Original Article

Changes in biochemical profiles of children with severe acute malnutrition on admission and after nutritional rehabilitation

Mithu Barman[1,2], Jolly Rabha[2], Syeda Mohsina Rohman[3]

From [1]Post Graduate Trainee, [2]Associate Professor, Department of Paediatrics, [3]Professor and Head, Department of Biochemistry, Assam Medical College and Hospital, Dibrugarh, Assam, India

ABSTRACT

Purpose: The given study was done to find out the changes in biochemical profiles before and after nutritional rehabilitation of the children admitted at the Department of Paediatrics, Assam Medical College with severe acute malnutrition (SAM). **Materials and Methods:** A hospital based observational study was conducted from May 2020 to April 2021 with 55 consecutive cases of SAM. Vitros System 5600 was used for analysis of 13 biochemical parameters. **Results:** The mean values of serum sodium, potassium, and chloride at admission were 134.59±19.37 mEq/L, 4.22±0.80 mEq/L, and 101.12±16.36 mEq/L and that after rehabilitation were 136.66±19.95 mEq/L, 4.42±0.68 mEq/L, and 103.97±4.83 mEq/L. While that for magnesium, calcium, and phosphorous on admission were 2.11±0.38 mg/dL, 8.70±1.00 mg/dL, and 4.33±1.23 mg/dL and that after rehabilitation were 2.10±0.29 mg/dL, 9.45±0.65 mg/dL, and 4.76±0.84 mg/dL, respectively. The mean values of serum total protein, albumin, globulin, and A: G on admission were 6.53±1.44 g/dL, 3.30±0.88 g/dL, 3.23±0.87 g/dL, and 1.06±0.33, respectively, and that after rehabilitation were 6.84±0.98 g/dL, 3.86±0.57 g/dL, 2.98±0.69 g/dL, and 1.34±0.28, respectively. The mean of urea and creatinine on admission were found to be 26.25±19.30 mg/dL and 0.34±0.24 mg/dL, respectively, and that after rehabilitation were 23.91±11.76 mg/dL and 0.31±0.15 mg/dL respectively. Random blood sugar (RBS) on admission was 85.20±17.88 mg/dL and that after rehabilitation was 94.18±14.82 mg/dL. After rehabilitation, the mean value of calcium, phosphorous, albumin, A: G, and RBS were significantly raised. The minimum duration required for rehabilitation was 12 days with prevalence being maximum among the Tea-tribes (80.00%). **Conclusion:** The biochemical derangements in a patient with SAM are associated with significant morbidity and get improved after nutritional rehabilitation.

Keywords: Biochemical profile, Nutritional rehabilitation, Severe acute malnutrition, Tea-garden community

Child's nutritional status has hardly changed since National family health survey (NFHS) 4 in Assam (underweight 32.8%, wasting 21.7%, stunting 35.3%; NFHS5); which poses a major impediment on the way of welfare of children in the state and it does contribute to the under-five mortality rate (39.1/1000 live births) [1]. Certain demographic characteristics had been sought responsible for the same. Each year, the Department of Paediatrics, Assam Medical College and Hospital, provides care and treatment to a good number of patients of severe acute malnutrition (SAM) with or without associated complications. The vast majority of the patients are from tea-tribe population with poor socioeconomic backgrounds and live in rural or peri-urban areas of Dibrugarh.

The striking biochemical changes encountered in a patient of SAM include lowering of serum protein, especially the albumin fraction, enzymes, carrier proteins, essential amino-acids, essential fatty acids, serum calcium, phosphorus, magnesium, sodium, potassium, iron etc. [2]. These biochemical and anthropometric changes have the potential to revert back to normal with standard management of SAM. With this objective, this study compared the various changes in biochemical profiles present in SAM patients on admission and after nutritional rehabilitation therapy.

MATERIALS AND METHODS

The place of our study was Department of Paediatrics, Assam Medical College and Hospital. It was a hospital based observational study conducted from May 2020 to April 2021 among 55 consecutive cases admitted at the department. All cases from 6 to 60 months who fulfill the criteria for SAM according to according to WHO, that is, weight for height below minus 3SD on the WHO standard growth chart; and/or presence of bipedal edema; and/or mid upper arm circumference (MUAC)

Correspondence to: Dr. Jolly Rabha, Department of Paediatrics, Assam Medical College and Hospital, Dibrugarh, Assam, India. E-mail: jollyrabha@gmail.com

below 11.5 cm were included in the study. All those who refused to give consent for the study; patients who were known case of malignancy, chronic kidney disease, immunodeficiency syndrome and metabolic diseases and patients who were taking any drugs that could bring out significant change in the metabolic profile were excluded from the study.

