Title: Safe Delivery of Intensive Care for Marburg Virus Disease in Rwanda

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Summary

Outbreaks of filovirus diseases (FVD) including Marburg virus disease (MVD) present a threat to global health security, with high case fatality rates and significant risks of nosocomial transmission to healthcare workers. Recent advances in the delivery of optimized supportive care and pathogen-specific treatments have improved outcomes. In the third largest outbreak of MVD (Rwanda, 2024), provision of critical care by highly skilled medical and nursing staff including invasive mechanical ventilation, blood product replacement, advanced imaging, and laboratory-guided electrolyte management led to the recovery of two critically-ill patients. Delivery of intensive care in endemic settings represents an evolving paradigm shift in FVD outbreak response. This report highlights the feasibility, effectiveness and safety of intensive care management including invasive mechanical ventilation combined with strict infection prevention and control practices in outbreaks of Marburg virus disease.

Introduction

On 27 September 2024, the Ministry of Health of Rwanda confirmed the country's first outbreak of Marburg virus disease (MVD), with healthcare workers primarily affected (1). MVD is a viral haemorrhagic fever with a high case fatality rate that presents a significant risk of nosocomial transmission. Seventeen outbreaks of MVD have previously been reported globally, with a clinical phenotype similar to Ebola virus disease. The most recent outbreaks were reported in Equatorial Guinea and the United Republic of Tanzania in 2023 (2, 3).

A total of 66 Marburg virus disease confirmed infections, including 15 deaths (case fatality rate (CFR) 23%) have been reported, making this the third largest MVD outbreak to date, with almost 80% of confirmed cases reported in healthcare workers (4). There is currently no approved therapeutic for MVD; treatment primarily involves optimised supportive care, which is challenging in remote, resource-limited settings. There are no prior reports of MVD patients recovering after intensive care including invasive mechanical ventilation, and few reports of patients with Ebola virus disease successfully treated with invasive mechanical ventilation exist(5). We describe the clinical course and successful critical care management of two patients with laboratory-confirmed MVD at the National MVD Treatment Centre in Kigali, Rwanda.

Ethical Considerations

Ethical approval was obtained from the Rwanda National Ethics Committee (121/RNEC/2024), with informed consent from both patients.

Case Report 1

A 33-year-old previously healthy male healthcare worker was admitted with fever, lower limb weakness, headache, vomiting, and dizziness for 5 days. He initially sought care at a district hospital on illness day 3

where a malaria rapid diagnostic test was negative and was transferred with suspected Marburg virus disease (MVD). The patient's exposure occurred while working in the intensive care unit when the earliest identified MVD patient underwent obstetric care for presumably Haemolysis, Elevated Liver Enzymes, and Low Platelet count (HELLP) syndrome resulting in the initial cluster of MVD infections. MVD was confirmed by PCR (Ct 25) on illness day 4. Malaria RDT was negative.

On admission, he was weak but alert and ambulatory. Vital signs were: T 38.2˚C, HR 90bpm, BP 123/77mmHg, and SpO_2 96% on room air. Initial labs were notable for sodium 119mEq/L, aspartate aminotransferase (AST) 828.5U/L, and alanine aminotransferase (ALT) 355.6U/L (**Figure 1**). Despite 2-3L IV fluids per day, antibiotics, and laboratory-guided electrolyte correction, his condition worsened and progressed with diarrhoea on illness day 7, hypotension on illness day 8, acute kidney injury, worsening transaminitis, and thrombocytopenia (**Figure 1**).

On illness day 9, hypoxia (SpO_2 of 88%), wheezes, and tachypnoea developed with an arterial blood gas resulting in pH 7.45, pCO_2 32mmHg, PaO_2 61mmHg and HCO_3 22mmol/L. He was treated with oxygen (4L/min by nasal cannula), nebulized salbutamol and hydrocortisone 100mg IV daily. Chest radiograph on illness day 11 revealed bilateral consolidations and effusions confirmed with ultrasound (**Figure 2**). A thoracentesis (illness day 12) drained 500ml serous fluid (right side) and 50ml (left side) but was complicated by bleeding and haemoglobin drop (14.4g/dL to 5.8g/dL) necessitating blood product transfusions (5 units of platelets, 7 units fresh frozen plasma, 3 units cryoprecipitate, and 3 units packed red blood cells between illness day 9 and 12), tranexamic acid (day 12) and vitamin K (day 13). The pleural fluid was not tested for Marburg virus. Its culture reported coagulase negative Staphylococcus which was considered contamination.

