

Moving Towards a More Aggressive and Comprehensive Model of Care for Children with Ebola

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Ebola is a devastating illness for children, particularly those under 5 years of age.¹⁻³ Although children are proportionally less affected than adults during outbreaks of Ebola, including in the current West Africa outbreak,⁴ it remains a major threat to child health in the affected nations and a neglected area of investigation and discussion.⁵ The threat is not only for those infected with Ebola, but for all children in the affected region because of the tremendous impact of this outbreak on national health care systems.⁶

In addition to what appears to be a different immunologic response to Ebola in children,⁷ the uniquely challenging bedside care of suspect and infected children plays a significant role in the increased morbidity and mortality in this age group. Little information has been published on efforts to care for children in Ebola treatment units (ETUs). We present a report of our experience caring for children at what was the largest ETU in Port Loko, Sierra Leone, and a discussion of our protocols for caring for children with Ebola, with the hope of stimulating an international dialogue regarding the care of children with this disease.

These protocols represent the culmination of the accumulated experience and knowledge of our ETU health care staff. Although, admittedly, they reflect some shared insights from staff at other ETUs, the majority stem from the published literature with adaptations of standard pediatric therapy. The protocols represent the care we aspired to provide to each child at the time our ETU closed in March 2015 and serve as a starting point for future ETU providers and policymakers for the next Ebola epidemic. Because of resource limitations, a rigorous evidence-based demonstration of efficacy for all of these recommended interventions remains to be done. Thus, the protocols are well rooted in solid, biological rationale and clinical experience but as yet lack ideal empirical support.

Setting

The Maforki ETU was a 106-bed facility opened in October 2014 in a former Red Cross Vocational School (Figure;

available at www.jpeds.com). The unit was operated by the Sierra Leone Ministry of Health and manned by national staff, international staff through Partners In Health, and members of the Cuban Medical Brigade.¹ The ETU was divided into a holding ward for suspected cases that were pending Ebola virus reverse-transcription polymerase chain reaction (RT-PCR) confirmation of infection and a treatment ward for confirmed Ebola cases.² The turnaround time for Ebola RT-PCR and malaria testing was typically 24-72 hours as venous blood samples were sent to an off-site laboratory. Point-of-care glucose and I-STAT (Abbott Laboratories, Abbott Park, Illinois) measurements (including sodium, potassium, chloride, carbon dioxide, anion gap, ionized calcium, glucose, blood urea nitrogen, creatinine, hematocrit, and hemoglobin) became available after the unit was in operation and were used as clinically indicated.

Suspected cases were separated into those with “wet” symptoms of hemorrhage, vomiting, and/or diarrhea, and those who were still “dry” and without such symptoms. Children represented one-tenth to one-third of the patient census at any given time.

Between November 1, 2014, and March 17, 2015, 910 patients were admitted to the Maforki ETU with suspected or laboratory-confirmed Ebola, 908 of whom had ages recorded. Of these 908 admissions, 261 (28.7%) were children under 18 years of age. Eighty-seven (9.6%) were less than 5 years of age, 117 (12.9%) were 5-12 years old, and 57 (6.3%) were 13-17 years of age.

Because Maforki was a holding unit before the treatment center component was added, diagnostic and outcome data are missing for patients in the first months of the unit’s operation, making it impossible to determine the specific pediatric case fatality rate (CFR). The published CFR of 75%-80% in children in this and previous epidemics, particularly those under 5 years of age, is consistent with the Maforki ETU experience.³⁻⁷

Impetus for Change

In December 2014, the ETU at the Hastings Police Training School near Freetown, Sierra Leone, reported an overall

| | |
|--------|---|
| ACT | Artemisinin-combination therapy |
| CFR | Case fatality rate |
| ETU | Ebola treatment unit |
| IO | Intraosseous |
| IV | Intravenous |
| PPE | Personal protective equipment |
| RT-PCR | Reverse-transcription polymerase chain reaction |

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CFR of 31.5% among 581 patients, significantly lower than what had been reported previously by other centers.⁸ The decrease in mortality was attributed to an aggressive regimen of intravenous (IV) fluids, antibiotics, anti-inflammatory, and nutritional agents. Age-specific mortality rates were not included in their report, so it is impossible to know how well the protocol performed for children. Their protocol influenced the World Health Organization recommendations (modified for Sierra Leone) for the care of patients with Ebola,² and served as a foundation for the development of similar aggressive protocols for the care of pediatric and adult patients at Maforki.

Evolution of Pediatric Ebola Treatment Protocols

The Maforki medical protocols assume a range of pediatric experience among practitioners and address the particular challenges in the care of children. The protocols recognize the need for the continuous accompaniment of children to ensure they receive fluids, nutrition, and medications, as well as psychological support. They also stress the critical recognition of chronic malnutrition in children presenting for care and the importance of modified fluid and nutrition protocols for malnourished children.⁹

At Maforki, children were initially integrated with adults in the suspect and confirmed wards of the ETU. Recognizing their need for specialized care, after about 2 months children were separated into their own wards within the suspect and confirmed units. The pediatric wards were stocked with supplies and equipment specific to children's needs (eg, diapers, nutritional products, small-gauge IV needles, toys). Parents and their children suspected of having Ebola were placed together in the pediatric suspect ward. As soon as Ebola was confirmed by RT-PCR in either parent or child, discordant dyads were separated. Similarly, as soon as Ebola was ruled out in 1 person, the 2 were separated and that individual discharged. Mothers were asked to stop breastfeeding on admission to reduce the risk of viral transmission. This required extensive time and reinforcement of alternative feeding methods.

Because parents often were unavailable to attend to their children, additional environmental adaptations were made for the safety of unattended children, who also presented unique challenges to the unit's infection prevention and control protocols (eg, leaving their beds, exploring medical supplies, etc.).¹⁰

The **Table** summarizes key elements of the medical treatment protocols with full details given in **Appendix 1** (available at www.jpeds.com). Given the severe gastrointestinal fluid losses found in almost all patients with Ebola, significant emphasis was placed on fluid and electrolyte resuscitation. In addition to the liberal use of oral rehydration solution (ideally flavored to improve intake), emphasis was placed on early and aggressive parenteral fluid resuscitation, even among those who appeared well-hydrated

Table. Key elements of Maforki pediatric treatment protocols

| |
|---|
| Initial assessments |
| Temperature |
| Weight |
| Mid-upper arm circumference |
| Blood pressure |
| Assessment of hydration status |
| Oral rehydration solution |
| IV/IO fluids |
| Bolus of lactated ringers with 5% dextrose |
| Reassessments of hydration status and repetition of half boluses |
| Potassium and magnesium supplementation for those with diarrhea |
| Nutritional supplementation |
| F-100 or ready-to-use therapeutic food or BP-100 biscuits |
| Antimalarials |
| IV/IM artesunate daily |
| Complete course with oral artesunate-combination therapy |
| Antibiotics |
| IV/IM ceftriaxone daily |
| Add metronidazole for selected cases |
| Zinc |
| Oral zinc daily |
| Vitamin K |
| Oral or intramuscular dose on admission |
| Consideration of additional doses for those with active bleeding |
| Ondansetron |
| As needed for nausea and vomiting |
| Loperamide |
| As needed for nonbloody diarrhea in confirmed patients with Ebola |

initially (except for children confirmed or suspected to have malaria or malnutrition, because of the risk of fluid overload¹¹). It was believed that IV access would be easiest to obtain at the time of admission before further fluid losses made finding vascular access difficult. After much consideration and recognition of the risks to both providers and patients, a second IV line was added to the protocol for "wet" patients with active vomiting and/or diarrhea. Pressure bags to increase the rate of fluid administration were also used. In the approximately 10% of children in whom IV access could not be obtained, intraosseous (IO)¹² and occasionally subcutaneous routes (**Appendix 2**; available at www.jpeds.com) were used for fluid resuscitation.¹³ The fluid of choice was lactated Ringer solution, ideally supplemented with glucose, potassium, and magnesium, as guided by clinical status and bedside I-STAT monitoring.