Methodology

The study was conducted with the approval from the Institutional Ethics Committee (AMC/EC/PG/8936). Informed consent was obtained from the parents and those children who fufilled the inclusion criteria were enrolled. Detailed history, physical examination, and anthropometric examination were performed and data were collected in predesigned proforma. Blood was obtained by venipuncture and collected in clot activator vial on hospitalization and after nutritional rehabilitation. The second sample was collected after a minimum duration of 2 weeks after starting nutritional rehabilitation; usually at discharge or on follow-up. Follow-up is usually done after 2 weeks as per the department protocol. After initial stabilization, F75 diet was started along with other supplements and gradually switched over to F100 diet as the child tolerated the F75 diet. Achievement of nutritional rehabilitation was assessed by specific anthropometric criteria and overall clinical improvement as per the WHO protocol (no edema for at least 2 weeks, plus weight-for-height reaches −2SD or higher on the WHO Growth Standard or MUAC more than 12.5 cm) [3].

Metabolic Profile

The biochemical profiles were done with all standard procedure at the Bio-Chemical laboratory of Department of Biochemistry, Assam Medical College and Hospital. Total 13 parameters were checked. Vitros system 5600 was used (Table 1) for analysis [4].

Statistical Analysis

The data collected were tabulated in Microsoft Excel Worksheet and computer-based analysis was performed using the statistical product and service solutions (SPSS) 20.0 software (SPSS, Chicago, Illinois, USA) and Microsoft Excel 2010. The categorical variables were summarized as proportions and percentages and were analyzed using Chi-square test and Fischer's exact test (where the cell counts were <5 or 0). For all analyses, the statistical significance (denoted by #) was fixed at 5% level (p<0.05).

RESULTS

Total 55 cases were studied; out of them 5 expired (9%); 24 were males and 31 were females. The cases lost to follow-up were not included in the study. The mean age of presentation was 32.02±15.84 months. Maximum number of cases were found to be under Upper-Lower class (58.18%) of Modified Kuppuswamy
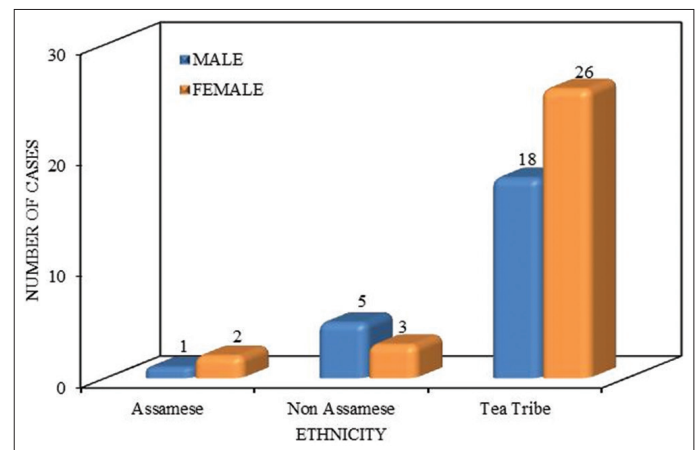

