Supportive Care of the First 2 Ebola Virus Disease Patients at the Monrovia Medical Unit

Karen K. Wong, Christopher L. Perdue, Jennifer Malia, James L. Kenney, Suzette Peng, Jamal K. Gwathney, and Gregory A. Raczniak; for the Monrovia Medical Unit

United States Public Health Service, Rockville, Maryland

We describe the first 2 patients admitted to the Monrovia Medical Unit, a facility established to treat Liberian and international response workers with suspected or known Ebola virus disease (EVD). Their recoveries illustrate the value of local point-of-care diagnostics, parenteral therapies, and electrolyte replacement in EVD supportive care.

Keywords: hemorrhagic fever; Ebola; acute kidney injury; point-of-care systems; Liberia.

The 2014–2015 Zaire ebolavirus (EBOV) outbreak in West Africa has affected national and international medical staff; several have become infected [1–4]. Bedside monitoring, point-of-care tests, and parenteral therapies are limited in West Africa. The Monrovia Medical Unit (MMU) in Liberia was established to treat national and international healthcare and response workers with suspected or known Ebola virus disease (EVD). Through a bilateral agreement between the US and Liberian governments, a temporary field hospital was constructed. It is staffed by personnel from the Commissioned Corps of the US Public Health Service, a uniformed service of public health professionals overseen by the Surgeon General [5].

Although the MMU does not have full US hospital capabilities [3, 6–8], it has capabilities that are not available in many West African Ebola treatment units (ETUs). Staff record vital signs ≥4 times daily. WelchAllyn Propaq units print adult 3-lead electrocardiograms. Precise monitoring of inputs/outputs is not possible as patients are not under constant observation, bedside commodes collect multiple body fluids (urine, diarrhea, vomitus), and patients are sometimes incontinent or use shared latrines. Bedside ultrasound is available for assessing volume status and assisting with procedures. Staff can deliver parenteral therapies, including fluids, electrolytes, antibiotics, antiemetics, and analgesics, ≥4 times daily. A 12-hour shift typically includes 2 providers and 8 nurses; they deliver meals, bathe patients, and clean up waste in addition to usual clinical duties. Staff also includes laboratory scientists, pharmacists, and administrative, planning, safety, logistics, and command officers. An onsite laboratory is equipped with Abbott i-STAT handheld analyzers (Abbott Laboratories, Abbott Park, Illinois), a Piccolo Xpress table-top, portable clinical chemistry system (ABAXIS, Inc, Union City, California), and a light microscope.

Protocols for patient flow, disinfecting patient areas, and managing waste are consistent with Centers for Disease Control and Prevention and World Health Organization guidelines [9, 10]. Staff in the high-risk zone communicate data and patient needs by speaking across the boundary between high- and low-risk zones or by handheld radios. Visual data, such as vital signs or electrocardiograms, are digitally photographed from the low-risk zone.

Since November 2014, the MMU has cared for >36 healthcare workers with confirmed or suspected EVD [11]. We describe the first 2 patients admitted to the MMU and the role of point-of-care diagnostics and parenteral therapies in their recoveries.

CASE REPORTS

Patient 1

A 28-year-old male physician assistant with a history of chronic hepatitis B and peptic ulcer disease was working at a general clinic when he developed fever, vomiting, and diarrhea. His clinic had limited personal protective equipment (PPE), so he reused PPE daily. Prior to illness onset, he cared for a colleague at the clinic who later died from EVD. The patient reported testing positive for malaria, and he treated himself with oral antimalarial therapy. When symptoms did not improve by illness day 8, he visited an ETU where EBOV reverse transcription polymerase chain reaction (RT-PCR) of blood was positive (cycle threshold [Ct] value 21.36) and a malaria test was negative.

Upon MMU transfer on illness day 9, he was afebrile (37.7°C [99.9°F]) and ambulatory. Laboratory data were significant for hypokalemia (<2 mmol/L), serum creatinine 1.3 mg/dL, and aspartate aminotransferase >2000 IU/mL. He received 3–4 L lactated Ringer’s solution (LR) per day and intravenous ceftriaxone.
and metronidazole; normal saline was used instead of LR when infusing at the same time as ceftriaxone. He had difficulty maintaining oral intake despite intravenous antiemetics. He remained afebrile initially without antipyretic medications. He required 40–80 mEq of potassium chloride intravenously and 1–2 g of magnesium intravenously daily for persistent hypokalemia (serum potassium range, <2.0–4.1 mmol/L) (Figure 1). By illness day 13 he experienced intermittent vomiting, but his diarrhea waned and energy level increased. He received oral rehydration solution (ORS) popsicles (0.5–1.5 L per day), which he tolerated better than liquids. On illness day 15, he developed a temperature of 38.2°C (100.8°F), and he received a single dose of mefloquine for possible malaria. On illness day 16, erythema and tenderness were noted at a right forearm peripheral intravenous cannula site. Intravenous piperacillin/tazobactam and vancomycin were started, then changed to oral cephalexin by illness day 18 as symptoms and fevers improved. All EVD symptoms remitted by illness day 19. He had no hemorrhagic symptoms during his hospital course. EBOV RT-PCR tests on blood drawn on illness day 21 and illness day 23 were negative, and the patient was

![Figure 1](image-url)

**Figure 1.** Selected laboratory values, signs and symptoms, therapies, and Ebola virus reverse transcription polymerase chain reaction (PCR) cycle threshold (Ct) values by symptom day for patient 1. *Serum potassium (K) <2.0 mmol/L. **Aspartate aminotransferase (AST) >2000 IU/L. Abbreviations: Cr, creatinine; EBOV, *Zaire ebolavirus*; HCO₃, bicarbonate; IVF, intravenous fluids; KCl, potassium chloride; Mg, magnesium sulfate; Pip/tazo, piperacillin/tazobactam.
discharged home without symptoms. He was advised that it was unclear how long EBOV could persist in the semen of EVD survivors and to avoid unprotected sex as a precaution.

