of study. Approval of the ethical committee of the faculty of medicine, Cairo University was obtained.

Inclusion criteria:

- All critically ill children with age group 1 month to 12 years old need mechanical ventilation either on admission or within 24hrs.
- Both genders.

Exclusion criteria:

- Children receiving palliative treatment at end of life (brain stem death).
- Patients on special nutritional status were excluded to minimize inaccurate nutritional status.

101 patients were reached based on the inclusion criteria listed above.

Intervention

All patients in the study were subjected to:

1. History taking:

- History of weight loss last week.
- History of decreased nutritional intake last week.
- Cause of admission in ICU.
- History of Duration of current illness.
- History of high-risk disease as celiac Disease.
- History of diarrhea or vomiting.
- Dietetic History: includes the type of feeding (breast or artificial feeding).

2. Clinical examination and laboratory results:

Detection of system failure, its type, and number:

Detection of Mortality risk using PRISM scoreIII according to Pollack et al., 1996 [15]

Clinicalassessment to detectpoornutritionalstatus (decreasedsubcutaneous fat and/or muscle mass and/or hollow face)

3. Anthropometry:

- Weight and height/length and apply on WHO weight and height percentile z score.
- Calculation of BMI and apply BMI using WHO BMI percentile z score:

Subjects were categorized as underweight (BMI Z-score < -2), normal weight (BMI Z-score≥ -2 and ≤ 1), overweight (BMI Z-score > 1 and ≤ 2), or obese (BMI Z-score > 2) [16].

Table 1: Diagnosis of System Failure [17]

Organ System	Criteria for Dysfunction
Cardiovascular	Despite administration of isotonic intravenous fluid bolus ≥60 mL/kg in 1 hr: decrease in BP (hypotension) systolic BP <90 mm Hg, mean arterial pressure <70 mm Hg, <5th percentile for age, or systolic BP <2 SD below normal for age *or* Need for a vasoactive drug to maintain BP in normal range (dopamine >5 µg/kg/min or dobutamine, epinephrine, or norepinephrine at any dose) *or* Two of the following: Unexplained metabolic acidosis: base deficit >5.0 mEq/L Increased arterial lactate: >1 mmol/Liter or >2× the upper limit of normal Oliguria: urine output <0.5 mL/kg/hr Prolonged capillary refill: >5 sec Core to peripheral temperature gap >3°C (5.4°F)
Respiratory	PaO2/FIO2 ratio <300 in absence of cyanotic heart disease or preexisting lung disease *or* PaCO2 >65 torr or 20 mm Hg over baseline PaCO2 *or* Need for >50% FIO2 to maintain saturation ≥92% *or* Need for nonelective invasive or noninvasive mechanical ventilation
Neurologic	GCS score ≤11 *or* Acute change in mental status with a decrease in GCS score ≥3 points from abnormal baseline
Hematologic	Platelet count <100,000/mm3 or a decline of 50% in the platelet count from the highest value recorded over the last 3 days (for patients with chronic hematologic or oncologic disorders) *or* INR >1.5 *or* Activated prothrombin time >60 sec
Renal	Serum creatinine >0.5 mg/dL, ≥2× upper limit of normal for age, or 2-fold increase in baseline creatinine value
Hepatic	Total bilirubin ≥4 mg/dL (not applicable for newborn) Alanine transaminase level 2× upper limit of normal for age

Table 2: Diagnosis of growth problems [16]:

Z-score	Growth problems		
(standard deviation)	Length\height-for-age	Weight-for-age	BMI-for-age
Above 3	Note 1	Note2	Obese
Above 2	Normal	Note2	Overweight
Above 1	Normal	Note2	Possible risk of overweight
0 (median)	Normal	Normal	Normal
Below -1	Normal	Normal	Normal
Below -2	Stunted	underweight	Wasted
Below -3	Severely stunted	Severely underweight	Severely wasted

Note 1: child in this range is very tall .tallness is rarely a problem unless it is so excessive that it may indicate an endocrine disorder such as growth hormone-producing tumor.

Note 2:child whose weight for age in this range may have growth problem but is better assessed from weight for length\height or BMI for age.