Just prior to the unit's closure, a portable bedside ultrasound machine became available. The instrument was used as an aid to IV line placement, for visualizing the inferior vena cava and descending aorta to assess hydration status, to assess the lungs and pleura for signs of effusion or pneumonia or pulmonary edema, and to assess for the presence of ascites as a late sign of fluid overload. Because of its late arrival, use was relatively limited, and it is unclear how much ultrasonography could have ultimately helped overcome the limitations imposed by personal protective equipment (PPE) in performing physical examinations and procedures.

Medications were used to decrease the amount of gastrointestinal losses including antiemetics such as ondansetron (IV and by mouth). Recognizing the controversy around its use, and after careful consideration of risks and benefits,

loperamide was introduced to decrease diarrheal fluid losses. Its use was limited to patients with RT-PCR-confirmed Ebola and nonbloody diarrhea¹⁴ because of the risk of toxicity in those with bacterial diarrhea. Loperamide was used successfully in a number of children without any observed adverse effects.

Micronutrient supplementation included empiric oral zinc for all patients based on the emerging consensus that this decreases the severity and duration of diarrhea in children due to other infections.¹⁵ Vitamin K was also provided at admission for all patients based on the suspicion that the elevated serum hepatic transaminases seen in early reports of severe Ebola also may have¹⁶ reflected decreased synthetic function and/or increased consumption of coagulation factors. These factors could contribute to prolonged prothrombin time, an assumption borne out to some degree in subsequent clinical reports.¹⁷

Empiric antibacterial therapy with ceftriaxone was included due to the high risk of severe bacterial infections (particularly because of *Salmonella* and pneumococcus) that could mimic the clinical picture of Ebola and given our limited diagnostic ability to differentiate between Ebola and bacterial sepsis. The concern for bacteremia, particularly attributable to gram-negative bacilli from gut translocation complicating Ebola also was believed to be high enough to warrant presumptive therapy.¹⁸ Other antibiotics such as ciprofloxacin, cefdinir, or amoxicillin/clavulanate were used if an oral option was required. Initially, all patients received metronidazole as had been standard at Hastings.⁸ After we observed that a large number of patients had a significant increase in abdominal pain and nausea, its empiric use was limited to those with severe or bloody diarrhea.

Similarly, endemic *Plasmodium falciparum* malaria was frequently found to mimic the clinical presentation of Ebola in children. Thus, all children received antimalarial therapy, begun on admission as IV artesunate, followed by a complete course of artemisinin-combination therapy (ACT). The laboratory available to us was off-site and used a commercial malaria rapid diagnostic test. Results generally were available 24-72 hours after admission. Given the limited ability and timeliness in diagnosing malaria, we elected to complete the full course of ACT even for patients with negative rapid diagnostic test results. Malaria potentially contracted in the unit and the theoretical benefit of a period of posttreatment prophylaxis that might extend some 10 days after completing ACT were additional rationales for the full course of ACT.¹⁹

After recognizing continued significant mortality in children, nutritional care evolved to take a high priority. The World Health Organization Ebola nutrition recommendations²⁰ were adapted to make liberal use of F-100 and ready-to-use therapeutic food (**Appendix 3**; available at www.jpeds.com). Brief nutritional assessments were made on admission using mid-upper arm circumference and weight when scales became available. Children with moderate acute malnutrition who were suspected or confirmed to have Ebola were considered to have “complicated moderate acute malnutrition” and treated according to standard outpatient therapeutic feeding protocols for severe acute malnutrition.²¹

Challenges in Pediatric Ebola Care

Even with pediatric-specific equipment, assessments, and protocol-guided treatments, the greatest limitation to effective pediatric care remained the intermittent presence of staff at the bedside because of the challenges of working in PPE under extremely hot and humid conditions. The current forms of PPE limit staff time with patients to 1- to 2-hour intervals, 2 or 3 times in an 8- to 12-hour shift, a challenge that must be rationally addressed in the future if patient care is to be optimized.²² This limitation made it particularly difficult to maintain parenteral access; resuscitation was interrupted and lines disconnected for safety when staff left the bedside.

Components of Western treatment were adapted in an effort to move toward optimal care and improved mortality for critically ill children with Ebola.²³⁻²⁷ Further improvements in the care environment may depend on better staffing models and climate-controlled ETUs in order to maximize staff accompaniment.

In addition to the limitations of current care models, other factors likely also contribute to the high mortality of children with Ebola, particularly those less than 5 years of age. Children have a shorter incubation period and a more rapid progression to death, perhaps as a result of a higher viral inoculum relative to body weight.⁷ The diagnosis of Ebola in the pediatric population may be delayed, as symptoms can mimic other common illnesses (eg, malaria, measles, and gastroenteritis). Children with Ebola are often brought for care later in the course of their disease, often after a period of underfeeding and its consequent immune deprivation, because their parents are ill or deceased.

Future Opportunities for Improving Pediatric Ebola Care

There remain a number of opportunities for further improvements in the care of children with Ebola. What is presented here is only the final iteration of our protocols that evolved over time based on accumulated experience and published literature. Interventions to improve the ability for providers to spend more time at the bedside, attempting to approach the level of attention and care children receive in traditional hospital settings or critical care units, has fundamental importance. Caring for patients in the hot and humid tropics is challenging to begin with and of course the addition of hot and stifling PPE makes this even more difficult. Lighter PPE and environmental cooling measures such as air conditioning would allow for longer and more focused periods of bedside care.

Given that such changes are likely too expensive and logistically challenging at the present time and given present resources, some limitations on performing a thorough physical examination while wearing PPE might be overcome through technological innovations such as digital stethoscopes²⁸ and remote monitoring of vital signs.²⁹ From a patient monitoring standpoint, an essential improvement in care would be more accurate methods for assessing and

improving hydration status in this infection that predominantly manifests as a severe gastroenteritis.³⁰ The most simple and essential aspect of assessing hydration status would be an accurate method to quantify intake and output, which proved remarkably challenging without a round-the-clock bedside presence. The use of adult Ebola survivors as caretakers who could spend long periods at the bedside without PPE should be considered, both for the sake of accompaniment but also as aides to ensure that each child's intake and output would be captured accurately. Frequent blood pressure monitoring and consistently obtained daily weights would be helpful as well, but these require careful consideration of the infection control implications.

