

**TO STUDY PH DISORDERS IN SEVERE ACUTE MALNUTRITION**Saurabh Kumar Patel<sup>1</sup>, Shabd Singh Yadav<sup>2</sup>, H. P. Singh<sup>3</sup>, N. Bajaj<sup>4</sup>**HOW TO CITE THIS ARTICLE:**

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**ABSTRACT: OBJECTIVE:** To study pH disorders in severe acute malnutrition. **DESIGN:** A prospective, cohort, observational study. **SETTING:** Severe malnutrition treatment unit in a tertiary level care hospital in central India. **PARTICIPANTS:** 202 children between 6 to 60 months of age. **METHODOLOGY:** Radial artery sample was taken at admission which was analyzed by automated blood gas analyzer; results were studied and correlated with nutritional status at discharge/outcome. **STATISTICAL ANALYSIS:** The data were analyzed using SPSS 20. Univariate and bivariate analysis of data was done using the Student t test and two-tailed Fisher exact or chi-square test. **RESULTS:** Out of 202 children studied 51.5% were males and 48.5% were females, 16.8% children had pH <7.35, 43.6% had pH between 7.35 to 7.45 and 39.6% had pH >7.45. The mean values of pH, HCO<sub>3</sub><sup>-</sup>, PCO<sub>2</sub>, PO<sub>2</sub> and Cl<sup>-</sup> were 7.42, 17.1mmol/l, 25.22 mmHg, 93.71mmHg and 109.05mmol/l respectively. Most children (n = 173/202; 85.6%) were discharged, 11(5.4 %) expired and 18 patients left the treatment. In pH < 7.35 group, mortality rate was highest (P value < 0.00001). Rate of weight gain in all groups were comparable and duration of stay was 16½ days in normal pH group and was 19 days in pH < 7.35 and 17 ½ days in pH > 7.46 group. **CONCLUSION:** In this study, metabolic acidosis with hyperchloremia was associated with poor outcome. There is no significant change in the duration of hospital stay and rate of weight gain in any pH group.

**KEYWORDS:** pH, severe acute malnutrition, metabolic acidosis

**INTRODUCTION:** Severe acute malnutrition is a metabolic disorder, characterized by profound disturbance of water, electrolytes, minerals, protein, fat, carbohydrates and energy metabolism, along with disturbances in function and composition of almost all tissues of the body. Nutrition has long been known to strongly influence acid-base balance. Malnutrition is a state of catabolism and severe malnutrition is a state of severe catabolism. In a healthy body homeostasis is maintained mainly by kidney, lungs, minerals and body fluids, and it is altered in malnutrition.

The present work is an attempt to study the prevalence of acid base disorder in severe acute malnutrition and its effect on outcome. Few studies have demonstrated the acid base disturbances in SAM children with associated diarrhea and pneumonia but their main focus was the underlying comorbidities rather than SAM.<sup>1,2,3</sup> The present study was conducted to evaluate prevalence of acid base disturbance in all SAM children irrespective of underlying etiology.

**METHODS:**

**(I) DESIGN AND SETTING:** This prospective observational study was carried out in the severe malnutrition treatment unit (SMTU), Department of Pediatrics, Shyam Shah Medical College, Rewa (SSMC) between March 2013 to July 2013.

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**(II) STUDY POPULATION:** Inclusion Criteria - Children between 6 to 60 months of age admitted in the Severe Malnutrition Treatment Unit (SMTU) in our hospital. WHO criteria<sup>5,6</sup> were used to define severe acute malnutrition viz. weight for height below  $-3z$  scores of the median NCHS/WHO growth standards, and/or mid upper arm circumference  $<11.5$  cm or presence of nutritional edema). The parents were duly informed and explained about study and their consent was taken Exclusion Criteria - Children of the parents who refused to give consent.

**(III) SAMPLE SIZE ESTIMATION:** Sample size was calculated using Right Size (China-Uganda-Zimbabwe) statistical software assuming that  $N=500$  i.e. total number of patient admissions at SMTU. During a one year study period, expected frequency of the SAM was presumed to be at least 20% (i.e. available prevalence of 9-15%), thus considering 95% confidence level with 80% power and confidence interval of 5%, a sample of 198 patients would be required. Simple random sampling technique was used to recruit the patients in this study who were admitted to SMTU and 202 were selected.

