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Review Article

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Management of Severe Acute Malnutrition: An Emergency Department Approach

Santosh K Rathia[1], Murugan TP[1], Richa Sinha[2], Prakash G Mathew[1] and Varun Anand[1*]

[1]Department of Paediatrics and division of Pediatrics Emergency Medicine, All India Institute of Medical Sciences, India

[2]Department of Pediatrics, Nair Hospital, India

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[*]**Corresponding author:** Varun Anand, Department of Trauma and Emergency (Paediatrics), All India Institute of Medical Sciences, Raipur, India.

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Abstract

Introduction: Malnutrition is a silent killer that is under reported, under addressed, and as a result under prioritized. It continues to be major cause of morbidity and mortality in children especially 6 months to 5 years old and is mainly because of deficiency or imbalance intake of macronutrient (carbohydrate, protein, and fat) or micronutrient (vitamins, minerals, and trace element). The spectrum varies from underweight, stunted, moderately acute malnutrition, and Severe Acute Malnutrition (SAM). Severe acute malnutrition is a medical as well as social problem as it afflicts over 6.4% of children who are under sixty months of their age. However current estimated total population of India crosses 1,410 million, it is expected that about 8.2 million are likely to be suffering from SAM.

Discussion: In malnutrition, physiologic and metabolic systems of body slow down to adapt the limited supply of nutrients and energy, and this process is called reductive adaptation. It results in certain changes which affect the ability to adapt various situations like tolerating excessive oral feeds, intravenous fluids, and combating infections. Here, we are discussing the comprehensive approach towards management of Severe Acute Malnutrition which is divided into two phases (initial stabilization phase to manage acute problems followed by a longer rehabilitation phase).

Conclusion: With timely diagnosis and comprehensive approach towards management of the undernourished, we can avert wasting, stunting, severe malnutrition, its complications, and thus eventually decrease the morbidity and mortality in children.

Introduction

According to data from a Joint Child Malnutrition Estimate (2020) of UNICEF, WHO and World Bank group from year 2000 to 2019, the global prevalence of under-five stunting declined from 199.5 million (32.4%) to 144 million (21.3%), but the figures have increased in West and Central Africa (from 22.4 to 29.0 million). Globally in the year 2020, as per WHO estimate 149.0, 45.0, 38.9 million children as stunted, wasted and overweight or obese

respectively; and 45% deaths of the under 5 children were linked to malnutrition in low-and middle-income countries whereas rate of childhood obesity also increased in the same countries [1]. In Western Europe and North America prevalence of wasting and stunting in under 5 children is low (<5%). More than half, and about a quarter of total wasted children in the world live in South Asia and sub-Saharan Africa, respectively. On the other extreme of malnutrition, globally 38.3 million of the under-5 children were over-weight as per the data published in the year 2019. In a study showing the data on burden and indicators of malnutrition in under-five children during 1990 to 2017 in India, it was concluded that malnutrition was cause of 68.2% of total deaths and 17.3% of total Disability-Adjusted Life Years (DALYs) [2].

Under NRHM (National Rural Health Mission) of Government of India (GOI), Nutritional Rehabilitation Centers (NRCs) have been set up at various health facilities, mostly at district level hospitals, that is resulting into high survival rate by providing acute symptomatic care of SAM and its complications, timely initiation of appropriate feedings, improving the skills of mothers/caregivers to identify health problems in their children, and teaching appropriate feeding practices [3-5]. As per National Nutrition Strategy- vision 2022, India has a target to reduce underweight from 35.7% to 20.7%. UNICEF, and Bill & Melinda Gates foundation planned to create Centres of Excellence (CoE) to sustain and strengthen the facility and community-based management of malnutrition. In India, currently a dedicated national CoE is functional at Kalawati Saran Children's Hospital, New Delhi and currently >10 states have their state or regional level CoEs.

As per WHO and UNICEF, Severe Acute Malnutrition (SAM) in 6-59 months of age is defined as Weight for Height/Length (WFH/WFL) less than -3 Standard Deviation (SD) and/or Mid-Upper Arm Circumference (MUAC) less than 11.5 cm and/or clinical sign of bilateral pedal oedema (sign of Kwashiorkor) and/or visible severe wasting. These cut-offs were selected because there is always a high chance of mortality in children with WFH/WFL < -3 SD and MUAC < 11.5 cm. Merely < 0.13% of well-nourished children comes under WHF/WFL below -3 SD which increases its specificity to > 99%. On the other hand, Moderate Acute Malnutrition (MAM) is labeled, if WFH/WFL lies between -2 SD and -3 SD and/or MUAC between 11.5 cm - 12.5 cm, without bilateral pedal oedema. Prevalence studies have shown that both the parameters (WFL and MUAC) applied to identify SAM in > 6 months of children have equal diagnostic potential; but MUAC is not a reliable parameter in infants < 6 months and thus WFL and/or bipedal edema are criteria used to diagnose SAM in that age group.

Emergency Department approach in SAM

Malnutrition can be treated with community or home-based and facility-based approach depending upon the severity and complications at presentation. The community-based approach involves timely detection of malnutrition in the community and early provision of RUTF or other nutrient-dense foods at home, and is preferred for the management of uncomplicated SAM [6-7].

The two phases of facility-based SAM management include, initial "stabilization phase" to cope with acute problems or comorbid emergencies followed by a longer "rehabilitation phase" for sustaining the weight gain with replenishment of micronutrients. Various country-specific adaptations of WHO guidelines for management of SAM and MAM are available worldwide but clearly defined Emergency Department (ED) approach is missing in them. Since differentiation between the treatment of SAM and MAM with different products and programs was complex and costly, a cluster-randomized controlled study (ComPAS trial - 'Combined Protocol for Acute malnutrition Study; 2020) was conducted to formulate an economically acceptable integrated or combined protocol-based treatment of both spectra of acute malnutrition, which was found non-inferior to the standard approach of SAM management [8].