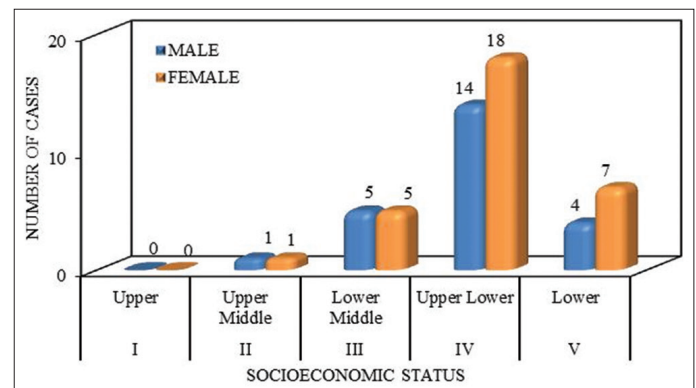Figure 1: Ethnicity-wise distribution

Figure 2: Distribution of socioeconomic status (modified Kuppuswamy scale, 2020)
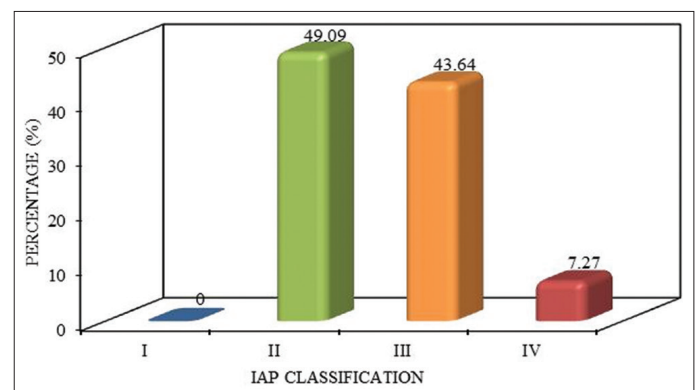

Figure 3: Distribution of cases according to IAP classification

Classification (Figure 2) with prevalence being maximum among (Figure 1) the Tea-tribes (80.00%). The cases were also classified under IAP classification (Figure 3) of classification of malnutrition and most of the cases were found to fall under Grade II (49.09%) followed by Grade III (43.64%). Among all the age group of 6–60 months for both the gender, the mean weight was 8.23±2.09 kg, height 83.23±12.35 cm, head circumference 46.83±2.58 cm, and MUAC 10.78±0.93 cm respectively. The mean duration of hospital stay was 12.49±5.64 days.

The most common presenting complaint (Fig. 4) was fever (72.73%) followed by Lethergy (40.00%); whereas among the finding on clinical examination (Fig. 5), most common were edema

(38.18%) and fever (34.54%). The distribution of comorbidities on admission according to different age-groups, we found that the most common comorbidity (Fig. 6) was tuberculosis (29.09%) followed by severe pneumonia (20.00%).
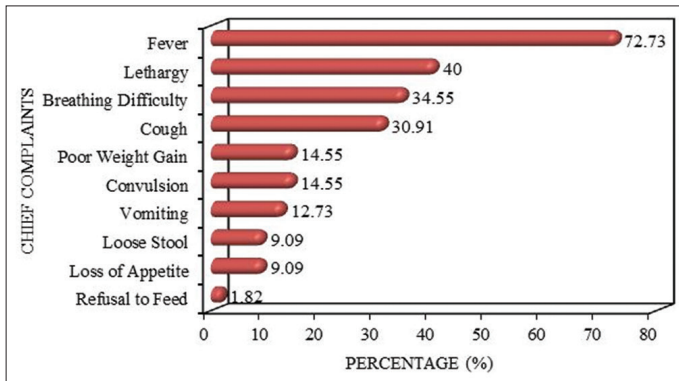

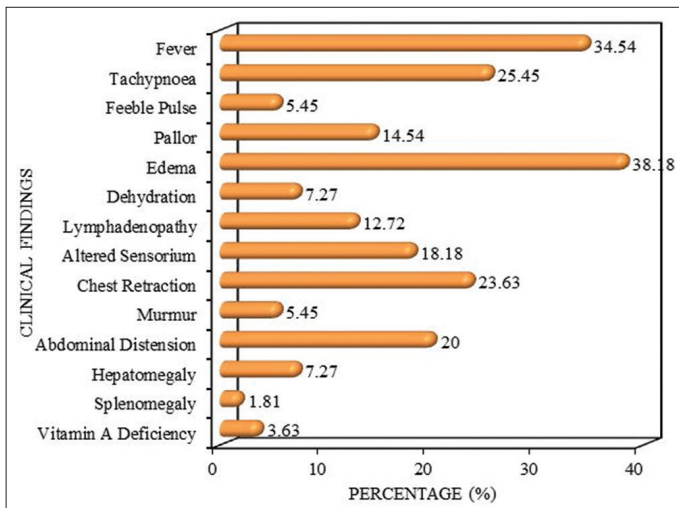**Figure 4: Distribution of cases according to presenting complaints**

Figure 5: Distribution of cases based on clinical findings on admission

Table 1: Parameters included in the study with standard procedures and normal range