Evaluation was done using: Length\Height For age BOYS Z- scores (Birth to 5 years), Weight For age BOYS Z-scores (Birth to 5 years), BMI For age BOYS Z-scores(Birth to 5years), Weight For age BOYS Z- scores (5 years to 10 years), Height For age BOYS Z- scores (5 years to 19 years), BMI For age BOYS Z-scores (5 years to 19 years), Height For age GIRLS Z- scores (Birth to 5 years), Weight For age GIRLS Z- scores (Birth to 5 years), BMI For age GIRLS Z- scores (Birth to 5 years), Height For age GIRLS Z- scores (5 years to 19 years), WEIGHT For age GIRLS Z -scores (5 years to 10 years), BMI For age GIRLS Z- scores (5 years to 19 years).

N.B:

Weight-for-age reference data are not available beyond age 10 because this indicator does not distinguish between height and body mass in an aging period where many children are experiencing the pubertal growth spurt and may appear as having excess weight (by weight-for-age) when in fact they are just tall.

4. Risk assessment of malnutrition using STRONGKIDS:

On admission, a questionnaire to score the risk for malnutrition was performed. This nutritional risk screening questionnaire consisted of 4 items and each item was allocated a score of 1–2 points with a maximum total score of 5 points:

(1) Subjective clinical assessment (1 point).

Was the patient in a poor nutritional status judged by subjective clinical assessment (diminished subcutaneous fat and/or muscle mass and/or hollow face)?

(2) High-risk disease (2 points).

Was there an underlying illness with a risk of malnutrition or expected major surgery?
High-risk diseases include:
Anorexia nervosa
Burns
Bronchopulmonary dysplasia (maximum age 2 years)
Celiac disease
Cystic fibrosis
Dysmaturity/prematurity (corrected age 6 months)
Cardiac disease,
Infectious disease (AIDS)
Inflammatory bowel disease
Cancer
Chronic Liver disease
Chronic kidney disease
Pancreatitis
Short bowel syndrome
Muscle disease
Metabolic disease
Trauma
Mental handicap/retardation
Expected major surgery
Not specified (classified by a doctor)
(3) Nutritional intake and losses (1 point).
Was one of the following items present?
Excessive diarrhea (≥5 per day) and/or vomiting (>3 times/ day) for 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?
(4) Weight loss or poor weight gain? (1 point)
Was there weight loss or no weight gain (infants <1 year) during the last few weeks/months?

5. Observation of the outcome of critically ill children in the form of:

A- **Development of infection** which was defined as an infection acquired after 48 hrs of admission in ICU includes:

1/Ventilator associated pneumonia (VAP): which was diagnosed by increase needs for Ventilator, development of fever, leukocytosis or leukopenia, changes in chest x-ray and sputum culture.

2/Urinary tract infection (UTI) detected by urinary culture.

3/ Bloodstream infection Diagnosed by blood culture

B/Duration of ventilation.

C/Length of ICU stay (LOS).

D/Mortality.

Statistical analysis:

Data was exported to Microsoft Excel spreadsheets and analyzed using SAS (Statistical Analysis System), SPSS (Statistical Package for Social Sciences), and R Studio soft wares. The quantitative variables were described using the mean and standard deviation, and qualitative variables were presented as absolute and relative frequencies. The correlation of the quantitative variables was analyzed using Pearson's correlation coefficient. P values ≤0.05 were considered significant.

RESULTS

This observational study was conducted on 101 mechanically ventilated children admitted in pediatric intensive care units at Cairo University Pediatric Hospital during six months period from December 2017 to May 2018.

1\Demographic Data:

The median age of the included cases was 8 months (IQ 3-20) with a minimum age of 1 month to 144 months max.

Table 3: Distribution of SEX:

		N=101 (%)
Sex	Male	55 (54.5%)
	Female	46 (45.5%)

Dietetic History: before ICU admission showed that out of 101 cases, 78 were breastfed (77.2%) in the first six months of life

Causes of admission:

Table 4: Causes of admission

		N=101	%
Cause of admission	Respiratory diseases	58	57.4%
	CNS diseases	23	22.8%
	Septic shock	17	16.8%
	CVS diseases	3	3.0%

Respiratory causes included (Pneumonia, RDS, Foreign body inhalation, Stridor,), CNS diseases included (meningitis, encephalitis, Guillain-Barre syndrome, neurometabolic diseases), CVS causes included (congenital heart disease, myocarditis, infective endocarditis, Heart failure).

