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Thyroid Status and Serum Protein Levels in Severe and Moderate Acute Malnourished Children Between 6 Months and 60 Months in a Tertiary Care Hospital

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Abstract

Background: Malnutrition in early childhood can significantly affect endocrine and metabolic function, particularly the thyroid axis and serum protein synthesis. Thyroid hormones are crucial for growth and development, while serum proteins such as albumin and globulin reflect nutritional status. Alterations in these biomarkers can influence the clinical course and recovery of malnourished children.

Objective: To assess and compare thyroid hormone levels (T3, T4, TSH) and serum protein levels (total protein, albumin, globulin) in children aged 6–60 months diagnosed with moderate acute malnutrition (MAM) and severe acute malnutrition (SAM).

Methods: This cross-sectional study included 90 children (45 SAM and 45 MAM) admitted to the paediatric ward of a tertiary care hospital. Anthropometric measurements were taken, and venous blood samples were analysed for serum T3, T4, TSH, total protein, albumin, and globulin. Statistical comparisons were made between the SAM and MAM groups.

Results: Mean serum T3 and T4 levels were significantly lower in the SAM group compared to MAM ($p < 0.05$), while TSH levels were within normal range in both groups. Serum total protein and albumin levels were also significantly reduced in the SAM group. A positive correlation was found between serum protein levels and T3 values.

Conclusion: Children with severe acute malnutrition exhibit depressed thyroid function and lower serum protein levels, even in the absence of elevated TSH. These changes reflect adaptive metabolic responses to malnutrition and may be useful as biochemical markers for severity and recovery monitoring.

Introduction

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Malnutrition remains a significant public health concern, particularly in developing countries, where it contributes substantially to childhood morbidity and mortality. Among the various forms of malnutrition, protein-energy malnutrition (PEM) is prevalent and manifests in conditions such as marasmus and kwashiorkor (1,2). These conditions not only affect physical growth but also have profound impacts on metabolic and endocrine functions, including the thyroid axis and serum protein synthesis.

The thyroid gland plays a crucial role in regulating metabolism, growth, and development through the secretion of hormones like triiodothyronine (T3) and thyroxine (T4) (3). These hormones are essential for normal physiological functions, and their levels can be influenced by nutritional status (4). In malnourished children, alterations in thyroid hormone levels have been observed, which may represent adaptive mechanisms to conserve energy. Specifically, studies have reported decreased levels of T3 and T4 in children with severe malnutrition, while thyroid-stimulating hormone (TSH) levels may remain within normal ranges or be elevated, depending on the severity and duration of malnutrition (5).

Serum proteins, including total protein, albumin, and globulin, serve as indicators of nutritional status. In malnourished children, serum protein levels are often reduced due to inadequate intake of dietary proteins and impaired hepatic synthesis (6). Hypoalbuminemia, in particular, is a hallmark of kwashiorkor and contributes to the development of edema (7). The relationship between serum protein levels and thyroid function is complex, as thyroid hormones are transported in the bloodstream bound to plasma proteins. Therefore, alterations in serum protein concentrations can influence the levels and activity of circulating thyroid hormones(8).

Understanding the interplay between thyroid function and serum protein levels in malnourished children is vital for comprehensive clinical assessment and management. While previous studies have explored these parameters individually, there is a paucity of research examining their relationship in the context of varying degrees of malnutrition. This study aims to assess and compare thyroid hormone levels (T3, T4, TSH) and serum protein levels (total protein, albumin, globulin) in children aged 6 to 60 months diagnosed with moderate acute malnutrition (MAM) and severe acute malnutrition (SAM). By elucidating these associations, the study seeks to enhance our understanding of the metabolic adaptations in malnutrition and inform targeted interventions to improve outcomes in this vulnerable population.

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Methods

Study Design and Setting

This was a hospital-based, cross-sectional observational study conducted in the Department of Paediatrics at a tertiary care teaching hospital in South India over a period of 6 months (January to June 2024).

Study Population

Inclusion Criteria:

- Children aged 6 to 60 months.
- Diagnosed with either moderate acute malnutrition (MAM) or severe acute malnutrition (SAM) based on WHO criteria:
    - **MAM**: Weight-for-height z-score between –2 and –3 SD, or MUAC between 11.5–12.5 cm, without edema.
    - **SAM**: Weight-for-height z-score < –3 SD, or MUAC <11.5 cm, or presence of bilateral pedal edema.

