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Original Article

Paediatrics Section

Impact of Malnutrition on Morbidity and Paediatric Risk of Mortality Score among Critically-ill Children: A Prospective Observational Study

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ABSTRACT

Introduction: Malnutrition among critically ill children admitted to the Paediatric Intensive Care Unit (PICU) continues to be a serious health concern, particularly in developing nations where the prevalence of malnutrition is disproportionately high. Malnourished children have weak immune system. This leads to higher chances of mortality and morbidity in such children.

Aim: To evaluate the impact of malnutrition on mortality and morbidity in critically ill children who were admitted to PICU in a hospital in Navi Mumbai.

Materials and Methods: The present prospective observational study was conducted in the PICU of the Dr. D. Y. Patil, Nerul Hospital from October 2022 to November 2023. Study included 144 children aged between 1 and 12 months who were admitted in the PICU of the institution. Anthropometric measurements based on World Health Organisation (WHO) growth standards were used to evaluate nutritional status. PRISM 3 scores were established within the initial 24 hours of admission. Clinical variables and outcomes with respect to their nutrition, mortality, PICU stay and ventilation duration was compared. IBM Statistical Package for Social Sciences (SPSS) Statistics 26.0 was used to analyse the data, and a p-value of less than 0.05 was deemed statistically significant.

Results: The study population's mean age was 4.13±3.65 years, with 45.1% of participants being female and 54.9% being male. Using Odd's ratio, severe malnutrition in children under five-year-old was significantly linked to an increased risk of death (OR=11.4, p=0.004) and the need for ventilation (OR=17.3, p<0.001). Severe thinness was associated with a significant increase in the odds of ventilation (OR=24.0, p=0.015) and prolonged PICU stay (OR=37.5, p=0.008) in children older than five years. In both age groups, there was no significant difference in PRISM 3 scores between nutritional groups (p=0.442 and p=0.910, respectively).

Conclusion: In critically ill children, severe malnutrition and thinness are powerful indicators of negative outcomes like higher mortality, the need for ventilation, and lengthier PICU stays. In PICU settings, improving prognosis and lowering complications requires early nutritional assessment and focused intervention.

Keywords: Anthropometric parameters, Mechanical ventilation, Nutritional status, Obesity, Prognosis

INTRODUCTION

Malnutrition in critically ill children is a major concern in developing countries [1]. According to the World Health Organisation, the prevalence of undernutrition in developing countries is approximately 25-30%, while childhood overweight and obesity affect about 5-10%; in contrast, developed countries report undernutrition rates of less than 2-3%, but overweight and obesity rates between 20-30% [1]. In the present study, the term "malnutrition" corresponds specifically to undernutrition and does not include overnutrition or obesity. Malnourished children have higher morbidity and mortality due to immune suppression and complications [2].

Studies have shown that malnutrition adversely affects clinical outcomes by prolonging PICU stay, increasing the duration of mechanical ventilation, and raising mortality rates [2-4]. The Paediatric Risk of Mortality (PRISM 3) score, a validated tool used to assess the severity of illness and predict mortality in critically ill children, has been shown to correlate strongly with nutritional status [5]. A previous study found association of malnutrition with increased mortality in PICU [4]. However there are various lacunae that exists in current literatures which the present study aimed to address. These lacunae are with respect to lack of standardised WHO grading of nutritional status, comparing their mortality and morbidity in PICU in a developing nation like India. The current study evaluates the independent prognostic contribution of nutritional status beyond PRISM 3 scoring [5,6]. Secondly, the authors have used standardised WHO growth parameters to define nutritional status and anthropometry for the children [7,8].

Various morbidity outcomes were also evaluated in relation to the duration of ventilation and PICU stay which was lacking in previous studies [4-6]. Overall, the present study gives an estimate of mortality and morbidity in PICU children in a developing nation like India, grading them across standardised WHO nutritional status and not just relying on PRISM scoring for prognostication. The study highlights the significance of early detection and suitable nutritional intervention in enhancing clinical outcomes by assessing the prevalence of malnutrition among children admitted to the PICU and its impact on outcomes. The study aimed to ascertain the impact of malnutrition on the PRISM 3 score, alongside morbidity and mortality rates in critically ill children.

MATERIALS AND METHODS

The present prospective observational study took place at the PICU at DY Patil Hospital in Navi Mumbai, Maharashtra, India over the course of one year from October 2022 to November 2023. The study protocol was approved by the Institutional Ethics Committee (IEC no: DYP/IECBH/2022/082). Informed consent was obtained from the parents or guardians of all participants.

Inclusion criteria: All children between 1 month to 12 years admitted in PICU irrespective of the type of illness were included.

Exclusion criteria: Patients with congenital anomalies, chromosomal disorders or prior nutritional interventions were excluded.