Better methods to consistently maintain IV access for fluid resuscitation in children are also needed; consideration should be given to obtaining early central venous access, as has been successfully demonstrated in adults.³¹ It should also be feasible to make better use of point-of-care testing (eg, lactate, blood gases, glucose) to individualize each child's fluid and electrolyte resuscitation. An even more ambitious goal would be to develop an infrastructure for safe blood transfusions as part of goal-directed therapy for septic patients.

We believe that even in the absence of marked infrastructure improvements such as climate-controlled ETUs or innovations such as lighter PPE, an early emphasis on appropriate and thorough training of both local and expatriate staff, as well as aggressive intervention and monitoring with already available technologies will lead to significant decreases in mortality.

More comprehensive nutritional care for pediatric patients also should be provided. Although our protocols aimed for nutritional care at all hours, we were still unable to have a clinician or survivor caregiver at the bedside at all times. Given the severe nausea and vomiting in children with Ebola as well as each child's unique development and behaviors including sleep/wake cycle and interest in activities, it was impossible to predict exactly when each child would be hungry. Thus, it should be the goal to have caregivers at the bedside with food or formula available at all times. Psychosocial support also should be available on the child's schedule as much as possible, conceivably as an adaptation of the Child Life services available in children's hospitals.

Given the relatively nonspecific case definition for suspect Ebola cases,^{2,32} at least one-half of the children we cared for did not have Ebola. Diagnostic capabilities were limited, so most children were treated with empiric antibiotics and antimalarials. A more refined care regimen would risk-stratify those children most likely to have Ebola based on algorithms incorporating clinical and historical criteria,³³ potentially isolating highest-risk patients (as identified by these algorithms) in their own "suspect" wards while testing is conducted. In infants and children where there is difficulty in obtaining blood samples, capillary samples could be used initially as an alternative, although it should be remembered that they would not be perfectly sensitive.³⁴ Future diagnostic regimens should incorporate rapid Ebola tests,³⁵ specific testing for common childhood illnesses,³⁶ including rapid malaria and

HIV tests, and rapid multiplex polymerase chain reaction-based bacterial and viral stool studies. All of these would of course require more sophisticated and complete laboratory facilities and isolation procedures. But as Ebola becomes a routine element of patient assessment and medical care in this region, the accurate diagnosis of common childhood diseases that mimic Ebola will become even more essential.

The disruption of routine primary care during the epidemic has led to significant delays in routine, critical vaccinations.³⁷ Catch-up immunizations should be provided to children admitted to an ETU while they are a "captive audience" in the health care system.

Finally, as children recover from Ebola, psychosocial support for re-integration back into their community should be formalized, including preparing their families for the continued physical and psychological challenges they are likely to face. If available, physical and occupational therapy could even be introduced while children are convalescing in the ETU prior to discharge.

In the future, frequent reassessment of the effectiveness of each new intervention and a flexibility to adapt to unpredictable problems and unanticipated consequences will be essential. Given the continued high mortality rate of children with Ebola, we should not remain satisfied with our current protocols. It is clear that with optimal care many of these children do not have to die.²⁴

Conclusions

The care of children with suspected or confirmed Ebola in West Africa is extremely challenging, and current models of intermittent care driven by the limitations inherent to PPE leaves room for significant opportunities for improvement. Nevertheless, despite these handicaps, a methodical and aggressive approach to patient care is possible. More work is needed to understand how underlying social and nutritional vulnerability may contribute to high mortality rates, and more effort is needed to provide age-appropriate supportive and critical care for hospitalized children.

It is worth emphasizing that the baseline mortality rate for children in the countries affected by Ebola was among the highest in the world even prior to this epidemic. Sierra Leone had the world's highest mortality rate in children under 5 years of age in 2012 (182/1000), Guinea was 15th (101/1000), and Liberia 32nd (75/1000).³⁸ These reflect a historical pattern of health care and social disparities characterized by limited access to primary care, poor-to-absent prenatal and neonatal care, a high burden of acute tropical infections, underlying chronic disease, and malnutrition. The loss of medical professionals in these countries and the devastation to health care systems further compound the impact of Ebola on the very young.³

As the current Ebola epidemic wanes,³⁹ the difficult but essential work of health systems strengthening continues, including preparation and coordination for the next

outbreak.^{40,41} Given the shortage of national pediatric professionals, age-specific resources, and dedicated pediatric facilities, significant investment from the international community will be needed.

We hope the protocols presented here serve as a starting point for future discussion and inquiry into providing optimal care for children with Ebola. In professions characterized by men and women who have dedicated their lives to the care of children, we are optimistic that a call for those willing to sacrifice time, accept personal risk to care for these desperately ill children, and invest their insights and efforts in the future of pediatric care in these nations will not go unheeded.⁴² ■