3\ Clinical examination:

**** Diagnosis of system failure:**

101 patients admitted in PICU had system failure with a minimum of 1 system failure (IQR 1-3) and a maximum of 6 median1.

Table 5: Number and percentage of system failure in 101 cases

		N=101	%
Number of system failure	One system failure	54	53.4%
	Two system failure	20	19.8%
	Three system failure	13	12.9%
	Four system failure	5	5.0%
	Five system failure	7	6.9%
	Six system failure	2	2%

** Type of system failure:

Table 6: Type of system failure

		N= 101	%
CNs failure	**No**	**59**	**58.4%**
	Yes	**42**	**41.6%**
CVS failure	**No**	**64**	**63.4%**
	Yes	**37**	**36.6%**
Respiratory failure	**No**	**18**	**17.8%**
	Yes	**83**	**82.2%**
Renal failure	**No**	**88**	**87.1%**
	Yes	**13**	**12.9%**
Hepatic failure	**No**	**94**	**93.1%**
	Yes	**7**	**6.9%**
Hematological failure	**No**	**84**	**83.2%**
	Yes	**17**	**16.8%**

Close inspection of this table reveals that respiratory failure represents the highest incidence (83 cases,82.8%), followed by CNS failure (42 cases,41.6%). Then the least incidence was noted in hepatic failure (only 7cases with 6.8%).

****Detection of Mortality risk using PRISM III score:**
Median of PRISM score was 10 (IQR 5-14) with minimum 2 and maximum 40.

3\Anthropometry:

A\Weight
The median of body weight in included cases was 7.5(5-11); the minimum weight was 2 kg while the maximum weight was 45 kg**.**

BW according to WHO Z Score

Table 7: BW according to WHO Z score

		NO=101 (%)
BW z score	Under weight	43 (42.6%)
	Normal	53 (52.5%)
	Overweight	4 (4.0%)
	Obese	1 (1.0%)

It is evident from inspection of this table that the BW Z score was normal in 53 cases representing 52.5%, while underweight in 43 cases representing 42.6% of cases. Only 4 cases (4%) were overweight while only one case was obese (1%).

B\ Height
The mean height of 101 cases was estimated to be 74.06± 22.57; the minimum height was 46 cm while the maximum height was 158cm.

Height according to WHO Z score

Table 8: Height according to WHO Z score

	Interpretation	N=101 (%)
Length /HT Z score	Normal	80 (79.2%)
	Stunted	21 (20.8%)

C\ BMI
Mean BMI was estimated to be 14.59± 3.12; the minimum BMI was 6.1kg/m2 while the maximum BMI was 25kg/m2cm.

BMI according to WHO Z score

Table 9: BMI according to WHO Z score

	Interpretation	N=101 (%)
BMI z score	Underweight	40 (39.6%)
	Normal weight	53 (52.5%)
	Overweight	8 (7.9%)

4\Risk assessment of malnutrition using STRONGKIDS:
STRONGKIDS score of malnutrition of included cases ranged from 0-5 median of 2 (IQR 1-3)

Table 10: Risk assessment of malnutrition using STRONGKIDS:

	Interpretation	N=101 (%)
STRONG KIDS Score	Low risk of malnutrition	18 (17.8%)
	Moderate risk of malnutrition	66 (65.4%)
	High risk of malnutrition	17 (16.8%)

5\ Outcome of critically ill children in the form of:
A-
evelopment of hospital-acquired infection (HAI):

Table 11: Development of hospital-acquired infection

		N= 101 (%)
A hospital-acquired infection (HAI)	No	58 (57.4%)

	Yes	43 (42.6%)

Table 12: episodes of HAI

	Interpretation	N=43 (%)
episodes of HAI	One episode of HAI	14 (32.5%)
	two episodes of HAI	17 (39.5%)
	three episodes of HAI	12 (28%)

The following HAIs were further evaluated:

1* Ventilator-Associated Pneumonia (VAP): out of 101 cases included in this study, 39 cases (38.6%) developed VAP.

2* Urinary tract infection (UTI):18 cases (17.8%) developed UTI.