Ten essential sequential steps have been advocated by WHO for SAM management, but at the ED level, many critical steps have to be followed simultaneously in the varying combination and permutation starting during triage of any sick child itself if SAM co-exists. According to a meta-analysis and systematic review (2013), even after following

the WHO protocol for managing admitted children with SAM, case fatality rate was not low rather was significant, ranging from 3.4% to 35% in low- and middle-income settings [9].

At ED or casualty setting, systematic approach with quick triage assessment followed by primary survey and concurrent emergency interventions is mandatory, and meanwhile steps of initial SAM management are followed in an efficient manner. Most of the triage systems miss the evaluation of malnutrition/SAM components which may cause delay in initiating its treatment especially when all of its essential components have to be addressed simultaneously by the treating team. We have tried to suggest a rearranged SAM management steps for easier understanding, early execution, and effectual outcome within a shorter period during emergency department care with special focus on early interventions while triaging, resuscitating, and rehabilitating any sick children with severe malnutrition.

Table 1: Essential steps of SAM management [in two phases - stabilization over 1 day to 7 days (with initial critical m/m of first 2 days in ED) and then rehabilitation over next 2-6 weeks]

1	Treat/prevent hypoglycemia
2	Treat/prevent hypothermia
3	Treat/prevent dehydration
4	Correct electrolyte imbalance
5	Treat/prevent infection
6	Correct micronutrient deficiencies
7	Start cautious feeding
8	Catch-up growth achievement
9	Sensory stimulation and emotional support
10	Follow-up after recovery

Reference: Joint statement of WHO and UNICEF.

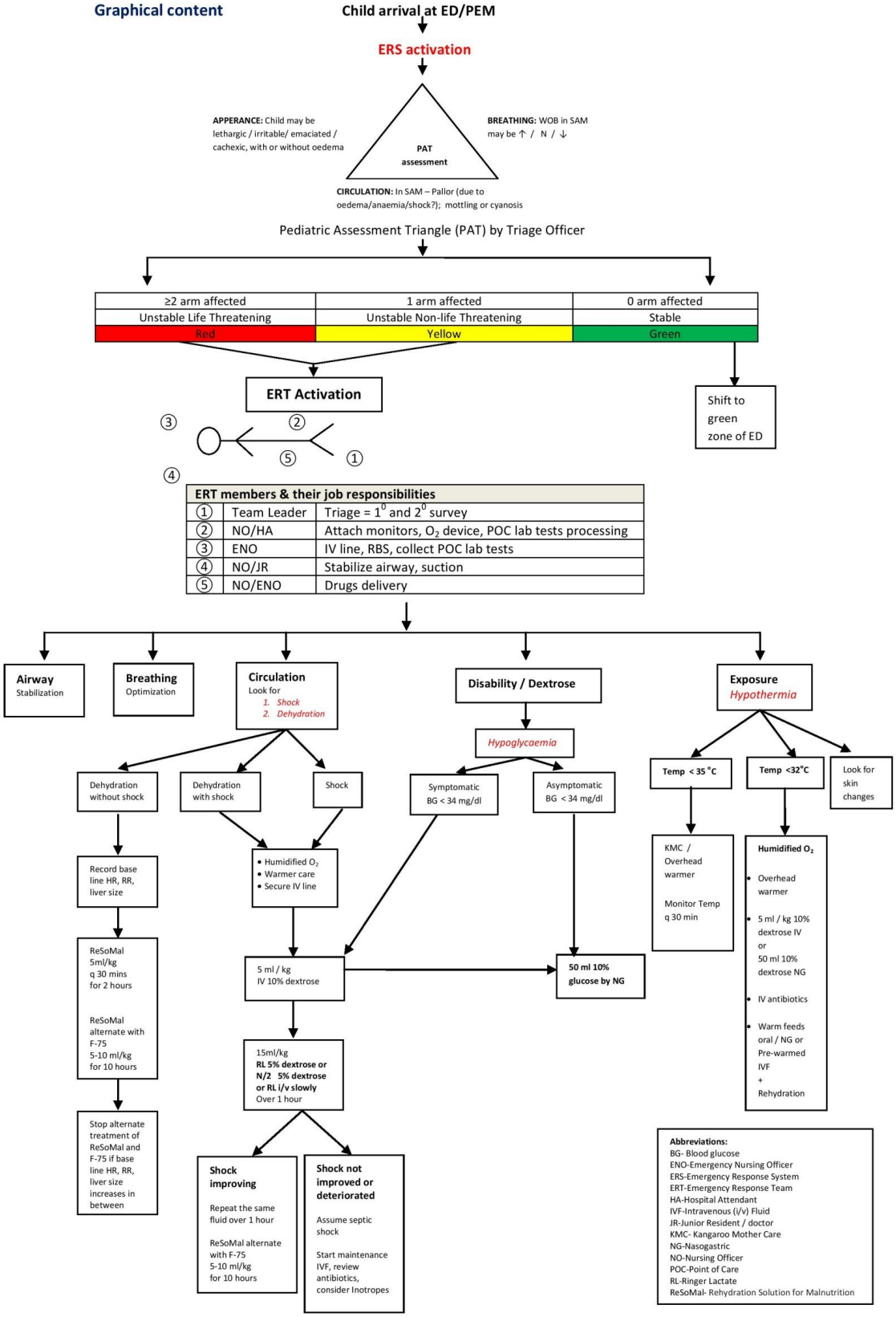
Step 1: Emergency Triaging: PAT Assessment, Primary and Secondary Survey

The instant when child with SAM/malnutrition arrives, prompt and coordinated actions are required to act on various facets simultaneously, which are often missed in a busy unformulated, undesignated emergency setting and that adds to higher mortality.