Remdesivir (200 mg loading dose followed by 100 mg daily) was started on illness day 12 and continued for 10 days until two negative blood RT-PCR tests for Marburg virus (MARV). On illness day 13, oxygen requirement increased to 15L/min; despite this, SpO_2 dropped to 63-70%. A supraventricular tachycardia (HR 232 bpm) improved to 141 bpm following synchronized cardioversion on illness day 14. He was

intubated on illness day 14 for acute respiratory distress syndrome (ARDS) and received lung-protective ventilation (6). Sedation was achieved with IV infusions of fentanyl, diazepam, and propofol. Omeprazole was added for stress ulcer prophylaxis. An internal jugular central venous catheter was placed under ultrasound guidance on illness day 17. The patient remained mechanically ventilated for two weeks with gradual improvement in oxygenation with diuresis. The patient was extubated on illness day 26 to high-flow nasal oxygen, weaned to low-flow nasal cannula on illness day 29 and then room air on illness day 30.

Due to persistent fevers, the patient was treated with a prolonged course of empiric antibiotics. A single blood culture on illness day 22 grew *Staphylococcus epidermidis*. The initial central venous catheter was removed and a new central venous catheter placed. Vancomycin was started on illness day 23 with resolution of fever. C-reactive protein peaked on illness day 19 and then trended back to baseline by illness day 31 (**Figure 1**). The patient was discharged to rehabilitation on illness day 31 and home 9 days later at full functional status.

Case Report 2

A 35-year-old woman was admitted with 4 days of fever, headache, nausea, vomiting, and a single episode of diarrhoea. Her MVD exposure occurred at a hospital where she had been a caregiver to her child in the intensive care unit (ICU) at the time of a nosocomial transmission event. MVD was confirmed (Ct 21) on illness day 3.

On admission vital signs: T 37°C, RR 18bpm, BP 81/63mmHg, SpO_2 95% on room air. Laboratory testing showed a venous blood gas: pH 7.35, PCO_2 30.1mmHg, bicarbonate 14mmol/L, platelets 75 x 10^9/L and white blood count 2.0x10^9/L (**Figure 1**). Malaria RDT was negative. She was treated with IV fluids, empiric antibiotics and esomeprazole.

During illness days 5-7, her condition deteriorated with progressive weakness and lethargy, vomiting, diarrhoea, fever, facial swelling, hypotension (BP 79/47mmHg) treated with 1mg IV

epinephrine, and electrolyte abnormalities. She was transferred to ICU on illness day 6 for closer monitoring, hypokalaemia (2.1 mmol/L), hyponatremia (119 mmol/L), metabolic acidosis (pH 7.30, pCO_2 12 mmHg, HCO_3 12 mmol/L), and need for multiple transfusions (**Figure 1**). Vitamin K and tranexamic acid were added on illness day 8 due to the development of oral mucosal, vaginal and IV cannula site bleeding.

Remdesivir (200 mg once, then 100 mg daily) was started on illness day 9 and continued until two negative MARV PCRs on illness days 17 and 19. On illness day 10, oxygen saturation at room air decreased (SpO_2 89%) in the setting of anasarca and suspected volume overload. Ultrasonography confirmed bilateral pleural effusions and ascites. She developed a paralytic ileus (diagnosed by ultrasound) requiring total parenteral nutrition for four days, and encephalopathy (Glasgow coma score 12/15) on illness day 14. Continued thrombocytopenia complicated by vaginal bleeding was treated with transfusions (**Figure 1**). An internal jugular central venous catheter was placed under ultrasound guidance.