3*Blood stream infection: 18 cases (17.8%) developed bloodstream infection.

B\ Period of ventilation: In this study,101cases were ventilated with a median of 7 days (IQR 4-12) (minimum 1 day and maximum 116 days).

C\Length of stay: median 9 days with minimum 1 day and maximum 116 days (IQR 5-16)

D\Mortality

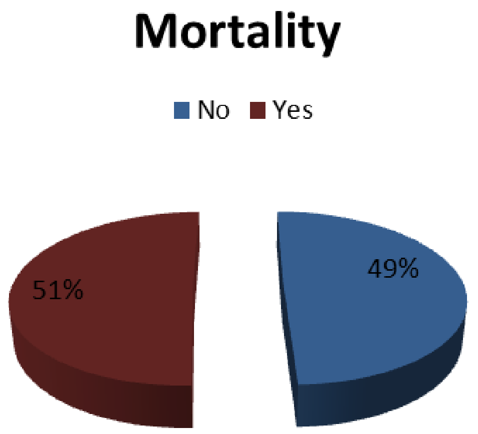

Figure 1: Mortality in included cases (51 cases died, 50 discharged)

The relationship between STRONG KIDS score and Anthropometry:

Table 13: Relation between STRONG KIDS score and Anthropometry:

		Low risk of malnutrition No.= 18	Moderate risk of malnutrition No.= 66	High risk of malnutrition No.= 17	Test value	P-value	Sig.
Wt (Kg)	Median (IQR)	7.9(6 – 11)	7.75(5 – 11)	5(3 – 12)	3.859	0.145	NS
	Range	3 – 45	3 – 40	2 – 25			
BW z score	Under weight	4(22.2%)	24(36.4%)	15 (88.2%)	20.957	0.002	HS
	Normal	12 (66.7%)	39(59.1%)	2(11.8%)			
	Overweight	2(11.1%)	2(3.0%)	0(0.0%)			
	Obese	0(0.0%)	1(1.5%)	0(0.0%)			
Ht (cm)	Median (IQR)	74.94± 26.70	74.20± 20.75	72.59± 25.95	0.050	0.951	NS
	Range	50 – 158	50 – 143	46 – 130			
Length /HT z score	Normal	15 (83.3%)	57 (86.4%)	8 (47.1%)	12.907	0.002	HS
	Stunted	3 (16.7%)	9 (13.6%)	9 (52.9%)			
BMI	Mean ± SD	16.03± 2.11	14.99± 2.97	11.49± 2.64	13.653	0.000	HS
	Range	12– 18.7	10 – 25	6.1 – 16.2			
BMI z score	Underweight	3(16.7%)	24(36.4%)	13(76.5%)	14.198	0.007	HS
	Normal weight	13(72.2%)	36(54.5%)	4(23.5%)			
	Overweight	2 (11.1%)	6(9.1%)	0(0.0%)			

*There was a highly significant (HS) correlation between BW- Z score and STRONG KIDS nutritional risk score with p-value 0.002, as 88.2% of those who had a high risk of malnutrition according to STRONG KIDS nutritional risk score were underweight according to WHO BW-Z score.

***There** was a highly significant correlation between LENGTH or HEIGHT Z score and STRONG KIDS nutritional risk score with P-value 0.002, as 83.3% of those who had low risk of malnutrition according to Strong Kids nutritional risk score was normal in height according to WHO Length\Height - Z score and 52.5% of who had high risk of malnutrition according to STRONG KIDS score were stunted.

*There was a highly significant correlation between BMI and STRONG KIDS nutritional risk score with p-value 0.000, a group of patients who had high nutritional risk score according to STRONG KIDS nutritional risk score had lowest BMI (11.49±2.64).

*There was a highly significant correlation between BMI Z SCORE and STRONG KIDS nutritional risk score with p-value 0.007, as 76.5% of cases who had a high risk of malnutrition according to STRONG KIDS nutritional risk score were underweight according to WHO BMI- Z score.