Emergency Response System (ERS) of the ED or PEM, which comprises of dedicated ER setting with adequate emergency drugs and equipment at one hand reach (crash cart) and a team of 4 members to 5 members, is by default activated on arrival of any sick child. In the ER team, one health personnel become team leader to guide, observe and monitor the whole emergency procedural steps including initial triaging, evaluation, lifesaving interventions, ongoing re-assessment, and initial counseling (done by NO/doctor/MSW) of the patient's relatives/guardians. In ideal emergency setting, 2 doctors (at least 1 being qualified pediatrician or emergency physician), 2 Nursing Officers (NOs), and 1 Hospital Attendant (HA or ward boy) may comprise the ER team to manage one sick patient at a given time.

Pediatric Assessment Triangle (PAT) is simplest and quickest initial triaging tool by which evaluation is done in all patients arriving at ED. It provides quick audio-visual assessment of the patient condition based on ABC (Appearance, work of Breathing and Circulation), that can be done by a triage officer who might be nursing officer or a doctor. In PAT evaluation, 'Appearance' (the first arm) of a child with SAM might be lethargic/irritable or sick looking (appearance indicates physiological impression of CNS status and gross sensorial alterations), but some experts and certain pediatric triage systems consider apparently visible physical abnormalities also as elements of 'Appearance' (especially if that can lead to physiological derangement or life-threatening issues) e.g. emaciation, cachexic look or visible oedema (generalized/bipedal). The second arm is 'WOB' (Work f "Breathing") that can either be increased, normal, or reduced than normal (as in SAM/asthenia). 'Circulation' (the third arm) can reveal signs of normal or poor peripheral perfusion, though skin pallor (can be due to edema or anemia) and similarly even in absence of shock, mottling or cyanosis can reflect hypothermia, secondary sepsis or severe pneumonia especially in complicated SAM. If 0, 1 or $\geq$ 2 arm of PAT triangle is affected child is categorized into stable (green-zone), unstable but non-life

threatening (yellow) and unstable & life threatening (red) category, respectively. Based on initial PAT impression, child is shifted to concerned zone (red/yellow/green) of PEM/ED, where ER team (ERT) of dedicated ED zone shall initiate their pre-designated activities.



The triage officer (NO/one of the doctors) will continue primary survey and can act as a **team leader** for guiding needed emergency interventions, reassessment, and ongoing monitoring of a SAM patient. The **second member** can be

NO or HA / ward boy who will attach vital monitors (for recording HR, RR, SpO_2, temperature, BP and ECG), oxygen device (if needed) and will help in Point of Care (POC) tests and documentation of events. The **third member** shall be a trained Emergency NO (**ENO**) who will secure intravenous line, check RBS by dipstick, and collect other laboratory/POC samples (electrolytes, blood gas, CBC, CRP, cultures). The fourth member shall be another **NO or junior doctor** who will stabilize airway, do suction (if needed) and will secure airway as per need. The **fifth member** shall be another **NO or ENO** (third of four members in resource limited settings) who will prepare and give emergency drugs like IV dextrose, IV fluid bolus, antibiotics or inotropes as guided by the team leader. All 4 or 5 ERT members should act simultaneously when life-saving resuscitation is needed in SAM, as for any critically ill child (as in ESI triaging system). All patients who get triaged as less critical (green/yellow zone) might be managed by 2-3 trained ERT members, and especially in human-resource limited settings. After PAT evaluation, team leader along with ER team carries out primary survey in ABCDE approach (airway, breathing, circulation, disability and exposure) with sequential interventions as per need.

PAT evaluation hints the presence of malnutrition by emaciated look, visible pedal edema, skin rash, flag hair sign, discordance of current weight with the age; thus, during primary survey, Weight for Height/Length (WFH/WHL) calculation becomes important to know the exact type of malnutrition (SAM/MAM/overweight/Obesity). Anthropometric assessment should be done using WHO standard growth-charts as it increases the chance of picking SAM 2-4 times more than previous NCHS references. We need a lower threshold for identifying SAM in EDs because of the difference in its management from moderate malnutrition. Broselow tape is another way to know the approximate weight depending upon the length of the child in condition, when child is very sick and weight cannot be measured or bed weighing scales are not available.

Secondary survey comprises of 'SAMPLE history' (Symptoms & Signs, Allergies, Medications, Past history, Last meal and Events leading to current manifestations) and 'focused examination' must be commenced only after the completion of primary survey and initiation of interventions if required. Child with malnutrition may arrive in an ED with either one or >1 presentation of tachypnoea, tachycardia, hypoglycemia and altered temperature. Brief SAMPLE history and relevant focused examination findings (taken within 2-3 minutes) guides us to know etio-pathophysiology of acute illness or current presentation, including co-morbidities, fluid losses, urine-output and oral acceptance in last 24 hours; which need special mention in a child with SAM.

If child is triaged between level III to V, or green to yellow zone (WHO entitle it as SAM without complications), appetite test with Ready to Use Therapeutic Food (RUTF) can be tried at the ED to take the decision on need of admission [10]. The test usually takes a short time but may take up to one hour. The child must not be forced to take RUTF and should be offered plenty of water to drink from a cup along with, to make it palatable [8]. As per NRHM and NRC (nutritional rehabilitation centres) in India, children between 7-12 months of age should be offered 30 ml/kg - 35 ml/kg of catch-up diet and on acceptance of >25 ml/kg suggests a good appetite and is considered as 'passed appetite test' and child can be treated on outpatient basis at home [11]. In child weighing <4.0 kg, 4.0 kg -6.9, 7.0 kg - 9.9 kg and 10 kg -14.9 kg should consume at least a total of 15 ml, 25 ml, 35 ml and 50 ml (or grams) of RUTF respectively at a time, to consider for the outpatient treatment option.