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References

- Baez F, Perez J, Reed G. Meet Cuban Ebola fighters: interview with Felix Baez and Jorge Perez. A MEDICC Review exclusive. MEDICC Rev 2015; 17:6-10.
- World Health Organization, Sierra Leone Ministry of Health. Clinical management of patients in the Ebola treatment centres and other care centres in Sierra Leone - modified from "Clinical management of patients with viral haemorrhagic fever: A pocket guide for the front-line health worker". Geneva: World Health Organization; 2014.
- Frieden T. Eight ways Ebola threatens the children of West Africa. [updated January 16, 2015] Fox News. <http://fxn.ws/1G6fSnZ>. Accessed December 18, 2015.
- McElroy AK, Erickson BR, Flietstra TD, Rollin PE, Nichol ST, Towner JS, et al. Biomarker correlates of survival in pediatric patients with Ebola virus disease. Emerg Infect Dis 2014;20:1683-90.
- Nebehay S. High rates of child deaths from Ebola, special care needed: WHO. [updated February 6, 2015]. Reuters. <http://reut.rs/1D5rmbR>. Accessed December 18, 2015.
- Peacock G, Uyeki TM, Rasmussen SA. Ebola virus disease and children: what pediatric health care professionals need to know. JAMA Pediatr 2014;168:1087-8.
- W. H. O. Ebola Response Team. Ebola virus disease among children in West Africa. N Engl J Med 2015;372:1274-7.
- Ansumana R, Jacobsen KH, Sahr F, Idris M, Bangura H, Boie-Jalloh M, et al. Ebola in Freetown area, Sierra Leone—a case study of 581 patients. N Engl J Med 2015;372:587-8.
- Iannotti LL, Trehan I, Clitheroe KL, Manary MJ. Diagnosis and treatment of severely malnourished children with diarrhoea. J Paediatr Child Health 2015;51:387-95.
- World Health Organization. Interim infection prevention and control guidance for care of patients with suspected or confirmed filovirus haemorrhagic fever in health-care settings, with focus on Ebola. Geneva: World Health Organization; 2014.
- Maitland K, Kiguli S, Opoka RO, Engoru C, Olupot-Olupot P, Akech SO, et al. Mortality after fluid bolus in African children with severe infection. N Engl J Med 2011;364:2483-95.
- Paterson ML, Callahan CW. The use of intraosseous fluid resuscitation in a pediatric patient with Ebola virus disease. J Emerg Med 2015;49:962-4.
- Rouhani S, Meloney L, Ahn R, Nelson BD, Burke TF. Alternative rehydration methods: a systematic review and lessons for resource-limited care. Pediatrics 2011;127:e748-57.
- Chertow DS, Uyeki TM, DuPont HL. Loperamide therapy for voluminous diarrhea in Ebola virus disease. J Infect Dis 2015;211:1036-7.
- Galvao TF, Thees MF, Pontes RF, Silva MT, Pereira MG. Zinc supplementation for treating diarrhea in children: a systematic review and meta-analysis. Rev Panam Salud Publica 2013;33:370-7.
- Lyon GM, Mehta AK, Varkey JB, Brantly K, Plyler L, McElroy AK, et al. Clinical care of two patients with Ebola virus disease in the United States. N Engl J Med 2014;371:2402-9.
- Liddell AM, Davey RT Jr, Mehta AK, Varkey JB, Kraft CS, Tsegay GK, et al. Characteristics and clinical management of a cluster of 3 patients with Ebola virus disease, including the first domestically acquired cases in the United States. Ann Intern Med 2015;163:81-90.
- Kreuels B, Wichmann D, Emmerich P, Schmidt-Chanait J, de Heer G, Kluge S, et al. A case of severe Ebola virus infection complicated by Gram-negative septicemia. N Engl J Med 2014;371:2394-401.
- Nosten F, White NJ. Artemisinin-based combination treatment of falciparum malaria. Am J Trop Med Hyg 2007;77:181-92.
- WHO/UNICEF/WFP. Interim guideline: nutritional care of children and adults with Ebola virus disease in treatment centres. Geneva: World Health Organization; 2014.
- Trehan I, Manary MJ. Management of severe acute malnutrition in low-income and middle-income countries. Arch Dis Child 2015;100: 283-7.
- Sprecher AG, Caluwaerts A, Draper M, Feldmann H, Frey CP, Funk RH, et al. Personal protective equipment for filovirus epidemics: a call for better evidence. J Infect Dis 2015;212(Suppl 2):S98-100.
- Chertow DS, Kleine C, Edwards JK, Scaini R, Giuliani R, Sprecher A. Ebola virus disease in West Africa—clinical manifestations and management. N Engl J Med 2014;371:2054-7.
- Fowler RA, Fletcher T, Fischer WA II, Lamontagne F, Jacob S, Brett-Major D, et al. Caring for critically ill patients with Ebola virus disease. Perspectives from West Africa. Am J Respir Crit Care Med 2014;190:733-7.
- Lamontagne F, Clement C, Fletcher T, Jacob ST, Fischer WA II, Fowler RA. Doing today's work superbly well—treating Ebola with current tools. N Engl J Med 2014;371:1565-6.
- Farmer P. The secret to curing West Africa from Ebola is no secret at all. [updated January 16, 2015]. The Washington Post. <http://wapo.st/14IXIAZ>. Accessed December 18, 2015.
- Eriksson CO, Uyeki TM, Christian MD, King MA, Braner DA, Kanter RK, et al. Care of the child with Ebola virus disease. Pediatr Crit Care Med 2015;16:97-103.
- McNeil DG Jr. In treating Ebola, even using a stethoscope becomes a challenge. [updated February 8, 2015]. <http://nyti.ms/1lwezng>. Accessed December 18, 2015.
- Steinhubl SR, Marriott MP, Wegerich SW. Remote sensing of vital signs: a wearable, wireless "band-aid" sensor with personalized analytics for improved Ebola patient care and worker safety. Glob Health Sci Pract 2015;3:516-9.
- Freedman SB, Vandermeer B, Milne A, Hartling L, Pediatric Emergency Research Canada Gastroenteritis Study Group. Diagnosing clinically significant dehydration in children with acute gastroenteritis using noninvasive methods: a meta-analysis. J Pediatr 2015;166: 908-16.e1-6.
- Rees PS, Lamb LE, Nicholson-Roberts TC, Ardley CN, Bailey MS, Hinsley DE, et al. Safety and feasibility of a strategy of early central venous catheter insertion in a deployed UK military Ebola virus disease treatment unit. Intensive Care Med 2015;41:735-43.
- Lado M, Walker NF, Baker P, Haroon S, Brown CS, Youkee D, et al. Clinical features of patients isolated for suspected Ebola virus disease at Connaught Hospital, Freetown, Sierra Leone: a retrospective cohort study. Lancet Infect Dis 2015;15:1024-33.

33. Levine AC, Shetty PP, Burbach R, Cheemalapati S, Glavis-Bloom J, Wiskel T, et al. Derivation and internal validation of the Ebola prediction score for risk stratification of patients with suspected Ebola virus disease. *Ann Emerg Med* 2015;66:285-93.e1.
34. Strecker T, Palyi B, Ellerbrok H, Jonckheere S, de Clerck H, Bore JA, et al. Field evaluation of capillary blood samples as a collection specimen for the rapid diagnosis of Ebola virus infection during an outbreak emergency. *Clin Infect Dis* 2015;61:669-75.
35. Broadhurst MJ, Kelly JD, Miller A, Semper A, Bailey D, Gropelli E, et al. ReEBOV Antigen Rapid Test kit for point-of-care and laboratory-based testing for Ebola virus disease: a field validation study. *Lancet* 2015;386:867-74.
36. O'Shea MK, Clay KA, Craig DG, Matthews SW, Kao RL, Fletcher TE, et al. Diagnosis of febrile illnesses other than Ebola virus disease at an Ebola treatment unit in Sierra Leone. *Clin Infect Dis* 2015;61:795-8.
37. Takahashi S, Metcalf CJ, Ferrari MJ, Moss WJ, Truelove SA, Tatem AJ, et al. Reduced vaccination and the risk of measles and other childhood infections post-Ebola. *Science* 2015;347:1240-2.
38. UNICEF. The state of the world's children 2014 in numbers: every child counts. New York: United Nations Children's Fund; 2014.
39. W. H. O. Ebola Response Team. Ebola virus disease in West Africa—the first 9 months of the epidemic and forward projections. *N Engl J Med* 2014;371:1481-95.
40. Gates B. The next epidemic: lessons from Ebola. *N Engl J Med* 2015;372:1381-4.
41. Brett-Major DM, Jacob ST, Jacquerioz FA, Risi GF, Fischer WA II, Kato Y, et al. Being ready to treat Ebola virus disease patients. *Am J Trop Med Hyg* 2015;92:233-7.
42. Mobula LM. Courage is not the absence of fear: responding to the Ebola outbreak in Liberia. *Glob Health Sci Pract* 2014;2:487-9.