2\Relation between STRONG KIDS score and OUTCOME in critically ill patients:

Table 14: Relation between STRONG KIDS score and OUTCOME in critically ill patient:

		Low risk of malnutrition	Moderate risk of malnutrition	High risk of malnutrition	Test value*	P-value	Sig.
		No. = 18	No. = 66	No. = 17			
Hospital acquired infection (HAI)	No	12 (66.7%)	41 (62.1%)	5 (29.4%)	6.681	0.035	S
	Yes	6 (33.3%)	25 (37.9%	12 (70.6%)			
Ventilator associatedPneumonia(VAP)	No	13(72.2%)	43(65.2%)	6(35.3%)	**6.169**	**0.046**	S
	Yes	5 (27.8%)	23 (34.8%)	11 (64.7%)			
UTI	No	15 (83.3%)	53 (80.3%)	15 (88.2%)	**0.601***	**0.741**	**NS**
	Yes	3 (16.7%)	13 (19.7%)	2(11.8%)			
Blood stream infection	No	15 (83.3%)	50 (75.8%)	9 (52.9%)	**4.726**	**0.094**	**NS**
	Yes	3 (16.7%)	16 (24.2%)	8 (47.1%)			
Period of vent	Median (IQR)	4.5 (2 – 9)	6 (4 – 16)	9 (6 – 12)	**3.693**	**0.158**	**NS**
	Range	1 – 29	1 – 116	1 – 36			
Length of stay	Median (IQR)	7.5 (3 – 13)	9.5 (5 – 16)	10 (7 – 18)	**1.969**	**0.374**	**NS**
	Range	1 – 30	1 – 116	1 – 36			
Mortality	No	13(72.2%)	31 (47.0%)	6(35.3%)	**5.259**	**0.072**	**NS**
	Yes	5(27.8%)	35(53.0%)	11(64.7%)			

*There was a significant correlation between STRONG KIDS score and HAI with P-value 0.035, as 70.6% of cases who had a high risk of malnutrition according to STRONG KIDS nutritional risk score had HAI during admission in PICU.

*There was a significant correlation between STRONG KIDS score and VAP with P-value 0.046, as 64.4% of cases who had a high risk of malnutrition according to STRONG KIDS nutritional risk score had VAP during admission in PICU.

3\Relation between BMI and OUTCOME:

Table 15: Relation between BMI and OUTCOME

		BMI		**Test value**	**P-value**	**Sig.**
		Mean ± SD	**Range**			
Hospital acquired infection (HAI)	No	15.1 ± 2.7	9.4 – 21	1.964	0.05	S
	Yes	13.9 ± 3.5	6.1 – 25			
Ventilator-associatedpneumonia (VAP)	No	15.2± 3	9.4 – 25	2.650	0.009	HS
	Yes	13.6 ± 3.1	6.1 – 20.8			
UTI	No	14.4± 3	6.1 – 21	-0.996	0.322	NS
	Yes	15.3 ± 3.7	10 – 25			
Blood stream infection	No	15.1 ± 2.9	9.4 – 25	2.647	0.009	HS
	Yes	13.3 ± 3.4	6.1 – 20.8			
Mortality	No	15.1 ± 3.2	8.6 – 25	1.740	0.085	NS
	Yes	14.1± 3	6.1 – 20.8			

*There was a significant correlation between BMI and HAI with P-value 0.05, as patients who had HAI during admission in PICU had lowest BMI (13.9 ± 3.5).
*There was also a highly significant correlation between BMI and VAP with P-value 0.009, as patients who had VAP during admission in PICU had lowest BMI (13.6± 3.1).
*There was a highly significant correlation between BMI and bloodstream infection with p-value 0.009, as patients who had bloodstream infection during admission in PICU had lowest BMI (13.3± 3.4).

Table 16: Relation between BMI and (Episodes of HAI, Period of vent and length of stay):

	BMI	
	r	**P-value**
Episodes of HAI	-0.222	0.026
Period of ventilation	-0.227	0.022
Length of stay	-0.167	0.095

*There was an inverse significant correlation between BMI and number of episodes of HAI with P-value 0.026, as it was noted that patients with lower BMI had more episodes of HAI.
*There was also an inverse correlation between BMI and period of ventilation with P-value 0.022 as it was noted that patients with lower BMI had a larger period of ventilation.