Parameters	Test type	Normal range
Sodium (Na)	Potentiometric	135–145 mEq/L [5]
Potassium (K)	Potentiometric	3.5–5.5 mEq/L [5]
Chloride (Cl)	Potentiometric	98–106 mEq/L [5]
Calcium (Ca)	Colorimetric	8–11 mg/dL [6]
Magnesium (Mg)	Colorimetric	1.5–2.3 mg/dL [5]
Phosphorus (P)	Colorimetric	1–3 years: 3.8–6.5 mg/dL 4–11 years: 3.7–5.6 mg/dL [5]
Total protein	Colorimetric	6.1–7.9 g/dL [7]
Albumin (A)	Colorimetric	3.5 [2]–5.0 [7] g/dL
Globulin (G)	Colorimetric	1.5–3.2 mg/dL [7]
A : G	Colorimetric	1.1–2.51 [8]
Urea	Colorimetric	5–18 mg/dL [7]
Creatinine	Two point rate	<3 years: 0.3–0.7 mg/dL 3–18 years: 0.5–1.0 mg/dL [7]
RBS	Glucose oxidase peroxidase [9]	54 [3]–140 [10] mg/dL

RBS: Random blood sugar

Metabolic Parameters

The mean value of serum sodium (134.59±19.37 mEq/L) was found to be subnormal at admission whereas other electrolytes (Potassium and Chloride) were found under normal limits and there was no significant difference noted among the mean values

Table 2: Comparison of mean values of parameters on admission and after nutritional rehabilitation

Parameters	On admission		After nutritional rehabilitation		p-value
	Mean	SD	Mean	SD	
Na (mEq/L)	134.59	19.37	136.66	19.95	0.087
K (mEq/L)	4.22	0.80	4.42	0.68	0.172
Cl (mEq/L)	101.12	16.36	103.97	4.83	0.052
Total Protein (g/dL)	6.53	1.44	6.84	0.98	0.149
Albumin (g/dL)	3.30	0.88	3.86	0.57	0.000#
Globulin (g/dL)	3.23	0.87	2.98	0.69	0.081
A: G	1.06	0.33	1.34	0.28	0.000#
Mg (mg/dL)	2.11	0.38	2.10	0.29	0.832
Ca (mg/dL)	8.70	1.00	9.45	0.65	0.000#
p (mg/dL)	4.33	1.23	4.76	0.84	0.038#
Urea (mg/dL)	26.25	19.30	23.91	11.76	0.461
Creatinine (mg/dL)	0.34	0.24	0.31	0.15	0.591
RBS (mg/dL)	85.20	17.88	94.18	14.82	0.006#

RBS: Random blood sugar

Table 3: Comparison of metabolic derangements on admission and after nutritional rehabilitation

Parameters	On admission		After nutritional rehabilitation	
	n	%	n	%
Na (mEq/L)				
• Hyponatremia: <135	27	49.09	21	38.18
• Hypernatremia: >145	3	5.45	5	9.09
K (mEq/L)				
• Hypokalemia: <3.5	11	20.00	4	7.27
• Hyperkalemia: >5.5	4	7.27	4	7.27
Ca (mg/dL)				
• Hypocalcemia: <8	13	23.64	2	3.64
• Hypercalcemia: >11	1	1.82	1	1.82
Mg (mg/dL)				
• Hypomagnesemia: <1.5	2	3.64	1	1.82
• Hypermagnesemia: >2.3	12	21.82	15	27.27
P (mg/dL)				
• Hypophosphatemia: <3.7	5	9.09	0	0.00
• Hyperphosphatemia: <4 yr: >6.5; >4 yr: 5.6	1	1.82	0	0.00
Albumin (mg/dL)				
• Hypoalbuminemia: <3.5	27	49.09	10	18.18
RBS (mg/dL)				
• Hypoglycemia: <54	1	1.82	0	0.00