Appendix 1

Maforki Ebola Holding and Treatment Center Pediatric Clinical Protocols Version 2.08, March 15, 2015

Initial Assessments for Children Being Admitted to Maforki Ebola treatment unit (ETU)

1. Check temperature, weight, and automatic blood pressure in all children.
2. Check mid-upper-arm circumference (MUAC) on the left arm. If the MUAC is below the age-adjusted threshold, refer to the Maforki Nutrition Protocol for guidance on therapeutic feeding.
3. Unless the child is extremely well-appearing and has an obvious alternative diagnosis (eg, uncomplicated malaria), attempt to place at least 1 intravenous (IV) on all children at the time of admission. Children with recent vomiting, diarrhea, or evidence of moderate (or worse) dehydration should ideally have 2 IV lines placed.
 - 3.1. For those with particularly voluminous gastrointestinal losses, 2 IVs are preferred. If consistent access is not available, consider IO access in the proximal tibia.
 - 3.2. If the child already has a Port Loko laboratory number, attempt to obtain 1 purple top tube of blood at the time of admission when starting the IV.

Parenteral Fluids

1. IV/IO fluid bolus at admission – use lactated Ringers' (LR) solution supplemented with 5% glucose
 - 1.1. Dry children: 20 mL/kg
 - 1.2. Wet children with significant concern for malaria (often marked by jaundice, pallor, fever, splenomegaly) or malnutrition: 20 mL/kg
 - 1.3. Wet children without obvious concern for malaria or malnutrition: 40 mL/kg
2. After initial boluses, reassess hydration status (capillary refill, skin turgor, warmth of extremities, mental status)
 - 2.1. Repeat bolus with one-half of the initial bolus and reassess
 - 2.2. Can repeat these one-half boluses 2-3 times or more as needed, with the caveat that an increased respiratory or heart rate during resuscitation may be a marker of intravascular fluid overload
3. After admission, children will require continued aggressive fluid rehydration to account for insensible losses (increased because of fever, acidosis, tachypnea, and high environmental temperature), even in the absence of significant gastrointestinal losses and hemorrhage.

- 3.1. Add glucose to fluids for any children with significant vomiting or anorexia. Give strong consideration to including glucose in most fluids given to children, especially the youngest children.
- 3.2. Frequent reassessments of hydration status and monitoring for fluid overload are needed, and care will need to be individualized, but the following general guidelines apply:
- 3.3. Dry children and children with significant concern for malaria or malnutrition: At least:
 - 3.3.1. 150 mL/kg/day for first 10 kg of body weight plus
 - 3.3.2. 75 mL/kg/day for next 10 kg of body weight plus
 - 3.3.3. 40 mL/kg/day of remaining weight
- 3.4. Wet children with significant concern for malaria or malnutrition: In addition to the rate above for dry children, provide at least an additional 100 mL for each loose stool.
- 3.5. Wet children without obvious concern for malaria or malnutrition: In addition to the rate above for dry children, provide at least an additional 200 mL for each loose stool.

Potassium Supplementation

1. Potassium supplementation of parenteral fluids should generally be included for children with significant diarrhea unless there is evidence of decreased urine output and renal failure.
 - 1.1. Titration of this supplementation is best guided by frequent I-STAT measurements because of the high risk of prerenal failure and consequent hyperkalemia. Nevertheless, the amount of potassium lost in diarrhea because of cholera and rotavirus suggests that empirically adding 10 mEq/L of potassium supplementation in IV/IO fluids (when replacing stool losses liter-for-liter) is safe.
 - 1.2. However, a rapid rate of potassium administration can be fatal and LR supplemented with additional potassium should not be infused by squeezing or pressure bag but rather only by gravity.
 - 1.3. Dosing: 10 mEq/L potassium chloride added to LR – to be infused by gravity rather than by pressure bag or squeezing
 - 1.4. Given that this slow infusion would limit the amount of fluids a child could receive, LR without added potassium should be administered via a second IV line at a more aggressive rate to achieve the fluid goals needed for adequate resuscitation.
 - 1.4.1. The goal of overall volume resuscitation likely supersedes the goal of electrolyte supplementation, but both goals must be balanced for each situation and also balanced with the time available for bedside patient care because of personal protective equipment.

Magnesium Supplementation

1. Magnesium should also be supplemented into parenteral fluids for children with significant diarrhea unless there is evidence of significant hypotension.
 - 1.1. Prior to giving any magnesium, the child's blood pressure should be evaluated to be sure the child does not have hypotension. If the systolic blood pressure is low for age (or if the pulse pressure is wide), the child should first be resuscitated with fluids without magnesium.
 - 1.2. Minimum systolic blood pressure before giving magnesium (check prior to each dose):
 - 1.2.1. Adolescents: 90 mm Hg
 - 1.2.2. School-aged children: 80 mm Hg
 - 1.2.3. Toddlers: 70 mm Hg
 - 1.2.4. Infants: 60 mm Hg
 - 1.3. Rapid infusions of magnesium can lead to significant hypotension and thus LR supplemented with additional magnesium should not be infused by squeezing or pressure bag but rather only by gravity.
 - 1.4. Dosing: 25 mg/kg magnesium sulfate, up to 100 mg/kg (maximum 2 g) per day
 - 1.5. Given that this slow infusion would limit the amount of fluids a child could receive, LR without added magnesium should be administered via a second IV line at a more aggressive rate to achieve the fluid goals needed for adequate resuscitation.
 - 1.5.1. The goal of overall volume resuscitation likely supersedes the goal of electrolyte supplementation, but both goals must be balanced for each situation and also balanced with the time available for bedside patient care because of personal protective equipment.

Oral Rehydration Solution (ORS)

1. All children should be encouraged to drink large volumes of ORS, both at admission and throughout hospitalization. There is no maximum amount that they should drink, but instead is guided by thirst, and frequent positive reinforcement for drinking ORS should be provided by all care providers.
2. The exact amount of ORS needed depends on a number of factors, including degree of initial dehydration, amount of ongoing losses, and amount of IV/IO fluids provided.
3. Children may be expected to consume up to 20 mL/kg of ORS per hour when initially dehydrated if not provided IV/IO fluids.
4. Sports drinks and sugary drinks such as fruit-flavored and carbonated commercial drinks should not be given to children as they can worsen diarrhea.

Nutritional Supplementation

1. All admitted children should receive aggressive nutritional supplementation. Refer to the Pediatric Nutrition Protocol ([Appendix 3](#)) for details.

