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Original Research Article

Vitamin D status in severe acute malnourished children

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ABSTRACT

Background: Childhood malnutrition is a major public health concern in India, contributing to high morbidity and mortality. Severe acute malnutrition (SAM) is the most critical form of undernutrition, leading to extremely low weight-for-height and significant muscle wasting. SAM children often have low vitamin D levels, essential for muscle, bone health and immune function. To assess vitamin D status in children with SAM.
Methods: A case-control study was conducted at RNT Medical College, Udaipur, involving 200 children aged 6 months to 5 years-100 SAM cases from the nutritional rehabilitation centre and 100 non-malnourished controls. SAM criteria included weight-for-height Z-scores<-3 SD, mid-upper arm circumference<115 mm or nutritional edema. Vitamin D was estimated using electrochemiluminescence. Data were analyzed using SPSS 20, with significance at $p<0.05$.
Results: The case group had a mean age of 28.08 months, while the control group had 28.95 months. The case group had lower averages in weight (7.36 kg vs 11.15 kg), height (78.48 cm vs 84.83 cm) and mid-upper arm circumference (11.2 cm vs 13.36 cm). Vitamin D deficiency was found in 28 (24.35%) cases, insufficiency in 49(42.61%) and normal levels in 38(33.04%). Mean vitamin D levels were significantly lower in the Case Group (23.9±11.71 ng/ml vs 29.9±14.78 ng/ml, $p=0.006$).
Conclusions: SAM children had lower vitamin D levels, highlighting the need for further studies and targeted interventions to improve nutritional outcomes.

Keywords: Vitamin D, Severe acute malnourished children

INTRODUCTION

Childhood malnutrition is a significant public health issue in India, leading to increased mortality and morbidity. Malnourished children face a higher risk of diseases and developmental delays, including stunted growth and hindered cognitive development. Malnutrition arises from inadequate or excessive nutrient intake, categorized as undernutrition or overnutrition.[1]

The World Health Organization (WHO) defines malnutrition as an imbalance between nutrient supply and the body's energy demands, which can lead to deficiencies in energy, protein and other nutrients, resulting in loss of body fat and muscle wasting.[2] Severe acute malnutrition (SAM) is a critical form of undernutrition, characterized by low weight-for-height, significant muscle wasting and high mortality risk. Nearly 50% of deaths in children under five are linked to undernutrition, increasing vulnerability to common infections.[3]

Globally, around 20 million children suffer from SAM, especially in Asia and Africa.[3] In India, the prevalence of severe acute malnutrition among children aged 6 months to 5 years stands at 6.4%.[4] SAM is defined by severe wasting (weight-for-height<-3 SD), mid-upper arm circumference (MUAC)≤11.5 cm or bilateral edema.[3] Children with SAM often suffer from vitamin and trace element deficiencies, particularly in calcium and vitamin

D, essential for skeletal growth and bone health.[5] Insufficient levels of vitamin D can lead to rickets and impaired muscle function, immune response and neurodevelopment.[6] Vitamin D deficiency (VDD) is a prevalent public health concern, affecting approximately 1 billion people worldwide.[7]

In malnourished children, the prevalence of VDD ranges from 31% to 61%, with estimates for Indian children between 50% and 90%.[8] A survey from 2012 to 2014 in sub-Saharan Africa reported a 28% prevalence of VDD among malnourished children.[9] Despite sufficient sunlight exposure in regions like Udaipur, high rates of vitamin D deficiency persist among children. To address this issue, we have established comprehensive guidelines for our Nutritional Rehabilitation Centre, which admits over a thousand SAM cases annually, primarily from rural and tribal communities. Our ongoing study aims to determine the precise prevalence of VDD in these children.

METHODS

Study design

The study on vitamin D deficiency in children with severe acute malnutrition (SAM) and non-malnourished counterparts was conducted at the RNT Medical College, Udaipur, in the Pediatric Department.

This case-control study included 200 children (100 from the MTC ward and 100 from the general ward) admitted to the Department of Pediatrics, approved by the institutional ethical committee.

Study type

Prospective cross-sectional.

Study period

The study duration was from June 2023 to June 2024 of 1 year.

Inclusion criteria

Children admitted to the MTC ward meeting SAM criteria: weight-for-height/length Z-score below -3 SD per WHO standards, mid-upper arm circumference<115 mm or presence of nutritional edema. Non-malnourished children aged 6 months to 5 years admitted to the pediatric ward. Parents willing to provide written consent.