**(IV) MEASURE OF ACID BASE PARAMETERS:**

**TIME:** An arterial sample within 6 hours of admission was taken from all patients fulfilling the above criteria for study.

**SITE:** Arterial sample from the radial artery by percutaneous needle puncture was taken after performing "Modified Allen's test".<sup>7</sup>

**PREPARATION OF SITE & COLLECTION:** Aseptic precautions were followed in arterial canulation. A 2ml syringe with 25 gauge needle was flushed with heparin (1000U/ml) and it was ensured that no residual heparin was left, even in the tip. The radial artery was palpated with the non-dominant hand's index and middle fingers over the styloid process between the tendons of abductor pollicis longus and flexor carpi radialis. The site was cleaned with alcohol followed by chlorexidine in an outward circle and allowed to dry.

The hand was kept hyper-extended and keeping the palpating fingers over the artery, it was pricked just proximal to the palpating fingers using the dominant hand with the needle at 45 degree angle and bevel up. As the artery was pricked, the syringe was allowed to fill itself if possible to minimize the chance of air contamination. After sampling, hemostasis was achieved by applying pressure over the site for 5 minutes. A minimum of 2 ml blood was taken to avoid dilutional effect of heparin if any.<sup>8,9</sup>

**SPECIMEN HANDLING:** The specimen was initially placed on an ice pack, primarily to reduce oxygen consumption by metabolism.<sup>10</sup> Within the next 10 minutes the specimen was transported to an automated blood gas analyzer, after thoroughly mixing the sample by repeatedly inverting and rolling it horizontally and ensuring that the syringe was kept upright and air bubbles if present were removed by gently tapping the wall of syringe.<sup>8,11</sup>

**SAMPLE ANALYSIS:** To maintain the homogeneity of the sample it was mixed thoroughly by repeatedly inverting it and rolling it horizontally. A few drops from the tip of the syringe were expelled on a gauge piece.

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The analyzer was calibrated at regular intervals as recommended by the manufacturer. Sample so prepared was analyzed by automated blood gas analyzer which automatically transports the specimen to electrochemical sensors, measure pH, PCO<sub>2</sub>, and PO<sub>2</sub>, rinses the system, calibrates the sensors, and provides a report of the arterial blood gas values along with electrolytes.

**(V) MEASURE OF OUTCOME:** At the time of admission, weight was recorded. Patients were followed and weighed daily as per SAM guidelines. The outcome measures in this study included – duration of hospital stay, rate of weight gain and mortality. Rate of weight gain of all the patients in gram/kg/day was recorded using formula - weight at outcome - weight on admission / admission weight × duration of stay. Total duration of stay was calculated amongst those who completed the treatment and compared with different pH groups.

**(VI) DATA ANALYSIS:** The data were analyzed using SPSS 20. Appropriate univariate and bivariate statistical analysis were carried out using the Student's t test for the continuous variable and two-tailed Fisher exact test or chi-square ( $\chi^2$ ) test for categorical variables. All means were expressed as mean  $\pm$  standard deviation and proportion in percentages were expressed as mean  $\pm$  standard deviation. The critical levels of significance of the results were considered at 0.05 levels i.e. P < 0.05 was considered significant.

**(VII) ETHICAL ISSUES:** A written, informed consent from parents and clearance from Institutional Ethics Committee (Human Studies) SSMC, Rewa was obtained prior to the start of the study.

**RESULTS:** Out of 202 patients 104 (51.5%) were males and 98 (48.5%) were females. On studying pH value it was found that only 43.6% of children had pH in the normal range (7.35 to 7.45), 16.8% children had pH < 7.35 and 39.6% had pH > 7.45. One hundred and eighty six (92.1%) children had HCO<sub>3</sub><sup>-</sup> < 21 mmol/l, 15 cases (7.4%) had normal HCO<sub>3</sub><sup>-</sup> (21 to 28 mmol/l) level and 1 had HCO<sub>3</sub><sup>-</sup> > 28 mmol/l. One hundred and ninety seven (97.5%) children had PCO<sub>2</sub> < 35mmHg, 2.5% (5 children) had pH in the normal range (35 to 45mmHg) and no child had PCO<sub>2</sub> > 45mmHg.