4- Relation between the PRISM III score and STRONG KIDS score:

Table 17: Relation between PRISM score and STRONG KIDS score

Prism score	Low risk of malnutrition	Moderate risk of malnutrition	High risk of malnutrition	Test value	P-value	Sig.
	No. = 18	No. = 66	No. = 17			
Median (IQR)	**8 (3 – 8)**	**10 (5 – 15)**	**11 (8 – 14)**	**4.195#**	**0.123**	**NS**
Range	**3 – 26**	**2 – 40**	**3 – 21**			

*There was no significant correlation between STRONG KIDS score and PRISM score P-value (0.12).

DISCUSSION

In intensive care units (ICU), the nutritional status of pediatric patients can worsen due to obstacles that do not allow the provision of proper nutrition, such as volume restrictions, procedures and interventions, disease severity, frequent food breaks and lack of standardization of evidence-based processes for better nourishment [18].
The detrimental effects of malnutrition on growth, morbidity, and mortality in hospitalized children are often underappreciated. Therefore, the European Society for Pediatric Gastroenterology, Hepatology and Nutrition (ESPGHAN) called for nutritional risk screening for hospitalized Children in 2005 [5].
Critical illness greatly influences one's nutritional status; therefore, assessment of nutritional status should be an essential part of patient care. During a child's intensive care stay, however, the focus is on the primary medical problem, e.g., hemodynamic instability, serious infection, congenital anomaly, and nutritional status is often neglected.
This cross-sectional, observational study was carried out on all mechanically ventilated children admitted in pediatric intensive care units at Cairo University Pediatric Hospital during six months period from December 2017 to May 2018 with a minimum number of 100 cases.
The aim of this study was detecting the prevalence of malnutrition among mechanically ventilated critically ill children, the sensitivity of NRS (STRONG KIDS) to diagnose malnutrition concerning body mass index (BMI) as well as the relation between malnutrition and outcome in critically ill pediatric patients in PICU.
STRONG KIDS nutritional risk score is easy method for assessment of malnutrition in children that were hospitalized as it consists of 4 items (clinical assessment, Nutritional intake, and losses, Weight loss or poor weight gain) each one of this items evaluated with one point while the fourth items (high-risk disease) evaluated with 2 points and total of points was classified into low risk (0 points), moderate risk (1-3 points), high risk (4-5) [13].
In this study, conducted on 101 cases, the most common cause of admission PICU was related to respiratory causes (Pneumonia, RDS, FB inhalation and stridor) with 57.4% percentage this is followed by central nervous system causes (meningitis, encephalitis, Guillain-Barré syndrome, and other neurometabolic diseases) with

22.8% percentage this result corresponds with the study done by **Costa et al.** [18]in Brazil which revealed that Respiratory causes and CNS are the most common cause of admission in PICU.

Regarding the assessment of nutritional status according to anthropometry, height was used as an indicator for chronic malnutrition and body mass index (BMI) was used as an indicator for acute malnutrition.

The results in the present study displayed that the percentage of malnutrition (acute) depending on BMI for age Z score in included cases was 39.6%. Another study done in India by **Bagri et al.** [19] recorded a 60.2% percentage of malnutrition among critically ill pediatric patients. However, the study was done by **Bechard et al.** [20]in the USA that included 90 PICUS in 16 countries depending also on BMI for the age Z score showed a 17.9% percentage of malnutrition.

Similarly, the percentage of chronic malnutrition depending on height for age Z score in the present study was20.8%. A study done in Brazil by **Grippa et al.** [21] revealed that chronic malnutrition according to HT Z -the score was 41.2 %. These discrepancies in the assessment of acute and chronic malnutrition may be secondary to socio-economic factors and environmental factors in developing countries [22].

Assessment of risk of malnutrition by STRONGKIDS nutritional risk score was done in the present study for all cases. It revealed that moderate risk of malnutrition occupied the greatest percentage 65.3% followed by a low risk of malnutrition (17.8%) and a high risk of malnutrition (16.8%). The same conclusion was ascertained by **Oliveira et al.** [23] and **Moeeni et al.** [24].Although in these 2 studies patients admitted in PICU were excluded from hospital inpatients, This indicates that STRONG KIDS score as an assessment method of risk of malnutrition might yield the same results regardless of the type of patients but it might have a different impact on other issues.