Sample size calculation: Sample size was calculated using the formula n=4pq/l*l, 'n' is sample size, 'p' is prevalence of malnourished children in PICU which is 10, 'q' is 100-p=90, 'l' is allowable error which we took as 5% [9]. Hence, sample size= 4*10*90/5*5=144.

Study Procedure

Data collection: Detailed nutritional history was obtained, and anthropometric measurements including weight, height and Mid-Upper Arm Circumference (MUAC) were recorded within 24 hours of admission. Nutritional status was classified based on weight-for-age, height-for-age, and weight-for-height z-scores, following growth charts and standards of 3 (WHO) for ≤5 years and IAP growth charts for >5 years [10,11]. The PRISM 3 score was calculated within the first 24 hours of admission to assess illness severity. Weight was measured using Phoenix NEP-10/40/120 scale (accuracy 10g; range 200g-120kg). Length/height were measured using a standard infantometer and stadiometer.

Nutritional status was classified using WHO criteria: for children <5 years as no malnutrition, Moderate Acute Malnutrition (MAM) defined by a weight-for-height/length Z-score between -3 and -2 and/or a mid-upper arm circumference of 115-125 mm, and Severe Acute Malnutrition (SAM) defined by weight-for-height/length Z-score less than -3 and/or a mid-upper arm circumference of less than 115mm and/or presence of bilateral pitting oedema; for >5 years as normal, thinness defined as BMI-for-age Z-score less than -2 Standard Deviations (SD), and severe thinness defined as BMI-for-age Z-score less than -3 SD.

Socioeconomic status was assessed using the Updated Kuppuswamy's Classification (2021) [12]. Data included demographics, diagnosis, ventilation duration, PICU stay, and outcome, in addition, data pertaining to admitting diagnosis, PRISM 3 score which had 14 components, scoring based on vitals and lab investigations [13] , duration of hospitalisation, mechanical ventilation (requirement and duration), and final outcomes were recorded for all participants. Higher the score, higher the probability of mortality.

PRISM 3 scoring, first developed by Pollock et al., needed validation to be used in a developing nation like India [13]. This is essential because mortality is affected not only by intrinsic PICU factors but also significantly depends on patient profile and demographics in a given particular area. Popli V et al., field tested and validated PRISM 3 scoring system in a similar tertiary care hospital in Jodhpur, India which comprised of 14 components which was used for this study [Annexure 1] [14].

STATISTICAL ANALYSIS

The BM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA) [2] was used to do the statistical analyses. Odd's ratio was used to compare the malnourished and well-nourished groups. A p-value of less than 0.05 was considered statistically significant. The study sought to ascertain the relationships among nutritional status, PRISM scores, and clinical outcomes.

RESULTS

The present study assessed 144 PICU admissions, comparing outcomes across nutritional categories revealing significant association between malnutrition and adverse clinical outcomes.

The baseline clinical characteristics of the study population, stratified by age group (≤5 years and ≥5 years) and nutritional status. In children ≤5 years, median age was similar across groups (p=0.83). Both severe and moderate malnutrition was more common in males 13 (72.2%) and 7 (53.8%), respectively. PRISM 3 scores were highest in the no malnutrition group (8.40±6.17) compared to moderate (7.26±8.01) and severe (6.61±5.26), but not statistically significant. In children >5 years, median age was similar across groups (p=0.521). Severe thinness was more common in males (75.0%), with significant association (p=0.034). PRISM 3 scores were comparable across the groups- 4.80±4.22 in the no thinness group, 4.89±2.96 in the moderate thinness group, and 5.20±3.33 in the severe thinness group. SE status was not significantly associated with nutritional status in this age group (p=0.830) [Table/Fig-1].

In children ≤5 years, severe malnutrition was significantly associated with higher ventilation needs 10 (58.3%) and mortality 7 (38.9%) (p<0.001). Although more frequent, prolonged hospital stays were not statistically significant (p=0.347) in children aged >5 years severe thinness was substantially associated with longer hospital stays (p=0.003) and ventilation (p=0.004). Severe thinness group had a higher mortality rate 3 (25.0%), although it was not statistically significant (p=0.296) [Table/Fig-2].