Patient 2
A previously healthy 43-year-old male medical records keeper without patient care duties worked at the same clinic as patient 1; he developed malaise, weakness, diarrhea, and vomiting and treated himself with ciprofloxacin. When symptoms did not improve by illness day 3, he presented to an ETU where EBOV RT-PCR of blood was positive (Ct value 26) and malaria testing was negative.

Upon MMU transfer on illness day 4, the patient was alert, ambulating independently, and afebrile (36.1°C [97.0°F]). Laboratory data showed hyperkalemia (5.9 mmol/L), blood urea nitrogen 101 mg/dL, serum creatinine 12.0 mg/dL, aspartate aminotransferase 354 IU/mL, and alanine aminotransferase 148 IU/mL. An electrocardiogram showed sinus rhythm without peaked T waves (Supplementary Figure 1). Urine output over the first 48 hours was 550 mL. He received ORS and ORS popsicles without potassium and with sodium bicarbonate (0.5–2 L/day) and 1–3 L of intravenous fluids daily. Normal saline was given initially to minimize potassium infusion, and fluids were changed to LR as serum potassium improved. EBOV RT-PCR on blood
collected on illness day 6 was positive (Ct value 34). His urine was tea-colored, and urine dipstick collected on illness day 6 was positive for blood. Microscopic examination of fresh, unspun urine revealed normal erythrocytes without cellular, hyaline, or muddy brown casts. Serum lactate dehydrogenase on illness day 7 was 798 IU/L, and the serum was clear and straw-colored. On illness day 7 he developed a cough; oxygen saturation was noted to be 92% and jugular venous pressure was estimated at 14–16 cm. Serum albumin was 2.4 g/dL. He received furosemide 20 mg intravenously, and the cough and oxygen saturation improved. He had intermittent hiccups that were treated with metoclopramide and haloperidol.

Gastrointestinal symptoms improved after illness day 5. On illness day 10 he developed fever (39.7°C [103.4°F]) and rigors (Figure 2). His abdomen was soft and nontender, and he was treated for presumed bacteremia with vancomycin and piperacillin/tazobactam, with dosing adjusted for renal function. He received mefloquine for possible malaria; subsequent malaria RT-PCR was negative. His fevers resolved by illness day 12. Antibiotics were changed to oral levofloxacin on illness day 13. Throughout his hospital course he had no hemorrhagic symptoms. By illness day 13, serum creatinine decreased to 1.9 mg/dL and serum potassium decreased to 4.6 mmol/L. EBOV RT-PCR tests on blood collected on illness day 13 and illness day 15 were negative, and the patient was discharged home without symptoms. He was counseled that it was unclear how long virus could persist in the semen of EVD survivors and to avoid unprotected sex as a precaution.

DISCUSSION

Supportive care for EVD in West Africa is based on often limited diagnostic information and protocol-driven administration schedules [1, 12–16]. At the MMU, bedside monitoring and point-of-care tests facilitated individualized treatment. These 2 survivors had EBOV RT-PCR Ct values as low as 21 and 26. Low Ct values correlate with higher EBOV RNA loads, which correlate with higher mortality [12].

MMU staffing allows frequent monitoring, management of intravenous lines, and phlebotomy. Our experience with these EVD patients suggests that limited point-of-care tests and bedside monitoring are feasible in resource-limited settings. Patient 2’s severe renal failure resolved with careful fluid and electrolyte management without use of renal replacement therapy. The etiology of the renal failure remains unknown; prerenal azotemia, acute tubular necrosis, and rhabdomyolysis were considered in the differential diagnosis when managing the patient. Studies of supportive therapies are needed to identify interventions that may mitigate EVD mortality.

Both patients developed late-onset fevers. Patient 1 had peripheral intravenous-associated superficial thrombophlebitis and cellulitis, whereas patient 2 was presumed to have bacteremia from an unknown source. Although invasive procedures present risk of iatrogenic complications, intravenous access and phlebotomy allowed precise and aggressive volume resuscitation and administration of electrolytes and medications. Staff managed fluid and electrolyte balances in these patients without choosing to use antimotility agents.

Resolving infusion pump failures or infiltrated intravenous lines could delay care significantly; precise scheduling of staff movements allowed safe and efficient patient care. Infusions were delivered under direct observation when possible, and staff optimized the compatibility of infusions to streamline nursing tasks.

Healthcare facilities in Liberia, including the clinic where these patients worked before developing EVD, suffered from inadequate PPE and training during the outbreak [17]. Before decommissioning the MMU, officers conducted trainings for Liberian healthcare workers and donated unused supplies to the Liberian government [5].

MMU patient care was guided by point-of-care testing and bedside monitoring, including electrocardiography. Additional point-of-care tests, such as serum lactate, may help in assessing adequacy of resuscitation [18]. The recoveries of these patients suggest that supportive care guided by bedside diagnostics may improve EVD outcomes in resource-limited settings [19–21].

Supplementary Data

Supplementary materials are available at Clinical Infectious Diseases online (http://cid.oxfordjournals.org). Supplementary materials consist of data provided by the author that are published to benefit the reader. The posted materials are not copyrighted. The contents of all supplementary data are the sole responsibility of the authors. Questions or messages regarding errors should be addressed to the author.

Notes

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