It is noteworthy to mention that in the present study, the percentage of included cases who developed HAI was 42.6% this more or less is in agreement with the study done in Brazil by **Grippa et al.**[21] which displayed that the percentage of HAI was 32.8%. However, the study was done by **Bechard et al.** [20] in the USA revealed a lower percentage of HAI of 14.7% only. This may be ascribed to bad Infection control measures in developing country; also prevalence of malnutrition in the study done by **Bechard et al.** [20] was only 17.9% denoting the importance of nutritional status in preventing hospital-acquired infection (HAI) Episodes of HAI were assessed by developing one or more of the following (Ventilator-associated pneumonia "VAP", urinary tract infection " UTI" as well as bloodstream infection). It is evident from the results of the present study that13.9% developed one episode of HAI, 16.8% developed two episodes of HAI while 11.9% developed three episodes of HAI.

It is also obvious that the Percentage of cases who developed VAP, UTI, bloodstream infection in included cases in this study was 38.6%,17.8%,26.7% respectively against 8.3%, 5%,4.3 respectively in a study done by **Bechard et al.** [20]. Again, these different results had an association with infection control measures, nutritional status as mentioned before.

Concerning the assessment of the period of ventilation and PICU length of stay in this study, it was found that the median was 7 days, 9 days respectively. These results are similar to the study done by **Grippa et al.** [21] and **Bechard et al.** [20].

The Percentage of mortality in this study was found to be 50.5 %. This percentage was high in comparison to the percentage of mortality in studies done by **Grippa et al., [21], Bechard et al. [20]**as well as **Bagri et al. [19]**(27.8%, 7%, 38.8%) respectively. This difference in percentage between this study and other mentioned studies is due to a higher risk of developed HAI in this study, in comparison to other mentioned studies. Quality of patients was also crucial; it was obvious that our hospital is a tertiary care hospital and referral center for high morbid patients. It is also noted that other factors affect mortality rather than malnutrition, such as time of diagnosis and time of interference with critical conditions.

In the present study, a comparison between Anthropometric measurements and STRONGKIDS nutritional risk score was done to detect the efficacy of STRONGKIDS score in the assessment of malnutrition in critically ill patients.

Anthropometric measures that were assessed in this study were Body Mass Index (BMI) for age Z score, Weight for age Z score as indicators for acute malnutrition and height for age Z score as an indicator for chronic malnutrition.

In this study, there was a highly significant correlation between STRONG KIDS nutritional risk score and all anthropometric measures included in this study (BMI for age Z score, Weight for age Z score, height for age Z score) with P-values (0.007,0.002,0.002) respectively. This result is similar to the study done in china by **Cao et al.**[25] that included 1325 patients as well as a study done by **Ling et al. [26].**

In both studies, PICU patients were not included. However, no significant correlation was found between STRONG KIDS score anthropometric measurement in another two studies done by **Oliveira et al. [23]**and **Wiskin et al., [27].** Such a divergence between the results can be as a result of the tool that do not contemplate anthropometric data in its research. Instead, they were concerned with two items closely related to anthropometric measurements, such as poor nutritional status verified by physical examination, as well as the occurrence of weight loss judged by parents. Accordingly, the data obtained might be affected by the subjective analysis imposed **[23].**

A study was done by **Spagnuolo et al.,2013** which included 144 cases suggested the consideration of STRONG KIDS score in conjunction with other nutritional parameters due to their numerical system of classification. During this Italian research, many pediatricians pointed out the incompatibility between the clinical judgment of nutritional risk of the patient with the categorization (low, moderate or high risk) produced by the tool **[28].**

Besides, a study done in Turkey by **Beser et al. [29]**suggested the use of STRONG KIDS score in addition to anthropometric parameters to avoid missing of a malnourished child.

The relationship between anthropometry (especially BMI) and STRONG KIDS score to outcome in included cases was assessed Outcome included HAI, length of stay in PICU, the period of mechanical ventilation and mortality.

Assessment of HAI included several episodes of HAI, VAP, UTI, Bloodstream infection. In this study, there was a significant correlation between malnutrition (assessed by BMI and STRONG KIDS score) and HAI (P-value 0.05, 0.035 respectively). It is also to be noted that there was a highly significant correlation between BMI and VAP, bloodstream infection as well as Episodes of HAI in PICU (P-value 0.009, 0.009, 0.02 respectively). On the other hand, the STRONG KIDS score had a highly significant correlation with VAP only (P-value (0.04). This emphasizes the fact that malnutrition is associated with increased risk of HAI, with an extended scope of infections concerning BMI rather than STRONG KIDS score.