Exclusion criteria

Children with chronic liver disease (e.g., jaundice, dark urine). Children with chronic kidney disease. Children with known metabolic disorders. Children whose parents did not consent.

Sample size

Based on a study by Walli et al, which indicated a 30.6% prevalence of hypovitaminosis D in children with SAM, the sample size was calculated using the formula: N=Z2 P(1-P)ε2 With a 95% confidence interval (Z=1.96), P=30.6% and a 10% absolute error, the calculated sample size was approximately 81.5.[10] After accounting for a 10% non-response rate, the final sample consisted of 100 children with SAM and 100 non-malnourished controls.

Statistical analysis

Data were collected and entered into Microsoft Excel to generate tables. The study data were recorded, validated and checked for errors, with coding and decoding completed before analysis using SPSS 20 software for Windows. Univariate and bivariate analyses, along with descriptive statistics, were performed. Means were expressed as mean±standard deviation and proportions were presented as percentages (%). A p value of<0.05 was considered statistically significant.

RESULTS

In the case group, 45 (39.13%) patients are aged 13-24 months, with a mean age of 28.08 months, while the control group has a mean age of 28.95 months. The gender distribution shows 57 (49.57%) females and 58 (50.43%) males in the case group, compared to 43 (43%) females and 57 (57%) males in the control group. Breastfeeding practices differ significantly, with 29.57% of cases exclusively breastfed versus 1% in controls ($p<0.001$). The case group has lower averages in weight (7.36 kg vs 11.15 kg), height (78.48 cm vs 84.83 cm) and mid-upper arm circumference (11.2 cm vs 13.36 cm).

Socioeconomically, 70.44% of the case group is in the lower or upper lower classes, similar to 66% in the control group. Immunization rates indicate 47.83% of cases were fully immunized, compared to 71% in controls.

The analysis of electrolyte levels shows no significant differences between the case and control groups for sodium (Na+, p=0.12), potassium (K+, p=0.29), chloride (Cl-, p=0.8) and calcium (p=0.21). However, phosphorus levels are significantly different, with the case group averaging 4.5 and the control group 7.9, resulting in a p-value of <0.0001. 13 patients have low calcium levels and 33 patients have low phosphorus levels beside.

In the case group, 28 (24.35%) patients had vitamin D deficiency, 49 (42.61%) had insufficiency and 38 (33.04%) had normal levels.

In the control group, 24 (24%) patients had deficiency, 21 (21%) had insufficiency and 55 (55%) had normal levels. The mean vitamin D level was significantly lower in the Case Group (23.9±11.71 ng/ml) than in the control group

(29.9±14.78 ng/ml, p=0.006). In the analysis of electrolytes across different Vitamin D status groups, Sodium (Na+) levels showed no significant differences, with p=0.6. Potassium (K+) also had no significant variation (p=0.49). Chloride (Cl-) approached significance with p=0.051, indicating some difference.

Calcium levels were significantly lower in the deficiency group (8.99) compared to normal (9.69) with a p-value of 0.0012. Phosphorus levels showed significant differences across groups (p=0.002). The analysis of parathyroid hormone (PTH) levels reveals that the cases had a mean PTH of 23.1 (SD 12.9), while the control group had a mean of 19.31 (SD 15.92). PTH levels across three vitamin D status groups: deficiency (mean 36.13), insufficiency (mean 20.71) and normal (mean 16.62).

PTH levels significantly decrease with increasing vitamin D status, indicating a strong inverse relationship. The Table shows PTH levels across three vitamin D status groups: deficiency (mean 36.13), insufficiency (mean 20.71) and normal (mean 16.62).

Table 1: Distribution of patients according to electrolytes.

Electrolytes	Case group		Control group		P value
	Mean	SD	Mean	SD	
Na+	134.68	5.99	132.82	17.64	0.12
K+	4.4	0.89	4.62	0.69	0.29
Cl-	97.47	13.82	97.09	13.89	0.8
Calcium	9.15	0.7	9.102	0.96	0.21
Phosphorus	4.5	1.9	7.9	1.8	<0.0001

Table 2: Distribution of patients according to Vitamin D.

Vitamin D	Case group		Control group	
	No. of patients	%	No. of patients	%
Deficiency	28	24.35	24	24
Insufficiency	49	42.61	21	21
Normal	38	33.04	55	55
Total	115	100.00	100	100
Mean±SD	23.9±11.71		29.9±14.78	
P value	0.006			

Table 3: Correlation of patients according to electrolytes and vitamin D.