Criteria to select patient for treatment on outpatient or inpatient basis are shown in Figure 1. Children with severe bilateral pedal oedema (+++), even if they present with no medical complications and have good appetite, should be admitted for inpatient care.

SAM ↓ • Good appetite (passed appetite test) • No IMCI danger sign • Alert • Clinically well ↓ Manage on OPD basis (course of oral antibiotic like amoxicillin)	SAM ↓ • Poor appetite (failed appetite test) • ≥ 1 IMCI danger sign • Bilateral severe oedema • Medical complications ↓ Admit the child

Weight of child (Kg)	Minimum RUTF to be consumed to pass appetite test (ml/gram)
<4	15
4-6.9	25
7-9.9	35
10-14.9	50

+ Mild: both feet; ++ moderate: bilateral feet plus lower legs, hands, or lower arms; +++ severe: generalized oedema including bilateral feet, legs, hands, arms and face. IMCI-Integrated management of childhood illness.

Figure 1: Criteria to opt for inpatient versus outpatient treatment of SAM.

Stage 2: Emergency management by synchronized DISH2 approach [Dehydration, Infection, Shock, Hypoglycemia & Hypothermia]

D: 'Dehydration correction' and early 'Dietary initiation' with F-75

As determination of dehydration is difficult in a child with SAM, it should be assumed in all cases presenting with acute watery diarrhea. Rehydration Solution for Malnutrition (ReSoMal) or low osmolar ORS 5 ml/kg every 30 min for two consecutive hours, orally or by nasogastric (NG) tube, should be given which is followed by Alternate Fluid Therapy (AFT) that includes ReSoMal at 5 ml/kg - 10 ml/kg hourly alternating with F-75 for subsequent 4 hours - 10 hours considering dehydration or severe diarrhea.

Systematic review of 74 studies revealed the more effectiveness of rice-based ORS than glucose-based ORS [12]. Fluid therapy should be commenced only after documenting baseline RR, HR and liver size. During the rehydration therapy, HR (change by 15), RR (change by 5), appearance of murmur or basal crepts on auscultation and change in liver size (any increased size) should be monitored along with urine, stool and vomiting frequency. Even on change of single monitoring parameter, AFT (F-75 with ReSoMal) should be stopped immediately and only F-75 feeds should be continued every 2 hourly (@130 ml/kg/day) with replacement of each loose stool by 5 ml/kg - 10 ml/kg of ReSoMal to combat ongoing losses.

Table 2: Rehydration solution for malnutrition (alternative to ReSoMal)

How to make local ReSoMal, if commercial preparation is not available:
Clean water 2 litre
WHO low osmolar ORS 1 packet of 1 litre
Sugar 50 gram
Electrolyte/Mineral solution 40 ml or 1 level scoop of commercially available combined minerals and vitamins mix (table 7)

Table 3: Comparison of ReSoMal and WHO low osmolar ORS (mmol/L).

	Low osmolar WHO ORS	**ReSoMal (mmol/L)**
Sodium	75	45
Chloride	65	70
Glucose	75	125
Potassium	20	40
Citrate	10	7
Osmolarity	245	300
Zinc	-	0.3
Copper	-	0.045
Magnesium	-	3

During the initial stabilization phase as soon as hemodynamic stability is ensured, cautious small and frequent milk-rice based feeds (F-75) with low osmolarity and low lactose containing 100 kcal/kg/day and 1 gm protein/kg/day -1.5 gm protein/kg/day should be started at the rate of 130 ml/kg/day *via* oral (cup with auxiliary option of spoon, dropper or syringe for very weak children) or NG route (if not accepting orally). Initial feeds should be given in 2 hourly frequency for 1-2 days, and subsequently 3 hourly for another 3-5 days, followed by 4 hourly for the next 5-7 days, but keeping the total amount unchanged i.e. 130 ml/kg/day. Rapid increment in gap between each feed can be achieved over 2 days to 3 days also (e.g. 24 hours duration for each increment level) especially in uncomplicated SAM for early discharge.

For lactose intolerance, starter F-75 which is low-lactose feed should be substituted with yoghurt or a lactose-free infant formula with gradual reintroduction of milk-based feeds in the rehabilitation phase. Osmotic diarrhea should be suspected, if diarrhea worsens with hyperosmolar starter F-75, but it ceases on modification of diet with reduction of sugar and osmolarity to <300 mOsmol/L. Isotonic F-75 or low osmolar cereal-based F-75 may be used with slow introduction of F-100 in the rehabilitation phase. Cereal-based, low-osmolar F-75 (334 mOsmol/l) is made by replacing 30 g of sugar with 35 g cereal flour in F-75 recipe and cooking it for 4 minutes.

WHO low osmolar ORS are available as 200 ml and 1000 ml packets as dry powder, so it is advisable to check the packet properly before making the rehydration solution. Body-weight on the day of admission should be used to calculate the total amount of feeds, even if the child loses or gains weight during the treatment phases. If commercial F-75 or F-100 is not available, its indigenous preparation can be made. Encourage breastfeeding after each episode of loose stool in <6 month of age.

Child with SAM who cannot be rehydrated orally or by NG tube should be treated with IV fluids (130 ml/kg/day), either by half-strength Darrow's solution with 5% dextrose, or Ringer's lactate solution with 5% dextrose or 0.45% saline in 5% dextrose. A systematic review concluded that fluid restriction policy in SAM is derived from low quality clinical evidence [13-14].