RBS: Random blood sugar

Table 4: Mean values of Na, K, and Cl according to presenting complaints

Parameters	Number	Na (mEq/L)		K (mEq/L)		Cl (mEq/L)	
		Mean	SD	Mean	SD	Mean	SD
Dehydration	4	139.61	4.27	4.92	0.47	102.40	8.27
Vomiting	7	135.44	9.47	4.12	1.10	101.95	7.83
Loose stool	5	133.47	6.20	4.07	0.75	101.64	9.68
Convulsion	8	136.22	48.64	4.44	0.84	104.30	37.77
Lethargy	22	135.81	6.15	4.18	0.79	101.31	8.51
Abdominal distension	11	134.96	4.60	4.20	0.79	98.81	6.60
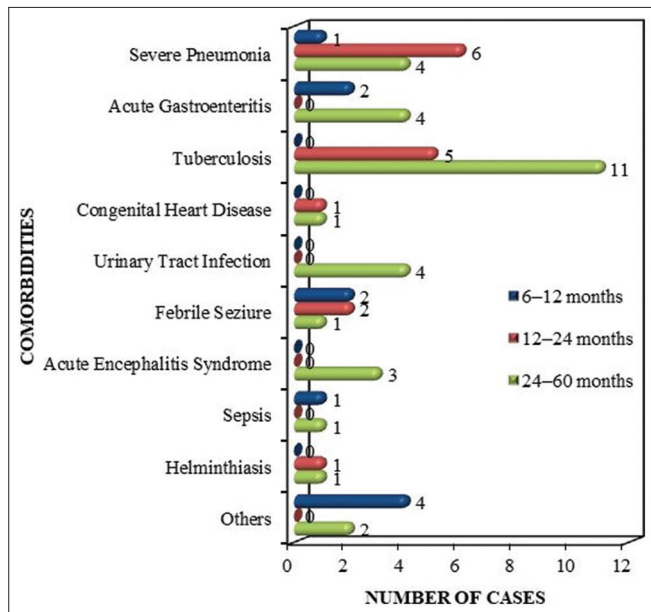
Figure 6: Agewise distribution of cases for comorbidities on admission

Table 5: Mean values of Mg, Ca, and P according to presenting complaints

Parameters	Number	Mg (mg/dL)		Ca (mg/dL)		p (mg/dL)	
		Mean	SD	Mean	SD	Mean	SD
Lethargy	22	2.08	0.31	8.59	1.16	4.13	1.56
Convulsion	8	2.23	0.52	8.72	0.99	4.40	0.86
Abdominal distension	11	2.13	0.18	8.40	0.83	3.86	1.46
Vomiting	7	1.91	0.47	8.36	1.23	3.52	1.63

Table 6: Mean of RBS according to presenting complaints

Parameters	Number	RBS (mg/dL)	
		Mean	SD
Lethargy	22	79.77	16.27
Convulsion	8	85.50	14.30

RBS: Random blood sugar

Table 7: Comparison of mean of albumin in edematous and non-edematous group

Parameters	Edematous		Non edematous		p-value
	Mean	SD	Mean	SD	
Albumin (mg/dL)	3.03	0.83	3.48	0.91	0.039#

Table 8: Comparison of present study with another study in term of mean of anthropometric parameters

Mean of anthropometric parameters	Present study	Borah [11]
Age (months)	32.02±15.84	31±15
Weight (kg)	8.23±2.09	8.9±2.34
Height (cm)	83.23±12.35	84.49±10.39
Head circumference (cm)	46.83±2.58	47.3±2.15
MUAC (cm)	10.78±0.93	12.4±1.01

MUAC: Mid upper arm circumference

(Table 2) at admission and after nutritional rehabilitation. The mean values of serum total protein, albumin, globulin, and A: G are displayed in Table 2. The mean value of serum albumin on admission was found to be below normal (3.30±0.88 mg/dL). After nutritional rehabilitation, the mean value of serum albumin was raised but below normal and the difference was significant (p=0.000). Furthermore, the A: G ratio difference on admission and after rehabilitation was significant (p=0.000). The mean values of serum magnesium, calcium, and phosphorous (Table 2) were found to be within normal range. After nutritional rehabilitation the mean value of serum calcium (p=0.000) and phosphorus (p=0.038) were found to be significantly raised but within normal range. The mean value of serum creatinine (Table 2) on admission and after nutritional rehabilitation was found to be within normal range but that of serum urea was found to be increased. After nutritional rehabilitation, the mean value of serum urea was found to decrease but still toward higher limit. The mean values of random blood sugar (RBS) on admission and after nutritional rehabilitation were found to be within normal range and the difference in mean was significant (p=0.006).

It was observed that the most prevalent derangement in biochemical profiles (Table 3) were hypoalbuminemia (49.09%) and hyponatremia (49.09%); among almost half of the cases. Hypocalcemia (23.64%) and hypermagnesemia (21.82%) were also considerably prevalent among the cases on admission. Maximum improvement was noted in the decrease in hypocalcemia (3.64%) followed by hypoalbuminemia (18.18%) after nutritional rehabilitation. However, there was an increase in number of Hypermagnesemia, this could be due to a lower cutoff set for the same in the present study.