Chloride level could be estimated in only 110 patients. Normal level of chloride (98-106 mmol/L) was found in 22 patients (20%), hypochloremia (<98mmol/L) was observed in 5 (4.5%) and hyperchloremia (> 106mmol/L) in 83 (75.45 %) patients. The mean values of pH, HCO<sub>3</sub><sup>-</sup>, PCO<sub>2</sub> and PO<sub>2</sub> were 7.42, 17.1mmol/l, 25.22mmHg & 93.71mmHg respectively.

On studying the outcome, it was found that 173(85.6%) had successfully completed the treatment course and were discharged, 11(5.4 %) expired, 18 patients left the treatment of whom 1 left against medical advice and 17 patients (8.4%) had absconded. Mortality in SAM was significant (P value < 0.01) with highest in pH < 7.35 i.e. 20.6% (n = 7/34). In pH >7.46 group 3 out of 80 expired and only 1 out of 88 expired in normal pH range. Of these deaths i.e. 54.54% (n = 6/11) occurred within 24 hours of admission.

Rate of weight gain in patient with normal pH was 7.85gm/kg/day and in those with pH < 7.35 and > 7.45 was 7.81gm/kg/day and 7.74gm/kg/day respectively. The mean duration of stay of all patients was 16.5 days. In patients with no pH abnormality it was 15 days (14.96), while in patients with pH abnormality it was higher which was 19 days in pH < 7.35 and 17.5 days in pH > 7.46 group.

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**DISCUSSION:** Out of the 202 patients, the ratio of male and female was almost similar to other studies with no significant sex predominance in malnourished children.<sup>12,13</sup> On systemic interpretation of arterial blood analysis, it was found that 16.8% children had pH < 7.35, 39.6% had pH > 7.45 and 43.6% children in the normal range.

Among 34 children with pH < 7.35, the mean value of HCO<sub>3</sub><sup>-</sup> was 10.11 mmol/l and PCO<sub>2</sub> was 22.72 mmHg to compensate for the change in HCO<sub>3</sub><sup>-</sup> which is almost compensated. Out of 88 children having pH in the normal range mean HCO<sub>3</sub><sup>-</sup> was 18.05 mmol/l and mean PCO<sub>2</sub> was 26.9 mmHg. This could be due to the secondary compensation or mixed disorder. Robertson SA<sup>14</sup> observed that metabolic acidosis is the most common disorder encountered in clinical practice. Odey FA et al<sup>1</sup> and Chisti et al<sup>2</sup> found metabolic acidosis to be the commonest abnormality in severe malnutrition with diarrhea. Shah G Set al<sup>3</sup> studied patients of diarrhea and observed that acid base disturbance was observed in all cases where the estimations were done.

Patients of SAM may have malaria, lower respiratory tract infection (LRTI) apart from diarrhea and these conditions are often present simultaneously in SAM children which may further worsen pH. In our study 94 cases (46.53%) had diarrhea of whom 13.8% (n = 13/94) had pH < 7.35, 41.48% (n = 39/94) had pH in normal range and 44.68% (n = 42/94) had pH > 7.45. On considering all patients the mean value of pH, HCO<sub>3</sub><sup>-</sup> and PCO<sub>2</sub> were 7.42, 17.1 mmol/l and 25.22 mmHg respectively. Thus, in severe malnutrition underlying metabolic acidosis was present in almost all patients, some having compensated, some un-compensated and others having mixed acid base disorders.

The decrease in HCO<sub>3</sub><sup>-</sup> was compensated by increase in chloride levels, as out of 110 patients, 83 (75.45%) cases had chloride level > 106 mmol/L. Rate of weight gain in patients with normal pH was 7.85 gm/kg/day and in those with pH < 7.35 and > 7.45 was 7.81 gm/kg/day and 7.74 gm/kg/day respectively. Rate of weight gain was similar irrespective of different pH. The duration of stay was calculated amongst those who completed the treatment. The mean duration of stay of all patients was nearly 16 ½ days (16.51). In patients with no pH abnormality duration of stay was 15 days (14.96). It was 19 days (19.04) in pH < 7.35 and 17 ½ days (17.43) in pH > 7.46 group. However difference was not statistically significant.

The mean duration of stay in each group was between 14 to 21 days. The mortality rate of all the SAM patients was 5.4%. It was least (1.1%; n = 1/88) in children with normal pH, followed by 3.8% (n = 3/80) in those with pH > 7.45 and highest (20.6%; n = 7/34) in those with pH < 7.35. This difference was statistically significant (P < .00001). Chisti et al<sup>2</sup> also observed that children with metabolic acidosis more often had higher case-fatality (16% vs. 5%, p = 0.039) compared to those without metabolic acidosis on admission.