On illness day 17, after a short trial of non-invasive ventilation, she was intubated and mechanically ventilated for hypoxic and hypercarbic respiratory failure consistent with ARDS. Post-intubation course was complicated by hypernatremia (158 mmol/L) that corrected with free water via nasogastric tube and 5% dextrose IV infusion, and melena in the setting of severe thrombocytopenia (platelets < $20x10^9$/L) requiring platelet, FFP, and cryoprecipitate transfusions. Mechanical ventilation was weaned with diuresis and she was extubated on illness day 25. Jaundice developed (total bilirubin 281.8μmol/L) but abdominal CT scan ruled out biliary obstruction. Antibiotics were stopped due to concern for antibiotic-associated cholestasis with gradual improvement in bilirubin levels. Following clearance of viremia, she was transferred to another hospital for further hepatic evaluation and was found to have a MARV-

associated myocarditis with an ejection fraction of 30% that resolved by discharge to home on illness day 62.

Discussion

This report describes the safe and effective delivery of intensive care to two patients with Marburg virus disease under high-level biosafety conditions in a dedicated hospital-based treatment centre, representing a significant advancement in the clinical management of filovirus infections. Despite the development of multi-organ failure, both patients received comprehensive critical care - including invasive mechanical ventilation, fluid resuscitation, blood product replacement, medical imaging, and laboratory-guided electrolyte correction - which supported them through the acute phase of illness until clearance of virus and survival. The successful provision of this level of care, without evidence of nosocomial transmission, demonstrates that advanced intensive care can be delivered safely in outbreak settings and may contribute to improved outcomes in patients with MVD.

Outbreaks and outcomes

In recent decades, outbreaks of filoviruses, primarily Ebola virus and Marburg virus have increased in both frequency and size posing a significant threat to global public health security (7). Since Marburg virus was first identified in 1967, more than 40 outbreaks of filovirus disease have been reported (8). Although, filovirus outbreaks have historically been confined to sporadic and isolated events, outbreaks are now occurring more frequently and often affecting more densely populated regions. Factors contributing to this trend include increased human encroachment into wildlife habitats, urbanization, and limited surveillance and diagnostic capacity. Case fatality ratios (CFR) have largely ranged between 23% and 90% as a result of the austere environments in which many outbreaks occur and clinical responses limited by critical

gaps in healthcare infrastructure including diagnostic testing, supportive and intensive care and availability of approved vaccines and therapeutics. However, in higher resourced settings, the provision of critical care has been associated with improved survival, as occurred in the two cases described here (5). During the 2013-2016 EVD epidemic, the CFR for 27 patients cared for outside of Africa (18.5%) was lower than the overall mean CFR (95% CI) of 62.9% (61.9%-64%) among patients with known outcomes cared for in Africa (5, 9). Similarly, the CFR for patients with MVD in the first outbreak in Germany and Yugoslavia in 1967 (23%) was lower than CFRs from outbreaks occurring in lower resourced settings (9, 10).

Critical Care for Filovirus Infections

Improved survival of patients with EVD cared for in higher resourced settings likely reflects the enhanced capacity to address key determinants of EVD-related mortality – viral load, organ dysfunction, and time from symptom onset to treatment (11-18). Among the 27 patients with EVD cared for outside of Africa during the 2013-2016 EVD epidemic, 100% received intravenous access including 11 (41%) with a peripherally inserted central catheter and 18 (67%) with a central venous catheter that facilitated a median maximum daily volume resuscitation of 4000ml (range, 0 to 13,734) to replace gastrointestinal volume loss (reported at 4 to 10L/day) and maintain organ perfusion, correction of electrolyte abnormalities most commonly, hypokalaemia, use of vasopressors in 8 (30%), and provision of parenteral nutrition (5, 19-23). Additionally, of these 27 patients, 23 (85%) received at least one investigational intervention with presumed antiviral or immunomodulatory activity and 19 (70%) received two or more interventions.

During the 2013-2016 EVD epidemic, the non-governmental organization EMERGENCY and the Istituto Malattie Infettive “Spallanzani” established an Ebola treatment unit (ETU) in

Goderich, Sierra Leone with an integrated ICU (ETU-ICU). Among the 106 patients admitted to the Goderich ETU, 62 (59%) received central venous catheters, 26 (25%) required vasopressors, 33 (14%) received invasive mechanical ventilation, and 21 (9%) received renal replacement therapy with an overall CFR of 50%. Among patients that required invasive mechanical ventilation, renal replacement therapy and vasopressors, 90% died. A longer time from symptom onset to diagnosis at the Goderich ETU-ICU (4 days) compared with patients cared for outside of Africa (3 days), longer time from symptom onset to hospitalization (Goderich ETU-ICU median [IQR] 5 [3,6] days; U.S/Europe median [range] 4 [0-15] days), lower ratio of providers to patients, higher viral loads at admission (mean values 7.8 vs 7.3 log copies/ml respectively) likely contributed to the differences in the CFR between critically ill patients cared for in Sierra Leone and outside of Africa (5, 24).