I: Infection Treatment (for prevention of complications and early nutritional recovery)

Antibiotic shot should be given immediately to all patients, since a child with SAM will often not depict any sign of **infection**. In a meta-analysis, good recovery rate was found in uncomplicated SAM if prophylactic antibiotic was given [15]. Current comprehensive WHO guidelines based on multiple studies including meta-analysis and taking in account of reviews of other available international guidelines support the use of broad-spectrum oral antibiotics for treating children with uncomplicated SAM on outpatient basis. For any child with complicated SAM who is severely ill (apathetic or lethargic) or has complications (hypoglycemia, hypothermia, broken skin, respiratory or urinary tract infection), we should start injection Ampicillin 50 mg/kg/dose (IM/IV) 6-hourly for 2 days followed by oral Amoxycillin in currently recommended higher dose of 80 mg/kg/day in two-three divided doses, for 5 days. **IV/IM antibiotics beyond 2 days can be continued if clinical condition is not improving or in presence of** severe pneumonia, diarrhea or sepsis. Gentamicin 7.5 mg/kg/day IM/IV once daily should be given in combination with IV or oral ampicillin/amoxicillin for 7 days in complicated SAM. We should consider ototoxic and nephrotoxic side-effects while giving Gentamicin in complicated SAM who commonly have dehydration and compromised renal function and thus its second/subsequent dose should be avoided if the child has not passed urine.

Parenteral third-generation cephalosporins do not replace first line use of Ampicillin and Gentamicin, as very limited evidence found it more effective in complicated SAM, rather it increases risk of antibiotic resistance. Some of the guidelines suggest its use as broad-spectrum antibiotic with or without Gentamicin in cases of failure to improve within 48 hours or deterioration within 24 hours or development of septic shock or meningitis [16]. If the child fails to improve clinically within 48 hours, Chloramphenicol 25 mg/kg/dose IM/IV 8-hourly for 5 days can be added as a second line antibiotic.

If anorexia persists even after 5 days of antibiotic-treatment then duration should be increased to total of 10 days. If anorexia still persists, child should be reassessed for resistant organisms and compliance of drugs, and vitamin and mineral supplements should be ensured. Some experts add Metronidazole (7.5 mg/kg 8-hourly for 7 days) in addition to broad-spectrum antibiotics, to hasten repair of the intestinal mucosa and reduce the risk of oxidative damage and systemic infection. FANTA trial found that in SAM patients treated with antibiotics there was a 36% to 44% reduction in the rate of mortality and higher rates of recovery [17].

In cases of SAM without complications, give Co-trimoxazole 5 ml Paediatrics suspension (5 ml = 40 mg Trimethoprim + 200 mg Sulphamethoxazole) orally twice daily for 5 days (2.5 ml, if patient weighs <6 kg) in order to treat occult/possible infection. According to a meta-analysis, use of Amoxicillin is preferred over Cotrimoxazole [18]. **Even latest WHO guidelines suggest amoxicillin as the first line antibiotic for uncomplicated SAM with the consensus of giving high dose oral Amoxicillin (80 mg/kg/day in 2 divided doses) for 7 days**. In a double blinded RCT of uncomplicated SAM (6 to 59 months of age, 2767 children), oral Amoxicillin or Cefdinir was found to be more effectual than placebo group; and mortality rate of the three groups were 4.8%, 4.1%, and 7.4% respectively [19]. But according to a double-blind placebo-controlled trial in Niger (2399 children, 6 to 59 months age-group, with uncomplicated SAM), nutritional recovery was statistically equivalent within Amoxicillin (65.9%) and placebo (62.7%) groups, but Amoxicillin (80 mg/kg/day for 7 days) decreased the risk of indoor admission by 14% [20].

Measles vaccine should also be given, if child is > 6 months of age and not yet immunized, unless child is in shock or having any septic/critical illness.

S: Treatment of Shock/Septic shock in SAM

Shock due to dehydration and sepsis are likely to coexist in children with SAM, and it requires humidified supplemental oxygen and cautious fluid resuscitation as per WHO guidelines with initial slow bolus up to 15 ml/kg - 30 ml/kg over 1-2 hours then slow rehydration over 6-10 hours. After initiation of fluid therapy, most children start improving within 30 minutes. If temperature falls or sensorium deteriorates during the treatment, recheck for **hypoglycaemia or dyselectrolytemia**, rule out poor cerebral perfusion, and treat like septic shock with adequate fluids and early inotropic support. Give maintenance i.v. fluid 4 ml/kg/hour, review antibiotic and start feeds as early as possible.

H: Hypoglycemia & Hypothermia - treatment and prevention

In resource limited settings, hypoglycemia and hypothermia should be considered as co-existent complications at presentation and treatment for the both should be started simultaneously. Point of care capillary test of blood glucose can confirm hypoglycemia (BS <34mg/dl). In symptomatic lethargic, comatose or convulsing child, i/v 10% dextrose (5 ml/kg) should be given rapidly and in asymptomatic cases, 50 ml of D10 or glucose solution can be given orally or by nasogastric tube [see algorithm 1]. If axillary temperature is <35.0 °C or rectal temperature <35.5 °C (<95.9 °F) and child is not in shock, then immediately feeds and rewarming should be started. Rewarming can be done by warm clothing of whole body (including head) with warm blankets and placing a heater/radiant warmer or lamp nearby, or by kangaroo mother care covering them together. Hot water bottle should not be used. During rewarming, rectal temperature should be monitored every 2 hourly until it rises to >36.5 °C (half-hourly monitoring, if heater device is used). For prevention of hypothermia, two hourly feeding, avoidance of prolonged exposures during clinical examinations, early changing of wet nappies and sleeping along with mother (cradles to be avoided) should be ensured.