Variables		≤5 years (n=90)				>5 years (n=54)			
		No malnutrition (n=59)	Moderate malnutrition (n=13)	Severe malnutrition (n=18)	p-value	No thinness (n=31)	Moderate thinness (n=11)	Severe thinness (n=12)	p-value
Age (Median, IQR) in months		15 (5.0-24.0)	11 (4.25-24.0)	11.5 (3.0- 25)	0.83	108.0 (84-120)	96.0 (78-126)	90 (79.5-105)	0.521
Sex (n, %)	Male	35 (60.0%)	7 (53.8%)	13 (72.2%)	0.521	10 (32.3%)	6 (54.5%)	9 (75.0%)	0.034
	Female	24 (40.0%)	6 (46.2%)	5 (27.8%)		21 (67.6%)	5 (45.5%)	3 (25.0%)	
PRISM 3 score (Mean, SD)		8.40 (6.17)	7.26 (8.01)	6.61 (5.26)	0.507	4.80 (4.22)	4.89 (2.96)	5.20 (3.33)	0.956
SES	Lower	4 (6.8%)	3 (23.1%)	0 (0.0%)	0.584	2 (6.5%)	4 (36.4%)	0 (0.0%)	0.830
	Upper lower	17 (28.8%)	6 (46.2%)	7 (38.9%)		12 (38.7%)	2 (18.2%)	8(66.7%)	
	Lower middle	27 (45.8%)	4 (30.8%)	8 (44.4%)		9 (29%)	3 (27.3%)	3 (25.0%)	
	Upper middle	9 (15.3%)	0 (0.0%)	2 (11.1%)		5 (16.1%)	2 (18.2%)	1 (8.3%)	
	Upper	2 (3.4%)	0 (0.0%)	1 (5.6%)		3 (9.7%)	0 (0.0%)	0 (0.0 %)	

[Table/Fig-1]: Baseline clinical characteristics.

Variables		≤5 years				>5 years			
		No malnutrition (n=59)	Moderate malnutrition (n=13)	Severe malnutrition (n=18)	p-value	No thinness (n=31)	Moderate thinness (n=11)	Severe thinness (n=12)	p-value
PICU stay (days)	≤7 days	50 (85.2%)	10 (74.2%)	11 (70.8%)	0.347	29 (92.6%)	9 (83.3%)	3 (25.0%)	0.003
	>7 days	9 (15.0%)	3 (25.8%)	7 (29.2%)		2 (7.4%)	2 (16.7%)	9 (75.0%)	
Ventilated		4 (7.5%)	2 (16.1%)	10 (58.3%)	<0.001	3 (11.1%)	1 (11.1%)	9 (75.0%)	0.004
Ventilation (days)	≤7 days	3 (75.0%)	1 (50.0%)	3 (30.0%)	0.303	2 (66.7%)	1 (100%)	2 (22.2%)	0.164
	>7 days	1 (25.0%)	1 (50.0%)	7 (70.0%)		1 (33.3%)	0 (0.0%)	7 (77.8%)	
Mortality		3 (5.1%)	0 (0.0%)	7 (38.9%)	<0.001	1 (3.2%)	1 (9.1%)	3 (25.0%)	0.296

[Table/Fig-2]: Comparison of outcome variables among the three nutritional categories.

[Table/Fig-3] shows that in children ≤five-year-old, severe malnutrition was significantly associated with higher odds of mortality (OR=11.4, p=0.004) and the need for ventilation (OR=17.3, p<0.001) and a longer PICU stay (OR=3.54, p=0.046). However, the chances of prolonged ventilation (OR=7.3, p=0.151) was not statistically significant. In children >5 years old, severe thinness was significantly associated with a higher need for ventilation (OR=2.84, p=0.027) and longer PICU stay (OR=3.75, p=0.08). Mortality was higher in children with severe thinness (OR=8.67) but this was not statistically significant (p=0.161). Moderate malnutrition or moderate thinness did not show any significant association with the outcomes [Table/Fig-3].

Additionally, studies by Bechard LJ et al., and Bagri NK et al., support the observation that undernutrition increases the risk of morbidity and mortality, especially in mechanically ventilated children [8,19,20]. These results were consistent with odds ratios. Severe malnutrition was significantly associated with increased mortality risk (OR=11.4, p=0.004) and the necessity for ventilation (OR=17.3, p<0.001) in children under five-year-old. The need for ventilation (OR=2.84, p=0.027) and prolonged PICU stay (OR=3.75, p=0.08) correlated significantly with severe thinness in children over five years age. The correlation with mortality in this cohort (OR=8.67) did not achieve statistical significance; however, the trend persists as clinically pertinent.

Age	Outcome Variables	Mortality	Ventilation	Prolonged PICU stay	Prolonged ventilation
≤5 years	Non-malnourished nutrition	1	1	1	1
	Moderately malnourished	0.633 (0.06- 7.3)	2.37 (0.52- 10.8)	1.67 (0.38- 7.27)	8 (0.31- 21.3)
	Severely malnourished	11.4 (2.2-59.01)	17.3 (4.1- 72.1)	3.54 (1.08- 11.55)	7.3 (0.48- 11.2)
	p-value	0.004	<.001	0.046	0.151
>5 years	No Thinness	1	1	1	1
	Moderate Thinness	3.25 (0.27- 33.8)	1 (0.15- 6.67)	0.5 (0.374- 16.7)	0.56 (0.01-24.45)
	Severe Thinness	8.67 (0.424- 177.32)	2.84 (1.27-6.8)	3.75 (2.56- 8.40)	0.25 (0.01- 7.45)
	p-value	0.161	0.027	0.08	0.423

[Table/Fig-3]: Odds ratio of the outcome variables in three nutritional categories in ≤5 years and >5 years age group.