There is less information on critically ill patients with MVD cared for in intensive care units. During the initial MVD outbreak in Germany and Yugoslavia in 1967, patients received intravenous fluid resuscitation, electrolyte repletion, empiric antibiotics, blood product replacement (fresh blood thrombocyte concentrates, fibrinogen, e-amino-caproic acid, vitamin K, and the French preparation PPSB including prothrombin, proconvertin, Stuart-factor and antihaemophilic globin B), and peritoneal dialysis in those that developed renal failure (10). A second case report described intensive care provided to a fatal case of MVD admitted 3 days after symptom onset who developed multiorgan failure including shock requiring intravenous fluid resuscitation (9-13L positive fluid balance daily for days 1-3) and vasopressors, electrolyte repletion, blood product replacement (40 units fresh frozen plasma, 6 units thrombocytes, and 9 units packed erythrocytes), metabolic acidosis and ARDS requiring invasive mechanical

ventilation, acute renal failure requiring continuous renal replacement therapy, acute liver failure, and cerebral oedema (25).

In the two MVD cases described here, both patients presented with typical signs and symptoms of Marburg virus disease including fever, headache and weakness that progressed to gastrointestinal losses through vomiting and diarrhoea complicated by hypoalbuminemia, electrolyte abnormalities, and increases in creatinine concerning for evolving renal injury. Admission to an established National MVD Treatment centre with trained healthcare providers enabled early intravenous volume resuscitation and laboratory-guided electrolyte correction that stabilized renal function and corrected electrolyte imbalances. Renal failure represents a preventable and treatable determinant of mortality in EVD and may play a role in MVD as well. Early fluid resuscitation, in response to significant gastrointestinal fluid loss, as was provided for the two MVD patients described here may have played a role in preventing progression to ARF.

Both MVD patients also developed respiratory failure requiring invasive mechanical ventilation following intravenous fluid resuscitation and blood product replacement. Similarly, 52% of patients with EVD cared for outside of West Africa during the 2013-2016 EVD epidemic developed hypoxemia and 33% developed respiratory failure – rates that were disproportionately higher than in patients cared for in West Africa (5, 26). The mechanism underlying this disproportionately higher incidence of respiratory failure is not clear from the case reports but potentially include pulmonary oedema in the setting of more aggressive fluid resuscitation, use of convalescent plasma and blood product replacement given temporal associations in the MVD cases described above and others and/or vascular leak due to filovirus-induced inflammation or vascular endothelial dysfunction. Given the significant volume resuscitation required by patients cared for in higher resourced settings and higher incidence of respiratory complications in these

patients, access to advanced respiratory support is an important consideration in future outbreaks (22, 25, 27, 28).

A recrudescent fever was also noted in both MVD patients – a phenomenon also described in the initial MVD outbreak and in case reports of critically ill EVD patients cared for in higher resourced settings. In the two cases described here, the late fever overlapped with a rise in CRP that followed the peak and subsequent decline in transaminases potentially indicating either immune-mediated phenomenon or possibly, a secondary bacterial infection.

The clinical complications of MVD described here including transaminitis, thrombocytopenia, electrolyte abnormalities, coagulopathy and bleeding, encephalopathy, myocarditis, vascular leak and respiratory failure provide important insights into the pathophysiology of MVD, and the need for organ supportive care that extends beyond clearance of virus in the blood(29).

Investigational Interventions

Although remdesivir has been shown to be effective in non-human primate models of filovirus disease, its efficacy decreases with increasing time from infection(30, 31). The only randomized controlled trial of remdesivir in acute filovirus infection found that it was not more effective than ZMAPP, a cocktail of monoclonal antibodies, in Ebola virus disease, in which patients were enrolled a mean of 5.5 days from symptom onset(16). Despite the lack of clinical efficacy data, remdesivir was incorporated into the clinical management paradigm in this outbreak. However, due to a lack of availability, remdesivir was started on illness days 12 and 9 in the two patients described here. Given the late initiation of remdesivir, its role in the recovery of these patients is uncertain.

