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Nutritional Status Assessment of Mechanically Ventilated Critically Ill Children and its Impact on Duration of Mechanical Ventilation

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ABSTRACT

Introduction: Nutritional support for children who are being seriously unwell has not thoroughly studied and is a contentious issue in Intensive pediatric care. Infants and children who are critically ill lack clear guidelines regarding the best type of nutrition to provide at what time.

Objectives: to assess the nutritional status of our patients during time of hospital stay, in critically ill children to investigate significance of nutritional condition on the effect of admission on length of stay of mechanical ventilation (MV) and to assess how mechanical ventilation affect the nutritional status of critically ill patients.

Methods: Sixty-four newborns and young children who were brought to PICU and required mechanical breathing were subjects of this research. Cases that required mechanical ventilation and were admitted to the PICU were included. Known malnutrition and cases with dehydration were excluded.

Results: There was significant difference between different Subjective Global Assessment (SGA) nutritional score groups and time to reach full caloric requirement with higher mean time in malnourished group and this indicates that the early nutrition leads to good outcome and needs less time to reach full caloric requirement. There was statistically significant difference between different SGA Nutritional score groups and ventilation duration with higher mean duration was in malnourished group and this mean that children who were underweight needed to be on mechanical ventilation support for longer.

Conclusion: Anthropometric parameters weight-age z score, height-age z score, MAC-age z score and calf circumference Z score were able to predict mechanical ventilation duration.

Keywords: Intensive care unit, Pediatrics, Anthropometry, Mechanical ventilation, Malnutrition.

INTRODUCTION

Malnutrition is a typical issue during hospital stays and tends to get worse as the length of stay increases[(1)]. Depending on the variables influencing the nutritional assessment, malnutrition affects critically sick children between 25% and 70% of the time[(2)].

Children and infants are particularly vulnerable to nutritional issues. Children's reserves are less and their resting energy expenditure is higher than adults' because they have lower proportions of muscle and fat. Children are less tolerant of fasting than adults and more susceptible to protein deficiency as a result and are more likely to have malnutrition when they experience major sickness [(3)].

Critically ill children often don't get enough calories due to enteral or parenteral feeding, and protein can't be started because of gastrointestinal intolerance or has to be delayed because they can't drink enough fluids or because enteral nutrition has to be stopped to give medicine or do procedures that require sedation [(4)].

Patients who are on a ventilator are more likely to be underfed in terms of energy and protein than non-ventilated patients [(5)]. Malnutrition also results in a decrease in the size of the diaphragm and a decline in the efficiency of the breathing muscles, as well as a reduction in lung capacity [(6)].

Early nutritional screening is crucial in determining the best nutritional management, which may shorten the amount of time a patient is dependent on a ventilator, how long they had to stay in the hospital or ICU, and their mortality [(7)].

Clinical indicators can be used to figure out a person's nutritional status. Anthropometric measurements (such as body weight, BMI, mid-arm muscle circumference (MAMC), triceps skinfold thickness (TSF), and calf circumference), biochemical indices (such as visceral protein [total protein, albumin, and pre-albumin], and immune competence markers (such as lymphocyte(s) count) are among them[(8)].

A clinical questionnaire used to assess nutritional status is the Subjective Global Assessment (SGA). It is based on the patient's medical history and a bedside physical exam. Laboratory information is not required for this screening tool. SGA is the nutrition screening test with the best diagnostic value for patients who are very sick [(9)].

In addition to a comprehensive physical exam, laboratory markers may be utilised to diagnose malnutrition [(10)].

So, we aimed to assess the nutritional status of our patients during the time of hospital stay, to ascertain

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the role of nutritional status at the time of admission as a predictor of the length of mechanical ventilation (MV) in children with critical illnesses and to evaluate how MV affects the nutritional status of critically sick patients.

PATIENT AND METHODS

This prospective cohort study was conducted on sixty-four infants and children of both sexes who were admitted to PICU and required mechanical ventilation.

They were brought in one by one from the Pediatric Intensive Care Unit at the Children's Hospital Zagazig University in Egypt. from December 2021 to June, 2022.

Cases admitted to PICU and required mechanical ventilation were included. Known malnutrition cases and cases with dehydration were excluded.

METHODS

All patients were subjected to the following:

A. **History taking** including subjective global assessment, history taking included socio-demographic and mother education, feeding problem, type of feeding, dietetic history, history of disease that might interfere with the nutrient intake and history of any acute or chronic illness.