Antimalarials

1. All children should receive empiric antimalarial therapy at the time of admission because the case definition for Ebola overlaps so much with the clinical presentation of malaria, particularly in children whose predominant clinical syndrome is mostly a febrile diarrhea.
 - 1.1. In general, even children with a negative malaria rapid diagnostic test can complete their course of antimalarial therapy as this would decrease the confusion about the cause of new fevers in the ETU and also is likely to provide some short-term protection against malaria during their post-Ebola convalescence when they are already likely to be weak and somewhat debilitated.
2. In order to most rapidly reduce parasitemia and symptoms, most children should begin therapy with IV/intramuscular (IM) artesunate at least at 0, 12, and 24 hours. Subsequent doses will then be every 24 hours thereafter.
3. After the initial 24 hours, if the child's clinical condition has improved to the point where per os (PO) medication intake appears likely to be reliable (ie, the child is without significant vomiting or diarrhea), the child can then be transitioned to oral artemisinin-combination therapy for 3 days. If the oral course of medications is ever interrupted or if the child needs to return to parenteral artesunate, the entire 3-day oral course must be restarted.
4. All children must complete a continuous 3-day oral course of artemisinin-combination therapy, either while in Maforki, or after discharge, regardless of how long they received parenteral artesunate.
5. Dosing: 2.4 mg/kg IV/IM
6. Oral dosing regimens will depend on whether artesunate-amodiaquine ("A-A") or artemether-lumefantrine ("Coartem") is available – dosing should follow the weight-based dosing instructions found on the packaging.

Broad-Spectrum Antibiotics

1. Almost all children should receive empiric antibacterial therapy at the time of admission because of the high risk of bacterial gut translocation, superimposed secondary bacterial infections, and the possibility that a primary bacterial infection is actually the primary diagnosis rather than Ebola (eg, typhoid fever).
2. Dosing: ceftriaxone 50 mg/kg IV/IM q24h (maximum 2 g)
3. Bowel wall edema and gut translocation are more likely to occur late in the course of the disease. Consideration should, thus, be given to treating children with metronidazole plus either ceftriaxone or ciprofloxacin for any child who develops signs and symptoms of sepsis or a worsening abdominal exam or worsening diarrhea after an initial improvement.
 - 3.1. If the child was previously on ceftriaxone, consideration could be given in this scenario to add ciprofloxacin to their antibiotic regimen.

- 3.2. Dosing: ciprofloxacin 20-30 mg/kg IV q12h (maximum 400 mg)
4. If an adverse reaction to antibiotics is suspected (eg, allergic reaction, antibiotic-associated diarrhea, etc), consideration could be given either to discontinuing antibiotics if the child is clinically well and/or convalescing or to changing to a different class of antibiotics (eg, changing ceftriaxone to ciprofloxacin).

Anaerobic/Antiprotozoal Medication

1. Children with significant voluminous diarrhea or bloody diarrhea should also receive empiric coverage for anaerobes, Giardia, and Cryptosporidium.
2. Dosing: metronidazole 15 mg/kg IV/PO q8h (maximum 500 mg)

Zinc

1. Zinc should be provided to all children to help decrease diarrhea and improve immune function.
2. Children over 6 months: zinc sulfate 20 mg PO q24h
3. Children under 6 months: zinc sulfate 10 mg PO q24h

Vitamin K

1. Vitamin K should be provided to all children at the time of admission to decrease the risk of hemorrhagic manifestations of Ebola.
2. The PO route is preferable to IM. Vitamin K should generally not be given IV as there is a high risk of anaphylaxis.
3. Children over 12 years: vitamin K 10 mg PO/IM at admission
4. Children under 12 years: 5 mg PO/IM at admission

Ondansetron

1. Children with nausea and vomiting should receive ondansetron to decrease the amount of fluids lost by vomiting, increase the amount of ORS they are able to consume, and to provide comfort.
2. Children over 12 years: ondansetron 4-8 mg PO/IV q8h-q12h
3. Children under 12 years: ondansetron 2-4 mg PO/IV q8h-q12h

Loperamide

1. Selected children with voluminous non-bloody diarrhea who have been confirmed to be Ebola-positive may receive loperamide to decrease their diarrheal losses.
2. Caution should be advised in these cases to be sure the child does not have bloody diarrhea and that their abdomen is examined frequently for rigidity that may be a marker of ileus or paresis. Should the child develop bloody diarrhea or a concerning abdominal examination or have a significant decrease in stool losses, loperamide should be discontinued.

3. Clinicians should maintain awareness of local epidemiology of other diarrheal disease outbreaks, most notably cholera outbreaks, and be particularly cautious about the use of loperamide when there is such an outbreak.
4. Dosing: 2 mg PO initially, then subsequent doses of 1 mg, up to 8 mg/d

Seizure Management

1. The first priority in managing seizures is to protect the child's airway and fall safety.
2. Consider an IV/IO push of glucose for actively seizing children. The glucose solutions should ideally be diluted with saline or LR because of how corrosive to subcutaneous tissue if it extravasates.
 - 2.1. Dosing: 1 mL/kg of G50 solution infused IV/IO over 2-3 minutes (maximum 50 mL)
3. Diazepam IV can be used for acute seizure management for prolonged or clustered seizures. This will not prophylax against future seizures.
 - 3.1. Children over 5 years old: 0.1-0.3 mg/kg IV/IM (maximum 10 mg)
 - 3.2. Children under 5 years old: 0.1-0.3 mg/kg IV/IM (maximum 5 mg)
4. Children with seizures refractory to glucose and diazepam may be given 10% calcium gluconate at a dose of 1-2 mL/kg IV/IO at an infusion rate of less than 1 mL per minute.

Appendix 2

Maforki Ebola Holding and Treatment Center Subcutaneous Fluid Administration (Hypodermocleisis) Protocol Version 2, February 24, 2015

Background: Subcutaneous infusion techniques allow administration of compatible crystalloid fluids in dehydrated patients. The subcutaneous route of administration may allow providers to administer needed crystalloid fluids when peripheral vein IV access attempts fail. The subcutaneous route of fluid infusion may be less painful than IV/IO insertion and IV/IO fluid administration.¹⁻⁴

Subcutaneous infusion requires the insertion of a needle or catheter under the skin. Crystalloid fluids are slowly infused into subcutaneous tissue over several hours, and are eventually taken into the intravascular space. Compatible crystalloid fluids are those that normally do not pose a risk of injury when IV/IO infiltration into subcutaneous tissue occurs. Medications that can be injected subcutaneously are also generally compatible.

Indications

1. Patients with dehydration who are unable to rehydrate orally and in whom IV/IO access attempts have failed.
2. Patients requiring ongoing maintenance fluids who are unable to take sufficient oral fluids and in who IV access has failed or is not possible.