STEP 3: Supportive therapy for early recovery - SAM supplements to be started in ED only

Children with SAM have high body sodium with low potassium and magnesium. **Magnesium** is also an essential component for calcium regulating hormones. There is correlation of potassium and thiamine deficiency, as well as with rickets supporting its therapeutic role [21]. Hother et al confirmed the escalation in serum magnesium level at

discharge of SAM children, when supplemented with magnesium rich F-75 and F-100 diet. [22]. At ED on day-1 itself we should start 50% magnesium sulphate intramuscularly stat (0.2 ml/kg) up to a maximum of 2 ml followed by (0.4 mmol/kg/day - 0.6 mmol/kg/day) orally for 2 weeks. If muscle mass of anterolateral aspect of thigh is very low in a child with SAM, the intramuscular dose can be split into two equal parts and given in both the thighs. If oral commercial preparation is not available, injection magnesium sulphate (50%) can be given at 0.2 ml/kg/day - 0.3 ml/kg/day orally mixed with feeds.

Table 4: Composition of F-75 and F-100.

	F-75	**F-100**
Dried skimmed milk (gram)	25	80
Sugar (gram)	100	50
Vegetable oil (gram)	30	60
Electrolyte/mineral solution	20	20
Water (ml)	1000	1000
Energy	75	100
Osmolarity (mOsmol/L)	413	419
Protein (gram)	0.9	2.9
Lactose (gram)	1.3	4.2
Potassium (mmol)	4	6.3
Sodium (mmol)	0.6	1.9
Magnesium (mmol)	0.43	0.73
Zinc (mg)	2	2.3
Copper (mg)	0.25	0.25

Potassium at 3 meq/kg/day - 4 meq/kg/day (twice the normal requirement) can be supplemented for two weeks as it remains low in SAM. Most common commercial oral syrup preparation is 20 meq/15ml strength which should be mixed with clean water or some compatible juice in 1:10 dilution.

All severely malnourished children have multiple vitamin and mineral deficiencies; thus, they should be supplemented with multivitamins in twice the RDA. Kumar R, et al. [23] found signs of vitamin B-complex and vitamin A deficiencies in 14.4% and 5.8% cases respectively [23]. Mehta S et al found low Vitamin D level (mean=68.8 nmol/l) in 32% of SAM children aged 6 months to 60 months [24].

Table 5: Method of titrating feed frequency in SAM.

Days	**Frequency**	**Volume/kg/feed**	**Volume/kg/day**
1-2	2 hourly	11 ml	130 ml
3-5	3 hourly	16 ml	130 ml
6-7	4 hourly	22 ml	130 ml

At ED, **Vitamin A** should be started orally (200,000 IU stat dose for all SAM children aged >12 months, and 100,000 IU for age group 6-12 months, while dose for < 6 months age is 50,000 IU) and the same dose can be repeated on the next day and day-14, if clinical signs of vitamin A deficiency are present. Eye care with atropine and antibiotics eye ointments is required for corneal ulcer. Lannotti LL, et al. [25] in their systematic review recommended low-dose protocols of vitamin-A (such as use of carotenoids or RUTF fortified with vitamin-A) in SAM, to avoid toxicity related to high doses of vitamin-A [25]. Similarly, a double-blinded RCT in Bangladesh (n =260 children) found no benefit of high dose of vitamin A over low dose vitamin A (5000 IU/day daily for 15 days) [26]. Children with SAM must receive at least Recommended Dietary Allowance **(RDA)** of Vitamin-A (5000 IU/day) throughout the treatment duration.

It is advisable to supplement daily doses of **folic acid** 1 mg/d (5 mg on Day 1 followed by 1 mg daily), zinc 2 mg/kg/day, and copper 0.3 mg/kg/day for 2 weeks.

Hiffler L, et al. [27] recommended 25 mg (1/2 tablet of 50 mg) of **thiamine** orally for all complicated SAM, preceded by a loading dose of 100 mg by slow IV infusion for the first 2 days in severe acute conditions [27]. In a randomized placebo-controlled study, 2 high doses of Vitamin D3 (2 lakh IU at 2nd and 4th week) improved the mean WFH/WHL z score and developmental indices among uncomplicated SAM [28]. So, in addition to other essential micronutrient supplements, adequate vitamin D and oral calcium (preferably as phosphate preparation) may be supplemented to all children with SAM once they start tolerating adequate feeds.

STEP 4: Rehabilitation Phase (Intensive Feeding, Sensory Simulation and Iron Supplementation)

Rehabilitation phase is often not the part of ED management and child should be shifted to Ward, NRC or any CoE for it. But sometimes child with SAM has to be kept at ED, if NRC or CoE facility is not available or general ward is full. The level of physical activity in children with SAM is very low but increases hastily during recovery [29].

Refeeding of SAM children with diets rich in carbohydrate but low in phosphorus and magnesium may result into 'refeeding syndrome' characterized by hypophosphatemia and hypomagnesemia, and sometimes resulting into respiratory or circulatory failure or even death [30-32]. In the rehabilitation phase, starter feeds (F-75) are converted into catch-up feeds (F-100) containing 100 kcal and 2.9 grams protein per 100 ml, with a transition phase of 24 hours - 48 hours.