Exclusion Criteria:

- Children with known thyroid disorders.
- Children on thyroid medications or corticosteroids.
- Children with chronic systemic illness (e.g., TB, HIV, liver or renal disease).
- Parental refusal for participation.

Sample Size and Sampling

A total of **90 children** were enrolled using purposive sampling:

- **Group A (SAM)**: 45 children
- **Group B (MAM)**: 45 children

Data Collection

Detailed history and clinical examination were performed for each child, including:

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- Age, sex, anthropometry (weight, height/length, MUAC).
- Signs of edema, developmental status, and dietary history.

Blood samples (5 mL) were collected aseptically from all enrolled children and analysed for:

1. **Thyroid function tests**: T3, T4, and TSH measured using chemiluminescent immunoassay (CLIA).
2. **Serum protein levels**:
    - Total protein
    - Serum albumin (via bromocresol green method)
    - Globulin (calculated as total protein – albumin)

Normal reference values:

- **T3**: 1.2–2.8 nmol/L
- **T4**: 60–160 nmol/L
- **TSH**: 0.5–6 μIU/mL
- **Total protein**: 6.0–8.0 g/dL
- **Albumin**: 3.5–5.0 g/dL

Statistical Analysis

Data were entered in Microsoft Excel and analysed using SPSS version 26.0 (IBM Corp., Armonk, NY). Descriptive statistics were used to summarize demographic and biochemical data. **Independent t-test** was used to compare mean values of thyroid and protein parameters between MAM and SAM groups. **Pearson correlation coefficient** was used to assess the relationship between serum proteins and thyroid hormone levels. A p-value of <0.05 was considered statistically significant.

Ethical Considerations

The study protocol was approved by the Institutional Ethics Committee. Informed written consent was obtained from parents or legal guardians. Confidentiality of patient information was strictly maintained.

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Results

A total of 90 children aged 6–60 months were enrolled in the study, including 45 with **severe acute malnutrition (SAM)** and 45 with **moderate acute malnutrition (MAM)**. The groups were age- and sex-matched.

Table 1: Baseline Characteristics of Study Participants

Characteristic	SAM Group (n = 45)	MAM Group (n = 45)	p-value
Mean Age (months)	26.4 ± 11.2	27.8 ± 10.4	0.52
Male : Female Ratio	1.2 : 1	1.3 : 1	0.71
Mean Weight-for-height Z	–3.8 ± 0.5	–2.4 ± 0.3	<0.001
MUAC (cm)	10.2 ± 0.5	11.7 ± 0.4	<0.001

Children with SAM had significantly lower anthropometric indices compared to those with MAM, confirming the nutritional status classification.

Table 2: Thyroid Hormone Levels in SAM vs. MAM

Parameter	SAM Group (Mean ± SD)	MAM Group (Mean ± SD)	p-value
T3 (nmol/L)	1.08 ± 0.26	1.31 ± 0.30	<0.001
T4 (nmol/L)	68.4 ± 13.7	82.1 ± 15.2	<0.001
TSH (μIU/mL)	3.2 ± 1.1	3.5 ± 1.3	0.18

Serum T3 and T4 levels were significantly lower in the SAM group, suggesting a suppressed thyroid state. TSH levels were within normal range in both groups and showed no significant difference.

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Table 3: Serum Protein Levels in SAM vs. MAM

Parameter	SAM Group (Mean ± SD)	MAM Group (Mean ± SD)	p-value
Total Protein (g/dL)	5.1 ± 0.7	6.4 ± 0.6	<0.001
Albumin (g/dL)	2.8 ± 0.4	3.5 ± 0.5	<0.001
Globulin (g/dL)	2.3 ± 0.5	2.9 ± 0.4	<0.001

Children with SAM had significantly lower levels of total protein, albumin, and globulin compared to MAM children, reflecting greater protein-energy deficiency.