B. Examination:

1. Each patient was subjected to thorough physical and general examination before enrollment with stress on the vital data of the patients [temperature, heart rate, blood pressure, and respiration rate].
2. Systemic examination, chest examination (in patients where the lung was the primary site of infection), heart examination, abdominal and neurological examination as well as Glasgow scoring in comatose patients.
3. The children were also examined in good light for general evaluation or any healthy hazard. To identify any child's signs of malnutrition. It included assessment of hair, face, tongue, eyes, lips, gums, and teeth for any signs of malnutrition and/or vitamin deficiency. It also included assessment of the child's nails, skin, muscles, and abdomen.
4. Anthropometric measurements using z-scores: Nutritional status was assessed within 72 h of admission. Body weight measurement (BW), body length measurement (BL), BMI, mid arm circumference (MUAC), and calf circumference were assessed.

C. Management in intensive care:

- Patients who were on mechanical ventilation were followed as regards the length of stay on MV.
- Early and good nutritional intervention and follow up of patient weight.
- Patients who were on vasoactive drugs were followed up as regards the type and doses of drugs taken.
- Patients who were on antibiotic and antifungal drugs were followed up as regards the type, days and doses of drugs taken.
- Blood transfusion, plasma transfusion, albumin transfusion and renal dialysis

Outcome: The primary outcome was the number of days of mechanical ventilation and the number of days in the PICU.

Ethical consent:

This study was ethically approved by the Institutional Review Board of the Faculty of Medicine, Zagazig University. Written informed consent was taken from all the caregiver of the participants. The study was conducted according to the Declaration of Helsinki.

Statistical analysis

Using SPSS 26.0 for Windows, all data were gathered, tabulated, and statistically examined (SPSS Inc., Chicago, IL, USA). Average, standard deviation, range, and median (interquartile range) were used to convey quantitative data, and absolute frequencies (number) and relative frequencies were used to express qualitative data (percentage). Independent t-test was used to compare two sets of normally distributed quantitative data, while Mann-Whitney test was used to compare two groups of abnormally distributed quantitative variables. Kruskal-Wallis test was used to compare more than two groups of non-normally distributed variables. Chi^2 test was used to compare qualitative data. Kaplan Meyer was also used. P value <0.05 was considered significant.

RESULTS

As shown in table (1), sixty-four patients were enrolled in the study. Equal participants from males and females with mean age was 36.73±45.36 months. There was no difference in nutritional status based on age or gender between the studied groups.

Table (1): Basic characteristics of the studied patients (n=64)

Characteristic		Study group (n=64)	adequately nourished (n=23)	Malnourished (n=41)	test	P value
Age by months Median (IQR)		38 (27-54)	30 (12-72)	22 (10-45)	-1	0.316
Sex	**Male**	32 (50%)	10 (43.4%)	22 (53.6%)	0.610	0.737
	female	32 (50%)	13 (56.6%)	19 (46.4%)		

Median was used for non-parametric data.

As shown in table 2, there was statistically significant difference between studied groups as regard anthropometric indicator. Based on WAZ anthropometric indicator, 58.5% of malnourished cases had z score < (-2), based on the HAZ, the number of people who were malnourished was 56.1% with z score < (-2), based on HCAZ, (34.1%) were malnourished with z score < (-2), and regarding calf circumference z score (48.8%) of cases were malnourished with z score < (-2).

Table (2): Comparing frequency distribution of anthropometric parameters based on Z-score cutoff within the studied group (n=64)

Variables		Adequately nourished (n=23)		Malnourished (n=41)		test	P value
		No.	%	No.	%		
BMI for age z score (WAZ)	**z score < (-2)**	0	0	10	24.4	6.649	**0.010***
	z score ≥ (-2)	23	100	31	75.6		
Weight for age z score (WAZ)	**z score < (-2)**	2	8.7	24	58.5	15.174	**<0.001***
	z score ≥ (-2)	21	91.3	17	41.5		
Height for age z score (HAZ)	**z score < (-2)**	7	30.4	23	56.1	3.897	**0.048***
	z score ≥ (-2)	16	69.6	18	43.9		
MAC for age z score	**z score < (-2)**	3	13	24	58.5	12.503	**<0.001***
	z score ≥ (-2)	20	87	17	41.5		
Head circumference for age (HCAZ)	**z score < (-2)**	2	8.7	14	34.1	5.090	**0.024***
	z score ≥ (-2)	21	91.3	27	65.9		
Calf circumference	**z score < (-2)**	0	0	20	48.8	16.319	**<0.001***
	z score ≥ (-2)	23	100	21	51.2		

*: Significant

As shown in table (3), (64.1%) of admitted cases were severely or moderately malnourished, (35.9%) of cases were well nourished.