This result was similar to a study done by **Bechard et al. [20]**and a study carried out by **Bagri et al. [19]** both of these studies assessed BMI only. Also, it coincides with the result of the study done by **Cao et al. [25]** concerning the relation between STRONG KIDS score and HAI; in this study, PICU patients were not included. All of these results are due to impaired immune response that occurs in malnutrition as Initiation of both innate and adaptive immune responses involves the activation and proliferation of immune cells and the synthesis of an array of molecules, the associated DNA replication, RNA expression, protein synthesis. Consequently, the nutritional status of the host critically determines the outcome of infection [30]**.**

The results of the present study also revealed the significant correlation between malnutrition (assessed BMI only) and period of ventilation as it was noted that patients were admitted with low BMI had a longer period of ventilation (p-value 0.02). This result is similar to the study done by **Bechard et al. [20]**and study done by **(de Souza et al. [31]**that included 385 cases as well as a study done by **Mota et al. [32]**. This can be ascribed to several factors as nutritional status alteration can lead to protein catabolism, with fat-free mass depletion, which reduces respiratory muscle strength, maximum voluntary ventilation, and vital capacity, and also affects the lungs and the immune function, increasing the risk of respiratory infections [33]**.** On the other hand, no significant correlation was found between the period of ventilation and the STRONG KIDS score.

Contrary to expectation, the present study showed no significant correlation between malnutrition (assessed by BMI) and length of the PICU stay. This is similar to the study done by **Vermilyea et al. [34].** However**,** the result was against the results of other studies done by **Bagri et al. [19]**, **Bechard et al. [20]**as well as **Zamberlan et al. [35].** This difference of results might be due to the difference in the number of included cases as there were 332 patients in a study done by **Bagri et al. [19]**. There were also 1622 patients in the study done by **Bechard et al. [20]**while the present study included 101 cases.other factors might be responsible as a type of disease, management of disease and ICU performance. For example in the study done by **Zamberlan et al. [35]**only patients after orthotopic liver transplantation were included.

Similarly, in this study, no significant correlation between STRONG KIDS score and length of PICU stay can be obtained this result is against study done by **Cao et al. [25]** which included 1325 cases (against 101 in this study). Also, also in the present study, we followed up a length of PICU stay only while in the study done by **Cao et al. [25].** they followed up the length of hospital stay

One of the outcomes that were assessed in this study was the risk of mortality. The risk of mortality also assessed by the PRISM III score as one of the scores that can predict mortality in PICU patients. In this study, there was a significant correlation between PRISM III score and mortality with P-value: 0.000 this result is similar to the study done by **Brady et al. [36].**

In this study, there was no significant correlation between malnutrition (assessed by BMI and STRONG KIDS score) and mortality this result corresponds with the studies done by **Zamberlan et al. [35]**, **de Souza et al. [31]**and **Bagri et al. [19].** However, this result is against studies done by **Bechard et al. [20]** and **Leite et al. [37]**. It is noteworthy to mention that all these 5 studies used BMI for assessment not STRONGKIDS score**.** This discrepancy in results might be due to a different number of patients included in each study and the fact that mortality not only depends on nutritional status of the patients but also the clinical characteristics of the patient, ICU performance, infrastructure [38]**.**

The present study also reveals the absence of correlation between STRONG KIDS score and PRISM III score. It should be noted that most of the studies done to detect the relationship between STRONG KIDS score and outcome were on hospitalized patients (not PICU population). Of course, this may be detrimental in the analysis of results.

CONCLUSION

- Malnutrition is common in critically ill children with a percentage of 39.6% depending on BMI.
- Malnutrition is associated with increased risk of hospital-acquired infection especially VAP.
- STRONGKIDS score can be used as an easy method of assessment of malnutrition (either acute or chronic) of critically ill children.
- STRONGKIDS score in addition to anthropometry can be used together in assessing nutritional status to avoid missing cases of malnutrition.

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