Table 4: Correlation Between Thyroid Hormones and Serum Proteins

Correlation Pair	Pearson's r	p-value
T3 and Total Protein	0.52	<0.001
T3 and Albumin	0.48	<0.001
T4 and Albumin	0.42	0.002
TSH and Proteins	–0.08	0.45

There was a significant positive correlation between thyroid hormones (T3, T4) and serum proteins, especially albumin, suggesting a link between nutritional status and thyroid activity.

Table 5: Frequency of Low T3 Syndrome (Euthyroid Sick Syndrome)

Group	T3 < 1.1 nmol/L	Percentage (%)	p-value
SAM	29/45	64.4%	
MAM	11/45	24.4%	<0.001

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A significantly higher proportion of SAM children had low T3 levels, indicating a high prevalence of euthyroid sick syndrome, a common adaptive response in malnutrition.

Discussion

This study evaluated thyroid function and serum protein levels in children aged 6–60 months diagnosed with moderate acute malnutrition (MAM) and severe acute malnutrition (SAM). The findings revealed significant alterations in thyroid hormones and serum proteins, particularly in the SAM group, highlighting the profound impact of malnutrition on endocrine and metabolic parameters.

Thyroid hormones, primarily triiodothyronine (T3) and thyroxine (T4), are crucial for regulating metabolism, growth, and development. In this study, children with SAM exhibited significantly lower levels of T3 and T4 compared to those with MAM, while thyroid-stimulating hormone (TSH) levels remained within normal ranges. This pattern is indicative of euthyroid sick syndrome (ESS), a condition characterized by low T3 and T4 levels without an accompanying rise in TSH, often observed in critically ill or malnourished patients as an adaptive response to conserve energy (9).

The prevalence of low T3 syndrome was notably higher in the SAM group, with 64.4% of children affected, compared to 24.4% in the MAM group. This significant difference underscores the severity of metabolic adaptation in response to the degree of malnutrition. Similar findings have been reported in previous studies, where the severity of malnutrition correlated with the extent of thyroid hormone suppression (5).

Serum proteins, including total protein, albumin, and globulin, were also significantly reduced in the SAM group. Albumin, synthesized in the liver, plays a vital role in maintaining oncotic pressure and transporting various substances, including thyroid hormones. Hypoalbuminemia observed in SAM children can lead to decreased binding and transport of thyroid hormones, contributing to the observed reductions in T3 and T4 levels (10).

The positive correlation between serum protein levels and thyroid hormones suggests a close interrelationship between nutritional status and thyroid function. As protein levels decline, the synthesis and transport of thyroid hormones are adversely affected, leading to the observed

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hormonal imbalances. This interplay emphasizes the importance of adequate protein intake in maintaining endocrine homeostasis.

The adaptive nature of ESS in malnourished children serves to reduce basal metabolic rate, thereby conserving energy during periods of nutritional deprivation. However, prolonged suppression of thyroid function can have detrimental effects on growth and neurodevelopment, particularly in young children. Therefore, while ESS may be beneficial in the short term, sustained hormonal imbalances warrant clinical attention.

The findings of this study have important clinical implications. Monitoring thyroid function and serum protein levels in malnourished children can aid in assessing the severity of malnutrition and guiding nutritional rehabilitation strategies. Early identification and correction of hormonal and protein deficiencies are crucial for optimal recovery and prevention of long-term complications.

Limitations of this study include its cross-sectional design, which precludes establishing causality, and the relatively small sample size, which may limit the generalizability of the findings. Additionally, the study did not assess free thyroid hormone levels or reverse T3, which could provide further insights into thyroid function alterations in malnutrition.

Conclusion

Severe acute malnutrition in children is associated with significant reductions in thyroid hormones and serum protein levels, reflecting adaptive metabolic responses to nutritional deprivation. These alterations underscore the need for comprehensive assessment and management of endocrine and nutritional parameters in malnourished children to ensure optimal growth and development.

Recommendations

Routine evaluation of thyroid hormone levels and serum protein parameters should be incorporated into the clinical management of children with moderate and severe acute malnutrition. These biochemical markers not only reflect the severity of malnutrition but also aid in identifying children at risk for delayed recovery and neurodevelopmental deficits. Nutritional rehabilitation programs should ensure adequate protein intake to support hormonal

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normalization and metabolic recovery. Further longitudinal studies are warranted to explore the reversibility of these alterations post-nutritional intervention and their long-term developmental outcomes.

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