On studying the general pattern of morbidity it was found that most of the death in children visiting hospitals occurred within first 24 hrs of admission.<sup>15,16</sup> In our study 54.54% (n=6/11) deaths occurred within 24 hours of admission, which was in accordance with findings of other workers.<sup>15,16</sup> Thus in patients of SAM, metabolic acidosis is an important morbidity leading to statistically significant mortality. High index of suspicion for acidosis and assessment on admission may decrease mortality in SAM.

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### What is already known?

SAM children have profound disturbances of water and electrolytes with altered homeostasis.

### What this study adds?

Metabolic acidosis is an important morbidity associated with SAM.

pH		HCO <sub>3</sub> <sup>-</sup> (mmol/l)		CO <sub>2</sub> (mmHg)		PO <sub>2</sub> (mmHg)		Cl <sup>-</sup> (mmol/l)	
Value	N	Value	N	Value	N	Value	N	Value	N
<7.35	34	<21	186	<35	197	< 80	76	98	5
7.35-7.45	88	21-28	15	35-45	5	80-100	61	98-106	22
>7.45	80	>28	1	>45	0	> 100	65	>106	83
Total	202	202		202		202		110	
Mean	7.42	17.1		25.22		93.17		109.05	

**Table 1: Distribution of cases according to pH, HCO<sub>3</sub><sup>-</sup>, PCO<sub>2</sub>, PO<sub>2</sub> and Cl<sup>-</sup>**

pH		PCO <sub>2</sub> (mmHg)	PO <sub>2</sub> (mmHg)	HCO <sub>3</sub> <sup>-</sup> (mmol/l)
<7.35	Mean	22.721	89.212	10.112
	Std. Deviation	±7.7084	43.4617	±4.2504
	N	34	34	34
7.36-7.45	Mean	26.967	86.333	18.052
	Std. Deviation	±3.6862	26.8588	±9.8897
	N	88	88	88
>7.46	Mean	24.375	103.758	19.040
	Std. Deviation	±3.3720	31.2835	±2.5948
	N	80	80	80
<b>Total</b>	<b>Mean</b>	<b>25.226</b>	<b>93.718</b>	<b>17.107</b>
	<b>Std. Deviation</b>	<b>4.7731</b>	<b>32.7787</b>	<b>7.6225</b>
	<b>N</b>	<b>202</b>	<b>202</b>	<b>202</b>

**Table 2: Distribution of HCO<sub>3</sub><sup>-</sup>, PCO<sub>2</sub> and HCO<sub>3</sub><sup>-</sup> according to pH**

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pH	Outcome				Total
	Discharge	Expired	LAMA	Abscond	
<7.35	24	7	1	2	34
7.36-7.45	80	1	0	7	88
>7.46	69	3	0	8	80
<b>Total</b>	<b>173</b>	<b>11</b>	<b>1</b>	<b>17</b>	<b>202</b>
	<b>85.6%</b>	<b>5.4%</b>	<b>.5%</b>	<b>8.4%</b>	<b>100.0%</b>

Table 3: Distribution of outcome in different pH group

Discharge V/S Expired Chi square =18.87 p<0.00001

pH		Duration of stay (day)	Rate of weight gain (gm/kg/day)
<7.35	Mean	19.04	7.81
	Std. Deviation	14.84	7.25
	N	24	34
7.36-7.45	Mean	14.96	7.85
	Std. Deviation	7.64	6.36
	N	80	88
>7.46	Mean	17.43	7.74
	Std. Deviation	8.48	4.81
	N	69	80
<b>Total</b>	<b>Mean</b>	<b>16.51</b>	<b>7.80</b>
	<b>Std. Deviation</b>	<b>9.33</b>	<b>5.94</b>
	<b>N</b>	<b>173</b>	<b>202</b>

Table 4: Distribution of duration of stay and rate of weight gain in different pH group

Duration of stay  $t^{1/2}=1.30$  ;  $p>0.05$

$t^{1/3}=0.50$  ;  $p>0.05$

$t^{2/3}=1.86$ ;  $p>0.05$

Rate of weight gain  $t^{1/2}=0.03$  ;  $p>0.05$

$t^{1/3}=0.05$  ;  $p>0.05$

$t^{2/3}=0.12$ ;  $p>0.05$

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