Feeds have to be increased by additional 15 ml/kg/day - 20 ml/kg/day till total of 150 ml/kg/day with daily measuring of weight gain and monitoring for tolerance, but feeds may also be further enhanced with the same rate (15 ml/kg/day - 20 ml/kg/day) till maximum of 200 ml/kg/day - 220 ml/kg/day (targeting a maximum of 150 kcal/kg/day - 220 kcal/kg/day and 4 grams protein/kg/day - 6 grams protein/kg/day). F-100 feeds can also be rapidly increased with an aim to achieve good weight gain of >10 gram/kg/d. If respirations increase by ≥ 5 breaths/min and pulse by ≥ 15 beats/min, we have to reduce the volume per feed and foods without added salt should be opted to avoid sodium overload. Iron should be essentially started in rehabilitation phase, but only when child starts gaining weight (usually after first week of intensified feedings) in the dose of 3 mg/kg/day, preferably in between meals or at night time 1 hour to 2 hours after dinner.

In severe malnutrition, there may be delay in motor skills, speech as well as mental and behavioral development, and there might be co-existent irritability, hyperactivity or attention deficit attributable to iron or other micronutrient deficiencies. So, we must provide them tender loving care, cheerful and stimulating environment, structured play therapy (15-30 minutes daily to improve motor activities and language skills), and initiate physical activity as soon as the child is well enough and maternal involvement whenever possible (e.g. comforting, feeding, bathing, play). Psychological problems like stereotyped movements (rocking), rumination (self-stimulation through regurgitation) and attention seeking behavior should be handled with extra tender love and care. Child should be taught local songs, poems and games using fingers and toes with description of the acts to the child as reinforcing feedback. For bedridden children, passive limb movements and bedsore preventive care should be done at regular intervals. We should keep in mind that marasmus requires longer hospital stay than Kwashiorkor [33].

STEP 5: Disposition from PEM, Care at Home and Follow-up

A child with WFL ≥ -1SD can be considered to have recovered from acute malnutrition, though even after adequate weight gain child may still likely to have a low WFA because of stunting. Child with WFH or WFL above -2 Z-score or MUAC >12.5 cm and no oedema for at least 2 weeks can be contentedly discharged satisfactorily.

The diagnostic parameter (WFH/WFL, or MUAC) with which the child was admitted, the improvement in defined cutoff of those same parameters should be major discharge criteria. Percentage weight gain should not be used as a discharge criterion. An infant <6 month without complications can be discharged if gaining weight for consecutive 5 days on breast feeding Table 6 denotes the criteria for adequate weight gain in malnourished infants and children.

Table 6: Weight gain assessment

Poor weight gain	<5 g/kg/d	do full reassessment of the child
Moderate weightgain	5-10 g/kg/d	check whether intake targets are being met or if infection has been overlooked
Good weight gain	>10 g/kg/d	continue to praise and reassure both caring staff and mothers

Good feeding practices with proper hygiene and sensory stimulation should be continued at home. We must emphasize on teaching parents about importance of frequent energy and nutrient-dense foods, structured play therapy, and counselling the parents about regular follow-up, due primary and booster immunizations, and need of vitamin-A every six months till age of five. At home, main meals ensured should be at least 5 times a day with locally available high-energy snacks (e.g. milk, bread, biscuits, eggs, jaggery, nuts, oil or peanut butter, banana, and other fruits) in between the main meals. Child should be appreciated and encouraged to complete intake of given amount of each feed. In addition to these, breast feeding should be continued for all children < 2 years old. A long-term periodic follow-up is imperative to monitor the status of relapses of SAM, persistent stunting and other associated co-morbid conditions. The primary cause of SAM is often lack in nutritional supply, intake, absorption, or assimilation; but its relapse may be multifactorial like various causes of secondary SAM like malabsorption, persistent infections, functional and structural organ dysfunctions, which may result into failure to thrive and chronic malnutrition. The relapse rate after discharge was found between 0% and 6.3% in a systematic review of follow-up studies of 6-24 months age-group children with SAM [34].

RUTF: Ready to Use Therapeutic Feed

RUTF is suitable option for children with SAM with or without diarrhea, in both inpatient and outpatient/community settings; as it is an energy-dense, mineral and vitamin-enriched, usually peanut butter or edible oil-based paste, with a similar nutrient profile but greater energy and nutrient density than water-based F-100 [35].

If child is not able to take full prescribed amount of RUTF then top-up with F-75 should be given and amount of RUTF should be increased over next 2-3 days, until child takes full prescribed amount. If the child is taking less than half of prescribed amount of RUTF in first 12 hours, then its trial should be omitted and F-75 can be restarted as initial feeds. Retrying with RUTF should be done 1-2 days later. If RUTF is not available, then F-100 can be given for early catch-up growth.

RUTF tested in a number of experimental settings was proved to be efficacious in treatment of SAM, as it decreased mortality rates and increased recovery rate [36]. According to a multi-center randomized trial (906 children with uncomplicated SAM, aged 6-59 months), centrally made RUTF was found to be more efficacious than homemade micronutrient enriched, energy-dense foods [37]. A study from Congo revealed that food rich in β-carotene protects against development of kwashiorkor [38].

A type of indigenously prepared RUTF also termed as Medical Nutrition Therapy (MNT) was found superior to imported RUTF as well as standard nutritional therapy in terms of weight gain in SAM [39-40]. RUTFs can be stored un-refrigerated for several months because of very low water content, but indigenous RUTF should be prepared only for one week and stored in refrigerator. In another study comparing RUTF constituents, Milk-Soya-Maize-Sorghum based (MSMS-RUTF) was more effective than classical and expensive peanut and milk based (PM-RUTF) in correcting malnutrition and iron deficiency anemia [41].

But RUTF with high micronutrient density may adjoin to higher mortality in children with SAM, possibly because of high iron content [42]. According to a systematic review and meta-analysis of studies on community-based treatment of SAM, children given RUTF was 51% more likely to achieve nutritional recovery than the standard care given as per WHO guidance [43].