Electrolytes	Vitamin D						P value
	Deficiency (n=28)		Insufficiency (n=49)		Normal (n=38)		
	Mean	SD	Mean	SD	Mean	SD	
Na+	134.61	6.81	136.23	5.62	134.9	5.95	0.6
K+	4.03	1.07	4.62	1.01	4.63	0.51	0.49
Cl-	92.59	25.42	100.83	6.39	96.74	5.24	0.051
Calcium	8.99	0.74	9.1	0.81	9.69	0.5	0.0012
Phosphorus	2.54	1.86	4.96	1.83	5.59	1.82	0.002

Table 4: Distribution of patients according to PTH.

Parameter	Case group		Control group		P value
	Mean	SD	Mean	SD	
PTH (pg/ml)	23.1	14.7	19.31	11.27	0.037

Table 5: Correlation of patients according to PTH and vitamin D.

Electrolytes	Vitamin D						P value
	Deficiency (n=28)		Insufficiency (n=49)		Normal (n=38)		
	Mean	SD	Mean	SD	Mean	SD	
PTH	36.13	15.03	20.71	14.69	16.62	14.82	<0.001

Table 6: Distribution of patients according to X-ray findings.

X-ray findings (Ricketic)	Case group (N)		Control group (N)		P value
Yes	33	28.70	19	19	0.09
No	82	71.30	81	81	
Total	115	100.00	100	100	

PTH levels significantly decrease with increasing vitamin D status, indicating a strong inverse relationship. The analysis suggests that vitamin D deficiency correlates with higher PTH levels. In the study of X-ray findings indicative of rickets, 33 patients (28.70%) in the case showed ricketic changes, compared to 19 patients (19%) in the control group.

DISCUSSION

Severe acute malnutrition (SAM) is a critical form of undernutrition, characterized by very low weight for height and significant muscle wasting, contributing to nearly 50% of deaths in children under 5. It not only increases the risk of mortality from common infections but also intensifies the frequency and severity of these infections and delays recovery. Vitamin D deficiency (VDD) is a widespread issue among children, particularly in low- and middle-income countries, affecting between 28% and 62% of children and adolescents. A study by Ejaz et al, found that 33.6% of children with severe malnutrition also had rickets, while a survey in sub-Saharan Africa reported a 28% prevalence of VDD among malnourished children.[6,7]

In this study, no statistically significant difference was observed in age between the case and control groups. The overall gender distribution was relatively balanced, with a slight male predominance, which was consistent within the control group. In a study by Walli et al, 75.4% of the 134 children were under 2 years of age, with a median age of 16 months. Notably, more than half (56.7%) of these malnourished children were males. Mehta S et al, also reported that over 60% of malnourished children were male.[10,11]

In our study, there was no significant age difference between the case and control groups, with a slight male predominance noted in both groups. Among the SAM group, 24.35% were classified as vitamin D deficient, while 42.61% were insufficient, indicating that about two-thirds of SAM patients have suboptimal vitamin D levels. The control group exhibited a significantly higher prevalence of normal vitamin D levels at 55%, with lower rates of deficiency and insufficiency at 24% and 21%, respectively. This stark contrast highlights a critical health concern for those with SAM.

The prevalence of vitamin D deficiency among malnourished children in our study was 24.35%, aligning with Mehta's findings of 32%. The elevated rates of VDD in these children may be due to impaired absorption linked to enteric dysfunction or disease processes, with complications like infection-associated vomiting exacerbating vitamin D malabsorption. Sihombing et al, reported mean vitamin D levels for different nutritional statuses, with the undernourished group showing lower mean levels compared to the well-nourished group. Similar findings were reported by Walli et al and Mehta et al, with 30.6% and 32% of malnourished children showing vitamin D deficiency.[10-12]

The limitations of the study were as follows. Bone mineral density testing was not conducted, which could have provided further insights into the impact of vitamin D deficiency on bone health. The data collection relied on self-reported dietary histories, which may have been subject to recall bias, potentially affecting the accuracy of nutritional assessments. Additionally, the study focused only on the tribal community of Udaipur, limiting the generalizability of the findings to other regions with different socio-economic and dietary patterns.

CONCLUSION

This study identified vitamin D deficiency among SAM children, including those from low socioeconomic backgrounds who appeared well-nourished. These findings highlight the need for long-term cohort studies to assess the impact of dietary intake on malnutrition in school-aged children. Such studies should evaluate quality of life and establish international standards for diagnosing and managing malnutrition, ultimately aiding in the development of targeted interventions to improve children's health and well-being globally.

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