Table (3): Incidence of malnutrition on admission according to SGA score within the studied group

Variables		Cases group (n=64)	
		No.	%
Medical class	well nourished **(A)**	23	35.9
	Malnourished **(B+C)**	41	64.1

A (well nourished), B (mildly/moderately malnourished), C (severely mal nourished)

There was statistically significant difference between different SGA Nutritional score groups and time to reach full caloric requirement with higher mean time in malnourished group. Ventilation duration and ICU duration were significantly higher in the malnourished group.

Table (4): Comparing time of nutritional start, time to reach full caloric requirement, ventilation duration and ICU duration in relation to SGA Nutritional score

Variable	SGA Nutritional score		Tests	
	Group A (n=18)	Group B+C (n=29)	*T/z*	***P* value**
Time of nutritional start by days Mean±SD (Range)	2.28±1.53 (1-6)	2.83±1.81 (1-7)	-1.071	0.290
Time to reach full caloric requirement by days Mean±SD (Range)	2.44±1.54 (1-8)	4.62±2.62 (2-10)	-3.185	**0.003***
Ventilation duration **Mean±SD**	5 (2-7)	7 (3.25-11.75)	3.16	**0.002***
Intensive Care Unit duration	8 (5-10)	9 (5-14.75)	3.18	**0.002***

Median was used for non-parametric data.
A (well nourished), B (mildly/moderately malnourished), C (severely mal nourished),
*: Significant

There was statistically significant difference between different SGA Nutritional score groups and mortality rate with higher percentage of death (53.7%) in malnourished group.

Table (5): Comparing Nutritional score of the studied groups in relation to survival status

Variable	SGA Nutritional score				Tests	
	Group A (n=23)		Group B+C (n=29)		X^2	***P* value**
	No	(%)	No	(%)		
Died	7	30.4	22	53.7	3.207	0.073
Survived	16	69.6	19	46.3		

A (well nourished), B (mildly/moderately malnourished), C (severely mal nourished)

There were statistically significant positive correlations between ventilation duration and each of time of nutritional start and time to reach full caloric requirement.

Table (6): Correlation between ventilation duration and each of time of nutritional start and time to reach full caloric requirement

Variables		Ventilation duration
Time of nutritional start by days	r	0.871*
	P	<0.001
Time to reach full caloric requirement by days	r	0.872*
	P	<0.001

*: Significant

According to the z-score threshold for MAC-age z score, there was a significant difference in the length of mechanical ventilation between patients who were undernourished (-2 Z-score) and sufficiently nourished (-2 Z-score). According to the z-score cutoff for weight-age z score, there was a significant difference in the length of mechanical breathing between patients who were undernourished (-2 Z-score) and appropriately nourished (-2 Z-score). According to the z-score cutoff for height-age z score, there was a significant difference in the length of mechanical breathing between patients who were undernourished (-2 Z-score) and appropriately nourished (-2 Z-score). According to the z-score cutoff for calf circumference, there was a significant difference in the length of mechanical breathing between patients who were undernourished (-2 Z-score) and sufficiently nourished (-2 Z-score).

Table (7): Kaplan-Meier analysis of the correlation between anthropometric measures and the time required for mechanical breathing in children with malnutrition

	Mean				Chi square	P value
	Estimate	Std. Error	95% Confidence Interval			
			Lower Bound	Upper Bound		
MAC-age z score						
z score ≥ (-2)	15.843	2.500	10.942	20.743	7.708	0.005*
z score < (-2)	43.203	10.672	22.287	64.119		
Weight-age z score						
z score ≥ (-2)	16.050	2.601	10.952	21.148	7.602	**0.006***
z score < (-2)	41.657	10.148	21.767	61.548		
Height-age z score						
z score ≥ (-2)	16.885	2.506	11.972	21.797	5.044	**0.025***
z score < (-2)	39.668	9.770	20.520	58.817		
Calf circumference z score						
z score ≥ (-2)	16.065	2.262	11.633	20.498	9.345	**0.002***
z score < (-2)	47.097	11.805	23.960	70.235		

DISCUSSION

Sixty-four patients were enrolled in the study. Their mean age was 36.73±45.36 months with median38(27-54). In agreement with our study, **Meyer *et al.*** [11] demonstrated that, all of the patients in the audits had the same mean (SD) age: 3.5 (4.3) years in 1994-1995, 3.2 (4.2) years in 1997-1998, 3.3 (4.3) years in 2001, and 3.2 (4.1) years in 2005. **Grippa *et al.*** [12] demonstrated that the population under consideration's demographic and medical characteristics showed that its median age was 21.1 months (range 4.4–82.2).