Unusual Conditions or Co-morbidities with Severe Acute Malnutrition

- **SAM with HIV infection**

  Antiretroviral drug treatment with weight-based recommended doses should be started as soon as child goes into rehabilitation phase. They should be monitored closely (both during in or outpatient care) in the first 6-8 weeks following initiation of antiretroviral therapy, to identify early metabolic complications and opportunistic infections. Feeding approaches are same

as that of a non-HIV child and breastfeeding of infants <2 years may be continued in developing countries. They should be given adequately higher doses of vitamin A and zinc, unless therapeutic food contains it. If diarrhea is persisting despite of standard management, then carbohydrate intolerance and other infections should be ruled out. Cotrimoxazole prophylaxis is to be continued as per NACO guideline or WHO guideline [44]. Kerac M, et al. [45] found more mortality in children who had concurrence of SAM and HIV [45].

- **SAM in <6 month of age**

As per AGREE appraisal of national SAM guidelines, on review of 36 various national guidelines, total space used for description of SAM in <6 month of age was 6% only [46]. To label SAM in infants <6 months of age, **same criteria are used except** MUAC.

SAM patients irrespective of age-group should receive the standard medical care [47]. Mother should be supported to breastfeed the baby. Supplementary suckling technique can also be tried in mothers who appear to have lactation failure. In SAM without oedema, expressed breast milk should be given and if not feasible then, commercial (generic) infant formula or non-cereal-based F-75 or diluted F-100 (diluted by adding plain water as 30% content, to avoid high renal solute load and risk of hypernatremic dehydration) may be given; either alone or as the supplementary feed together with breast milk. In SAM with oedema, infant formula or F-75 should be given as a supplement to breast milk.

Evaluation of locally prevalent socio-cultural practices, parenting knowledge/attitude, physical and mental health status of mothers or caregivers, and implementing needed interventions should be promoted. If mother is not ready for hospitalization due to any reason, the infant or child should be called on weekly follow-up for weight monitoring and checking parental compliance after counseling for home/community-based intensified feeding and other supportive care.

- **SAM with severe anemia**

Whole blood 10 ml/kg body weight can be given slowly over 3-4 hours with Furosemide (1 mg/kg IV at the start or middle of the transfusion), if hemoglobin is <4 g/dl or between 4-6 g/dl (if there is mild cardiorespiratory compromise). If the severely anemic child has signs of congestive cardiac-failure, transfusion of packed cells in lesser volume (5 ml/kg - 7 ml/kg) rather than whole blood, and should be transfused slowly over 3-5 hours and with intravenous diuretic given pre-transfusion. Also monitor the respiratory rate and pulse rate every 15 minutes and if either of them rises, transfuse more slowly. Following the transfusion, if the hemoglobin still remains <4 g/dl or 4 g/dl to 6 g/dl in a child with continuing respiratory distress, do not repeat the transfusion within next 4 days. In mild or moderate anemia, oral iron therapy should be started in a dose of 3 mg/kg/day - 6 mg/kg/day, but only after initiation of weight gain and given for 2-3 months to replenish iron stores.

- **Other conditions requiring specific supportive care**

Deworming is highly essential to break the vicious cycle of worm infestation, anemia, and malnutrition, so either Albendazole (200mg for <2-year-old and 400mg for >2 old children) or oral Mebendazole (100 mg, twice daily for 3 days) can be given.

False negative Mantoux test are common in SAM, therefore tuberculosis should be assessed carefully. Similarly, HIV-TB coinfection may warrant eagle's eye approach for early diagnosis and treatment.

For nutritional dermatosis, zinc supplementation and barrier cream help. Nappies should be avoided as a fancy measure to keep the perineum dry.

Prognosis

Dereje N [48] found the momentous relationship of SAM with maternal education, freedom in decision making and badly chosen child-caring practices [48]. Low score of Kuppuswamy scale i.e. poor socio-economic status, premature birth, recurrent diarrhea and respiratory tract infections are an assorted risk factors leading to development of SAM and higher mortality [49]. Malnutrition advancement can be hindered with early therapeutic intervention [50]. Case fatality rate more than

5% should be a major alert for healthcare systems to curtail further preventable deaths due to malnutrition. Severely wasted children are nine times more likely to die than well-nourished children if not treated promptly. In a study, with same PRISM (Pediatric Risk of Mortality) score, child with severe malnutrition had higher mortality [51]. The table7 enlists the major killer factors responsible for likely mortality even during management of severe acute malnutrition.

Table 7: Causes of mortality during SAM management

Duration	Reason of mortality
Within 24 hours	Delayed or no treatment of hypoglycaemia, hypothermia, septicaemia, severe anaemia or incorrect rehydration fluid or volume
Within 72 hours	High volume and wrong formulation of feeds
At night	Hypothermia and no night feeds
When changing to catch-up F-100	Very rapid transition

Chro SAM study found association of SAM with long term adverse effect in terms of cardiovascular and metabolic disease [52].

A study done in non-HIV-infected SAM children found correlation of reduction in life threatening events (severe pneumonia and diarrhea) with improvement in anthropometric parameters [53]. Malnutrition is spatially clustered indicating gross impact of regional and socio-cultural factors thus can be reduced by the targeted interventions at hotspots, education of mother about health, adequate feeding, sanitation and reduction of poverty [54].

Focus on the community-level correction is as important as facility-development focus because according to a WHO estimate, 50% of the malnutrition was related to repeated diarrhea or intestinal worm infections because of unsafe water and inadequate sanitation or insufficient hygiene especially in nutritionally vulnerable community groups (tribals, minorities) responsible for anemia, poor physical growth, and cognitive impairments.

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