Contraindications

1. Soft tissue infection or bleeding at injection site
2. Need for rapid administration of fluids (consider IO line)

Equipment

1. Solution bag (see list of compatible fluids)
2. IV tubing with drip chamber
3. 21 g, 22 g or 23 g butterfly needle or angiocatheter
4. Alcohol swab
5. Sterile occlusive dressing

Compatible fluids and additives

1. Normal saline, half normal saline, D5-NS, D5-1/2 NS
2. Lactated ringers, D5-lactated ringers
3. Additives: may infuse 20-40 mmol/L of electrolytes safely

Technique

1. Select insertion site:
 - a. Abdomen
 - b. Chest above breasts
 - c. Upper outer arm
 - d. Thighs
 - e. Infrascapular (preferred in children)
2. Wash hands
3. Prepare site with alcohol or betadine swab
4. Insert needle or catheter subcutaneously with bevel up at a 45-60 degree angle
 - a. Avoid inserting needle too deep (muscle infusion painful)
 - b. Avoid infusion if blood seen in tube on needle insertion
5. Secure needle and tubing with occlusive dressing (ideally)
 - a. Date and time dressing and tubing
6. Start infusion by slow gravity drip
 - a. Typically 1 mL per minute (1.5 L per day per site)
 - b. May use 2 sites if indicated
 - c. Discomfort may be indicator of too fast rate
 - d. Do not administer more than 1 L in 2 hours
7. Check infusion site within 1 hour (if possible) for signs of subcutaneous edema or leakage
 - a. Infusion site may be massaged to reduce edema
8. Periodically check solution, tubing, and needle for malfunction or dislodgement
9. Change needle and tubing every 1-4 days.
10. Observe patient for signs of fluid overload (rare)

References

1. Sasson M, Schwartzman P. Hypodermocleisis: an alternative infusion technique. *Am Fam Physician* 2001;64:1575-9.
2. Hypodermocleisis technique. Family practice notebook. <http://www.fpnotebook.com/ER/Procedure/HypdrmlcysTchnq.htm>. Accessed January 21, 2015.
3. Spandorfer P. Subcutaneous rehydration: updating a traditional technique. *Pediatr Emerg Care* 2011;27:230-6.
4. Rouhani S, Meloney L, Ahn R, Nelson BD, Burke TF. Alternative rehydration methods: a systematic review and lessons for resource-limited care. *Pediatrics* 2011;127:e748-57.

Appendix 3

Nutritional Care for Children at Maforki Ebola Holding and Treatment Center Version 2.2, March 9, 2015

Rationale: Since Nevin Scrimshaw's pivotal studies in Guatemala from the 1960s demonstrating a strong bidirectional link between malnutrition and infection,^{1,2} a large body of literature has emerged demonstrating that undernourished children fare worse when faced with a severe infection. Similarly, survivors of severe infectious diseases often find themselves newly malnourished and with lingering weakness and long-term disability.³ Malnutrition is the primary cause of immunodeficiency worldwide and acts through a number of mechanisms; those relevant to Ebola include compromised immune defenses at epithelial barriers (respiratory mucosa, skin, and most importantly, the architecture of the gut mucosa with flattened microvilli, reduced lymphocyte counts in Peyer's patches, and reduced IgA secretion), reduced availability of complement components, and decreased leptin levels (needed for T cell activation).⁴ Specific immunodeficiencies attributable to limited intakes in overall calories, specific amino acids, vitamin A, vitamin D, iron, magnesium, and zinc have all been described.^{5,6}

The traditional rural diet in sub-Saharan Africa is heavily dependent on staple starch crops, whether maize, cassava, millet, or sorghum, with minimal diversity. This relatively monotonous diet is not conducive to a sufficient diversity of protein, fatty acid, or micronutrient intake.^{7,8} In addition, dietary sources of sufficient protein are generally expensive and extreme poverty results in large nutritional gaps, particularly for children under age 5 years. Although some portions of Sierra Leone have relatively good access to fish as a source of protein and essential fatty acids, some 25% of the population remains undernourished,⁹ and nearly 45% of children are stunted.¹⁰ Children with Ebola are particularly vulnerable, as they suffer 2 acute "hits" in addition to their chronic undernutrition. First, children are infected with Ebola after a caregiver falls ill, and then secondly, their nutrition also suffer as their caregiver is often unable to provide the child with as much nutrition and care. When children are confronted with a serious illness such as Ebola, their already deficient nutritional reserves and compromised immune systems are

ill-equipped to deal with large volumes of fluid and electrolyte losses. Further, given the frequency of sore throat, anorexia, nausea, vomiting, and abdominal pain, children with Ebola have minimal oral intake, further limiting their nutritional status.

Goal: Children with Ebola must receive sufficient quantities of calories, macronutrients (protein, fat), and essential micronutrients to aid their immune systems in clearing the virus and to aid in decreasing post-Ebola morbidity among survivors. This is particularly true for children under age 5 years. Given the nausea and dysphagia that Ebola patients frequently suffer from, the quantity of food eaten is low, and the food provided needs to be energy- and nutrient-dense in order to provide maximal nutrition in a small volume. Ideally, food would also be available to children 24 hours a day without spoiling in between prespecified meal times.

Recommendation: All Maforki patients should be provided with a daily supply of ready-to-use therapeutic food (RUTF) of which Plumpy'Nut is the best-known brand and encouraged to use this as their primary form of nutritional intake. (Partners In Health actually has a long history of using RUTF and in fact manufactures this for children locally in Haiti, where it is called Nourimanba.¹¹) RUTF is a peanut-based lipid-nutrient spread with a number of characteristics that make it an ideal nutritional supplement for children with Ebola:

- Very energy dense (500 kcal plus a full complement of micronutrients in a single 92-g sachet) to provide excellent nutritional intake even if small quantities are consumed
- Does not require cooking
- Resists spoilage and microbial contamination (because it contains no water)
- Palatable to most children
- Can be consumed on-demand, day or night, in small or large quantities, whenever children are hungry
- Locally produced by the nonprofit Project Peanut Butter in Freetown, thus, ensuring easy availability along with supporting local farmers and jobs

An alternative new formulation of RUTF, BP-100 biscuits, can also be used instead of standard RUTF. These biscuits can be eaten directly as-is or crumbled into clean drinking water and eaten as a porridge. Whichever formulation is most palatable to each child should be chosen.

Pediatric Nutritional Protocol Based on WHO Guideline¹² (modified for Maforki ETU):

1. All children should receive ample quantities of ORS throughout their hospitalization. An estimate of the quantity consumed (eg, number of bottles) should be entered into the patient's clinical record to help track overall fluid intake.
 - 1.1. ORS should preferably be prepared using bottled or bagged water, although the use of calcium or iodine purification powder and tap water is acceptable should there be a water shortage.

- 1.2. Children who prefer water over ORS should be supplied with ample water instead.

- 1.2.1. Infants under 6 months should not receive water alone to drink, except in rare circumstances. They should be provided with ready-to-use infant formula instead.

2. Children who are not tolerating any oral intake at all should have dextrose added to their LR resuscitation fluids in order to limit the risk of hypoglycemia and excess catabolism.

- 2.1. Up to 20-40 mEq of KCl can be added to their IV fluids per day for those with significant diarrhea. An attempt should be made to check electrolytes and renal function using the I-STAT machine whenever children receive KCl for more than 1-2 days.

3. All children who are able to tolerate solid or semi-solid foods should be provided with RUTF and/or BP-100 in ample quantities (**Table I**).

- 3.1. Children, caregivers, and staff should be educated that nutritional care will be optimized if children eat all of their intended RUTF and/or BP-100 each day. The intake of RUTF and/or BP-100 should always be prioritized over the standard hospital food, which generally does not provide as complete a daily diet of fats, proteins, and micronutrients. Children should always be provided with more RUTF and/or BP-100 if they consume all of this amount.

- 3.2. Because RUTF and BP-100 do not contain any water, children are likely to want more water or ORS than they otherwise would. This should be provided to them as well.