Frisancho, [13] showed that TSF and UAMA may be useful in determining body structure. TSFZ Z-score decreases are associated with a lack of fat stores and chronic malnutrition, whereas UAMAZ decreases are associated with a lack of protein stores and acute malnutrition.

We revealed that (64.1%) of admitted cases were mildly or moderately malnourished, (35.9%) of cases were severely malnourished and (37.5%) were well nourished. In agreement with our study, **Bagri *et al.*** [14] showed that, 57.2% overall prevalence of malnutrition was discovered. There is a high frequency of malnutrition in poor nations; in India, approximately fifty percent of children under the age of five were stunted [15].

In the current study, no statistically significant distinction existed between the various SGA Nutritional score groups and the time of nutritional initiation with a higher mean time was in the severely malnourished group. However, there was a statistically significant difference between the various SGA Nutritional score groups and the time to meet the full caloric requirement with a higher mean time in the severely malnourished group, suggesting that early nutrition leads to good outcomes and is necessary.

Martinez *et al.* [16], who looked at a global population, came to similar conclusions. They discovered that only 13% of patients were receiving appropriate enteral nutrition by day 3, which is defined as 66.6% of their caloric needs, and that only 33% of patients were malnourished in the PICU by day 7. Although enteral nutrition has been shown to be beneficial, there are still considerable barriers standing in the way of its widespread use. We found that, there were statistically significant positive correlations between ventilation duration and each of time of nutritional start and time to reach full caloric requirement.

For appropriate overall care, management, and outcome for babies and children who are critically sick, adequate nutritional support must be provided [17].

The survival time of nutritional start had a statistically significant difference in the current investigation, with the shortest mean time in survived cases. Additionally, there was a statistically significant difference in survival with regard to the amount of time needed to meet the full caloric requirement, with a lower mean duration in the survivors group. This shows that good outcomes come from early nutrition and that it takes less time to meet the full caloric requirement, which raises the survival rate in individual cases.

Similar to our study, **Larson-Nath and Goday** [18] discovered that early enteral feeds, based on studies conducted at a single centre, have demonstrated improved outcomes in terms of time to enteral nutrition [19,20] and the proportion of calories received from enteral nutrition [21], as well as decreased gastrointestinal complications and improved anthropometric measurements [22]. If growth and energy targets are not being met, KDOQI, [23] advises the early use of supplemental oral, enteral, or parenteral feeding.

By using the z-score cutoff for the height-age z score, we were able to conclude that there was a substantial difference in the length of mechanical breathing between patients who were enough nourished (-2 Z-score) and those who were sufficiently malnourished (-2 Z-score).

According to **Grippa *et al.*** [12], Children who satisfied the HAZ criterion for malnutrition were more likely to require mechanical ventilation in the future than those who did not meet the requirements, according to Cox's regression analysis. Even after taking into account sex, age, and severity of illness scores, this was still true.

We showed that there was a significant difference in the length of time malnourished patients needed to utilise mechanical breathing (-2 Z-score) and those who were adequately nourished (-2 Z-score). This was in agreement with **Grippa *et al.*** [12], who demonstrated that among their sample of critically ill children, malnutrition was related to the length of mechanical ventilation. One such anthropometric parameter was the calf circumference z score. At the time of admission to the PICU, an anthropometric assessment of the child's nutritional status should be made. This will make it possible for the group of kids who are already underweight to receive targeted nutritional rehabilitation.

CONCLUSION

On admission to the PICU, the prevalence of malnutrition was high. The duration of mechanical ventilation was predicted by the anthropometric parameters weight-age z score, height-age z score, MAC-age z score, and calf circumference z score. When a child is admitted to the PICU, their nutritional status should be checked with anthropometry. This will make it easier to find underweight children who could benefit from a targeted individualized nutrition intervention.

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