The mean values for all the parameters in relation to clinical manifestation under study were found to be under normal range except that there was hypophosphatemia (3.52±1.63 mg/dL) in

the vomiting group; subnormal sodium among the loose stool and abdominal distension (Tables 4-6) and the difference in mean albumin between the edematous and non-edematous group (Table 7) was significant (p=0.039).

DISCUSSION

The prevalence of SAM is commonly seen in lower socioeconomic class. In the place of study, maximum prevalence was found among the Tea-tribes. Table 8 compares mean anthropometric parameters with Borah [11], a study done at the same institution in 2014.

The subnormal serum sodium in a SAM patient can be explained due to diarrheal loss or SIADH due to respiratory/CNS infections; also dilutional in edematous SAM [12]. Table 9 shows the subnormal nature of sodium in different studies on admission. Owais and Sridhar showed improving Na on day 8 which became normal in the present study after rehabilitation. However, the percentage of each dyselectrolytemia is less in present study compared to Owais and Sridhar.

The serum level of calcium and phosphorous in a SAM patient improves after nutritional rehabilitation with a significant increase. Serum magnesium remains normal. All these elements play important role in catch up growth. Phosphorus has also been linked to refeeding syndrome. Adequate supplementation of these elements with locally available ingredients is a matter of concern. Furthermore, Vitamin D deficiency prevails in epidemic

Table 9: Comparison of Na, K, Cl in different studies

Parameters (Mean±SD)	Present study on admission	Owais and Sridhar[13] on admission (n=50)	Dakshayani et al.[14] on admission (n=113)	Meena et al.[12] on admission (n=100 complicated SAM)	Mbethe and Mda[15] on admission (n=104)	Samad et al. [26] on admission (n=200)	Owais and Sridhar[13] on day 8	Present study after rehabilitation
Na (mEq/dl)	134.59±19.37	133.23±5.45	134.58±5.45	131.82±6.66	135±6.55	137.5	135.8±5.45	136.66±19.95
K (mEq/dl)	4.22±0.80	-	4.29±0.75	4.17±1.03	3.81±1.23	4.2	5.5±1.24	4.42±0.68
Cl (mEq/dl)	101.12±16.36	-	103.31±7.16	-	-		-	103.97±4.83
Hyponatremia (%)	49.09	72	43.4	-	-		30	38.18
Hypernatremia (%)	5.45	6	-	-	-		2	9.09
Hypokalemia (%)	20	38	7.1	-	38 (K<3 mEq/L)		2	7.27
Hyperkalemia (%)	7.27	32	-	-	-		18	7.27

Table 10: Comparison of Ca, Mg, P in different studies

Parameters	Ca (mg/dL)	Mg (mg/dL)	P (mg/dL)	Hypocalcemia (%)	Hypomagnesemia (%)	Hypophosphatemia (%)
Present study on admission	8.70±1.00	2.11±0.34	4.33±1.23	23.64	3.64	9.09
Present study after rehabilitation	9.45±0.65	2.10±0.29	4.76±0.84	3.64	1.82	0
Bushra et al.[18] on admission (n=60)	5.59±0.98	1.01±0.24	2.81±0.45	-	-	-
Chanchal et al.[19] on admission (n=65)	-	-	2.61	47.7	24.61 (Mg<1.7 mg/dL)	60 (P<3.68 mg/dL)
Khan et al.[20] on admission (n=384)	-	-	-	30.47	42.45 (Mg<1.5 mg/dL)	30.21 (P<2.1 mg/dL)
Dakshayani et al.[21] on admission (n=43)	-	2.49±0.55	-	-	-	-
Dakshayani et al.[21] after rehabilitation	-	2.36±0.47	-	-	-	-
Mbethe and Mda[15] on admission (n=104)	9.62	2.45	4.27	-	-	-
Bartz et al.[22] on admission (n=62)	-	-	3.23±1.11	-	-	-
Bartz et al.[22] after rehabilitation (at 2 week)	-	-	4.47±0.86	-	-	-

Table 11: Comparison of total protein, albumin, globulin, and A: G in different studies