DISCUSSION

With a focus on PRISM 3 scores, this study assessed the effect of malnutrition on morbidity and mortality in critically ill children admitted to the PICU. The results support the conclusions of a number of earlier studies by showing that malnutrition has a substantial impact on clinical outcomes. Of the children in the current study population, 50% of those over five had some degree of thinness, and 34.4% of those under five were malnourished.

Significant mortality (38.9%, p<0.001) and high incidence of mechanical ventilation (58.3%, p<0.001) was seen in severely malnourished children under five years of age. This finding was corroborated by de Souza Menezes F et al., which found that recovery was longer and mortality was higher in PICU children in malnourished category [4]. In a similar vein, Daskalou E et al., observed that children who were malnourished had worse outcomes and needed mechanical ventilation for longer periods of time [15]. On the other hand, this study found no significant differences in PRISM 3 scores between nutritional categories. It's interesting to note that the well-nourished group had the highest mean PRISM 3 score among children ≤5 years (8.40±6.17), indicating that factors like the type of diagnosis or the severity of the underlying disease may have a greater impact on PRISM scores than nutritional status alone. This contrasts with the results of Pollack MM et al., and Khajeh A et al., who found that higher PRISM scores were linked to higher mortality in undernourished children [13,16]. Severe thinness was significantly associated with prolonged PICU admissions (75.0%, p=0.003) and increased mechanical ventilation needs (75.0%, p=0.004) in the >5 year age cohort.

Older children were more susceptible to have severe thinness as per theses correlations. Albadi MS and Bookari K in their study also highlighted increased mechanical ventilation and hospitalization duration in malnourished pediatric population [17]. Also, Hulst J et al., and Feng S et al., reported increased hospital-acquired infection rates along with prolonged recovery in undernourished children population [3,18]. In accordance with the findings of Nangalu R et al., the association did not reach statistical significance (p=0.296), despite the fact that mortality was higher among children with severe thinness (25.0%), who also reported elevated mortality without significant PRISM score differences [6].

Teka SG et al., and Patel M et al., also found significant correlation between low socioeconomic status and poor nutrition in children population [21,22]. All things considered, the present study results support the necessity of early detection, regular nutritional screening, and focused intervention to enhance outcomes for pediatric patients in critical condition.

Limitation(s)

Due to low sample size, it might not give an accurate picture of the entire population. Many patients failed to continue treatment due to unaffordability, hence these patients could not be included in the present study leading to a small sample size. Patients getting discharged early has affected the morbidity status of the current study.

CONCLUSION(S)

Severe malnutrition in children ≤5 years and severe thinness in children >5 years were significantly associated with increased need for mechanical ventilation and higher risk of prolonged PICU stay. PRISM 3 scores did not significantly vary by nutritional status, indicating that illness severity may also depend on other clinical factors. Timely intervention depends on the early detection of malnutrition using z-scores and standardized anthropometric evaluations. To confirm these results and direct the creation of evidence-based dietary guidelines in pediatric critical care settings, larger, multicenter prospective studies are required.

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ANNEXURE 1

Variable	Age restrictions and Range		Score
Systolic blood pressure (mm Hg)	Infants	Children	
	130-160	50-200	2
	55-65	65-75	
	>160	>200	6
	40-54	50-64	
	<40	<50	7
Diastolic blood pressure (mm Hg)	All ages		6
	>110		
Heart rate in beats per minute	Infants	Children	
	>160	>150	4
	<90	<80	4
Respiratory rate in breaths per minute	Infants	Children	
	61-90	51-70	1
	>90	>70	5
	apnea	apnea	5
PaO2/ FiO2	All ages	200-300	2
		<200	3
PaCO2 (mm Hg)	All ages	51-65	1
		>65	5
Glasgow coma score	All ages	<8	6
Pupillary reactions	All ages	Unequal or dilated	4
		Fixed and dilated	10
PT / PTT	All ages	1.5 times control	2
Total bilirubin (mg/dL)	>1 month	>3.5	6
Potassium (mEq/L)	All ages	3.0-3.5	1
		6.5-7.5	1
		<3.0	5
		>7.5	5
Calcium (mg/dL)	All ages	7.0-8.0	2
		12.0-15.0	2
		<7.0	6
		>15.0	6
Glucose (mg/dL)	All ages	40-60	4
		250-400	4
		<40	8
		>400	8
Bicarbonate (mEq/L)	All ages	<16	3
		>32	3

[Annexure 1]: PRISM III score.