- 3.3. Young children may not be able to eat RUTF without some mixing with water in a spoon or cup. BP-100 can be crushed and mixed with water to make a porridge. These may be tried on a case-by-case basis.

- 3.4. Packages of RUTF and/or BP-100 should be provided to children on a daily basis and do not need to be removed or discarded once they are open unless obvious insect or ant infestation has occurred. Packages of RUTF may be opened and the food squeezed out into a cup or plate for young children to eat with their hands or a spoon ad lib.

Table I. Nutritional intake goals for children at Maforki

| Age | RUTF sachets per d | BP-100 biscuits per d |
|---------|--------------------|-----------------------|
| 1-4 y | 2-3 | 3-5 |
| 5-9 y | 3-4 | 5-7 |
| 10-14 y | 4-5 | 6-8 |

- 3.5. The youngest published age at which children have been safely fed RUTF is generally established as 6 months,¹³ although many operational malnutrition feeding programs do feed children RUTF as young as 3-4 months of age on a case-by-case basis.
4. Children over 6 months of age who are only able to tolerate liquid foods should be provided with F-75 or F-100 formula instead of ready-to-use formula milk as these formulas provide much higher nutritional content.
 - 4.1. F-100 is in general a better nutritional choice for these children but has a higher likelihood of causing diarrhea due to its higher osmotic load, and, thus, F-75 may be a better choice for some children.
 - 4.2. These formulas do spoil if unrefrigerated and, thus, may need to be reconstituted multiple times per day.
 - 4.3. Children should generally not be given fruit juices, sodas, or other non-nutritive beverages as these only serve to exacerbate diarrhea and decrease more nutritious intake.
5. Children under 6 months of age should be provided with ready-to-use formula milk instead, as the safety of F-75 and F-100 has not been fully established in this age group.
6. Nasogastric tubes may be considered on a case-by-case basis for children without vomiting who are too weak to eat or drink.
 - 6.1. The decision to place a nasogastric tube in a child should always be made in consultation with a Port Loko clinician with extensive pediatric experience. Ideally, this person will be at the bedside when the nasogastric tube is placed, position is confirmed, and feeding initiated.
 - 6.2. Generally, feeding F-75, F-100, or ready-to-use formula milk will be the indications for nasogastric tubes, but water/ORS hydration can also be considered in select circumstances where vascular access is unavailable.
7. Children with acute malnutrition (both moderate and severe) should be identified at the time of admission based on their MUAC (**Table II**).
- 7.1. The MUAC thresholds presented are well-established in children under 5 years old and for adults but are only extrapolated estimates for the other ages and, thus, should be used as guidelines. Clinical judgment, incorporating signs of visible wasting and history of recent weight loss, should be used in all circumstances.
- 7.2. All of these children should receive empiric antibiotics¹³ (ceftriaxone 50 mg/kg/d or amoxicillin 40-45 mg/kg/dose every 12 hours, up to adult maximums) from the time of admission, regardless of fever or other signs or symptoms of infection.¹⁵
- 7.3. These children, especially those under 5 years of age, should be fed only F-75, F-100, RUTF, or BP-100. Breast milk and water should be the only additional liquids that they drink.
- 7.4. These children will require particularly aggressive therapeutic feeding during their hospitalization at Maforki and special arrangements should be made to provide frequent directly observed feedings around the clock, using a combination of Partners In Health staff, national nurses, and survivor caregivers at the bedside frequently.
 - 7.4.1. These feedings should be planned so that they are provided every 2-3 hours for young children, every 3-4 hours for older children, and every 4-5 hours for adolescents.
 - 7.4.2. It should not be assumed that children (even those with a guardian at the bedside) will feed themselves at these intervals, but instead plans should be made for directly observed feedings of F-75, F-100, RUTF, or BP-100 at these intervals in order to achieve the goal nutritional intake.

Table II. MUAC thresholds for identifying acute malnutrition¹⁴

| Age | MUAC |
|----------|----------|
| 6 mo-5 y | <12.5 cm |
| 6-7 y | <14.0 cm |
| 8-9 y | <15.5 cm |
| 10-11 y | <17.0 cm |
| 12-13 y | <18.5 cm |
| 14-15 y | <20.0 cm |
| 16-17 y | <21.0 cm |

References

1. Scrimshaw NS. Historical concepts of interactions, synergism and antagonism between nutrition and infection. *J Nutr* 2003;133:316S-21S.
2. Scrimshaw NS, Taylor CE, Gordon JE. Interactions of nutrition and infection. *Monogr Ser World Health Organ* 1968;57:3-329.
3. Katona P, Katona-Apte J. The interaction between nutrition and infection. *Clin Infect Dis* 2008;46:1582-8.
4. Schaible UE, Kaufmann SHE. Malnutrition and infection: complex mechanisms and global impacts. *PLoS Med* 2007;4:e115.
5. Krawinkel MB. Interaction of nutrition and infections globally: an overview. *Ann Nutr Metab* 2012;61(Suppl 1):39-45.
6. Guerrant RL, Oria RB, Moore SR, Oria MO, Lima AA. Malnutrition as an enteric infectious disease with long-term effects on child development. *Nutr Rev* 2008;66:487-505.
7. Semproli S, Canducci E, Ricci E, Gualdi-Russo E. Nutrient intake in 5-17-year-old African boys and girls in a rural district of Kenya. *Nutr Hosp* 2011;26:765-74.
8. Burlingame B. The food of Near East, North West and Western African regions. *Asia Pac J Clin Nutr* 2003;12:309-12.
9. FAO, IFAD, WFP. The state of food insecurity in the world 2014: Strengthening the enabling environment for food security and nutrition. Rome: Food and Agriculture Organization; 2014.

10. IFPRI. 2014 global nutrition report: Actions and accountability to accelerate the world's progress on nutrition. Washington: International Food Policy Research Institute; 2014.
11. Nourimanba: fighting malnutrition, fighting poverty in Haiti. <http://www.pih.org/blog/nourimanba-malnutrition-haiti-poverty>. Accessed December 18, 2015.
12. WHO/UNICEF/WFP. Interim guideline: Nutritional care of children and adults with Ebola virus disease in treatment centres. Geneva: World Health Organization; 2014.
13. Trehan I, Manary MJ. Management of severe acute malnutrition in low-income and middle-income countries. *Arch Dis Child* 2015;100:283-7.
14. Tang AM, Dong K, Deitchler M, Chung M, Maalouf-Manasseh Z, Tumilowicz A, et al. Use of cut-offs for mid-upper arm circumference (MUAC) as an indicator or predictor of nutritional and health-related outcomes in adolescents and adults: a systematic review. Washington: FHI 360/FANTA; 2013.
15. Trehan I, Goldbach HS, LaGrone LN, Meuli GJ, Wang RJ, Maleta KM, et al. Antibiotics as part of the management of severe acute malnutrition. *N Engl J Med* 2013;368:425-35.

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Figure. Survivor tree outside Maforki ETU. Each fabric “ribbon” on the tree represents an Ebola survivor. The sign credits the national and international coalition of professionals who provided patient care and support.