Parameters	Present study on admission	Present study after rehabilitation	Gupta and Gupta[23] on admission (n = 250)	Duwarah[24] on admission	Borah[11] on admission	Bartz et al.[22] on admission (n = 62)	Bartz et al.[22] after rehabilitation
Total protein (mg/dL)	6.53 ± 1.44	6.84 ± 0.98	5.23 ± 0.34	5.53 ± 1.3	6.86 ± 0.63	-	-
Albumin (mg/dL)	3.30 ± 0.88	3.86 ± 0.57	3.13 ± 0.45	2.56 ± 0.5	3.1 ± 0.60	2.0 ± 0.8	2.5 ± 0.8
Globulin (mg/dL)	3.23 ± 0.87	2.98 ± 0.69	-	2.77 ± 1.19	-	-	-
A: G	1.06 ± 0.33	1.34 ± 0.28	1.02 ± 0.12	-	0.85 ± 0.21	-	-

Table 12: Comparison of creatinine and urea in different studies

Parameters	Present study	Hari et al.[25] (n=77)	Afifi et al.[26] (n=60)	Mbethe and Mda[15] (n=104)	Bartz et al.[22] (n=62)	Kumar et al. [27] (n = 55)	Samad et al.[16] on admission (n=200)
Creatinine (mg/dL) at admission	0.34±0.24	0.42±0.14	0.53±0.13	0.45 mg/dL	0.28±0.18	0.44±0.18	0.63
Creatinine (mg/dL) after rehabilitation	0.31±0.15	-	0.56±0.08	-	0.34±0.39	-	
Urea (mg/dL) at admission	26.25±19.30	-	-	17.12 mg/dL	-	34.5±10.16	

Table 13: Comparison of RBS in different studies

Parameters	Present study	Mbethe and Mda[15] (n=104)	Gangaraj et al.[28] at admission (n=76)	Ashok et al.[29] at admission (n=75)	Bartz et al.[22] (n=62)
RBS on admission (mg/dL)	85.20±17.88	-	-	-	83±28
RBS after rehabilitation (mg/dL)	94.18±14.82	-	-	-	77±14
Hypoglycemia on admission (%)	1.82	2 (RBS<2.6 mmol/L)	3.9	25.3	-

RBS: Random blood sugar

proportion in India that can lead to low level of Ca and P. A study done at the same institution by Gogoi [17] among SAM patients found the prevalence of Vitamin D deficiency to be as high as 31.43% with mean value of Vitamin D to be 34.31±20.78 ng/dL. Compared to Bushra *et al*. [18], the values of Ca, P, Mg are much higher in the present study. Furthermore, the percentage of hypocalcemia, hypomagnesemia, and hypophosphatemia were much less in the present study as found in Chanchal *et al*. and Khan *et al*. (Table 10). The discrepancy in cutoff limit set for different studies can also affect the result.

The serum albumin level is subnormal in the present study which is consistent with other studies compared in Table 11. Borah [11] had correlated decreasing level of albumin with increasing grades of malnutrition. The difference of mean values of serum albumin for edematous group and non-edematous group on admission was found significant (p=0.039). Although it strongly suggests that low serum albumin is associated with Kwashiorkor, recent studies postulated that it is not essential for the development of edema [2].

Reduced creatinine level can be correlated to decreased muscle mass due to wasting (Samad *et al*.) [16]. Serum urea is elevated which decreases after nutritional rehabilitation but still remains higher which can be explained by the ongoing Catabolic state (Table 12).

Hypoglycemia (Table 13) in Mbethe and Mda (2%) and Gangaraj *et al*. (3.9%) were found comparable to the present study, contrary to which it was much higher in Ashok *et al*. (25.3%).

The study comprehensively describes nutritional rehabilitation in terms of biochemical changes and its correlation with clinical changes and demographic parameters. Replication of the study in large scale can add more significance to the study. The small size of the sample was the main limitation. The study missed the cases at the community who did not reach health-care facility. Furthermore, the study reflects the nutritional status of children only at a small part of the country. Ionized calcium would have been a more physiological indicator of the metabolic state. Samples at transition phase and on long-term follow-up would have helped better in understanding the pathophysiology of SAM.

CONCLUSION

Maximum prevalence was noted among the Tea-tribes. Sodium and albumin in a SAM patient are subnormal. There is significant increase in calcium and phosphorous after the treatment. The increase in serum albumin after nutritional rehabilitation is significant. Urea is elevated which decreases after rehabilitation but still remains higher. Hypoalbuminemia and hyponatremia are present in almost among half of the cases. Hypocalcemia is also prevalent. The minimum duration required for rehabilitation is 12 days.

AUTHORS CONTRIBUTION

All authors in this study contributed to the data collection of the patients.

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