Treatment units in Filovirus Outbreaks

The implementation of critical care in a filovirus outbreak requires a comprehensive response including a well-resourced intensive care unit that supports advanced oxygen, ventilation, medication, and nutrition delivery, medical and IPC staff with technical expertise in critical care medicine, infectious disease and filoviruses, sufficient staffing to ensure continuous monitoring and care, use of established critical care protocols and checklists, access to diagnostic laboratory testing and medical imaging and strict adherence to infection prevention and control practices for high consequence pathogens (**Figure 3**). The success of the Rwandan Ministry of Health's response reflects the resilient healthcare system that pre-existed this outbreak and afforded the ability to designate an entire hospital containing a functional ICU, diagnostic imaging capabilities, and an onsite laboratory as the National Marburg Treatment Centre. This designated space, operationalized under the auspices of rigorous infection control allowed multidisciplinary providers to safely provide comprehensive care.

Although patients in the ICU were not able to be monitored from the low-risk setting, continuous monitoring and care of critically ill patients was possible because of 1:1 staffing by critical care nurses and continuous availability of in-house ICU physicians. Continuous bedside presence of health workers in PPE was facilitated in part by a temperature-controlled environment (32). Additionally, multidisciplinary providers from around the country were deployed to the National MVD Treatment Centre and supported by World Health Organization (WHO) physicians with filovirus expertise. In settings where a large number of providers are not readily available, innovations in treatment unit design, including the use of the ALIMA CUBE and transparent walls that allow close monitoring and intervention from the low-risk zone, can increase visibility of the patient and enable continuous monitoring and care (33).

Treatment of haemorrhagic complications is challenging in the absence of coagulation testing. While electrolyte management has increasingly benefited from laboratory support in outbreaks of filoviruses, treatment of suspected coagulation abnormalities is often guided clinically. In both of the MVD cases presented here and the primary case reports reviewed, blood products including packed red blood cells, platelets, and FFP were largely provided based on clinical signs and symptoms of bleeding rather than based on laboratory-identified deficiencies. Access to coagulation testing during filovirus outbreaks can both help identify when blood products are indicated and mitigate the complications of unnecessary transfusions.

Infection Control

While intensive care management is essential to prevent and treat organ dysfunction that is common in filovirus infection, some interventions including intubation and mechanical ventilation, nasogastric tube insertion, and cardiopulmonary resuscitation, all have the potential to facilitate nosocomial transmission should appropriate infection control measures not be in place (16, 34). Environmental sampling studies have demonstrated the potential persistence of Ebola virus (EBOV) for as long as 192 hours on steel and plastic surfaces (35). Similarly, environmental sampling following provision of intensive care for EBOV-infected non-human primates including with central line placement and invasive mechanical ventilation, found evidence of EBOV on the bed, floor, ventilator, and infusion pumps indicating environmental contamination during intensive care (36). With implementation of strict infection prevention and control (IPC) measures at the Rwanda National MVD Treatment Centre including environmental control with regular disinfection of clinical space, use of comprehensive personal protective equipment (PPE), and closely monitored donning and doffing, no nosocomial transmission occurred to ICU providers.

Conclusion

The safe and successful delivery of intensive care to two patients with Marburg virus disease, represents an evolving paradigm shift in the management of patients with filovirus disease in outbreak settings (33). While the success of this outbreak response was built on a foundation of a resilient Rwandan healthcare system, further work is needed to operationalize the delivery of critical care in filovirus outbreaks in less resourced settings, and at even greater scale in larger outbreaks to continue to reduce the high mortality associated with FVD.

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Authors contribution:

TT, ES, TF, and WAF were involved with conceptualization, data curation, formal analysis, investigation, methodology, patient care, writing of the original draft and review editing.

EN, FU, JB, FH, MN, DT, HM, BB, LM, RF, RG, JG, FJ, EM, MN, MN, GI, JG, FJ, JD, and AR were involved in patient care, data collection, revision and editing

AB, NN, JPS, TF, LI, GN, EK, JR, JN, GN, DN, SK, HN, ER, LM, MS, CM, YB, SN, were involved in outbreak response, revised and edited manuscript.

EM organized the systematic review.

RW revised and edited manuscript

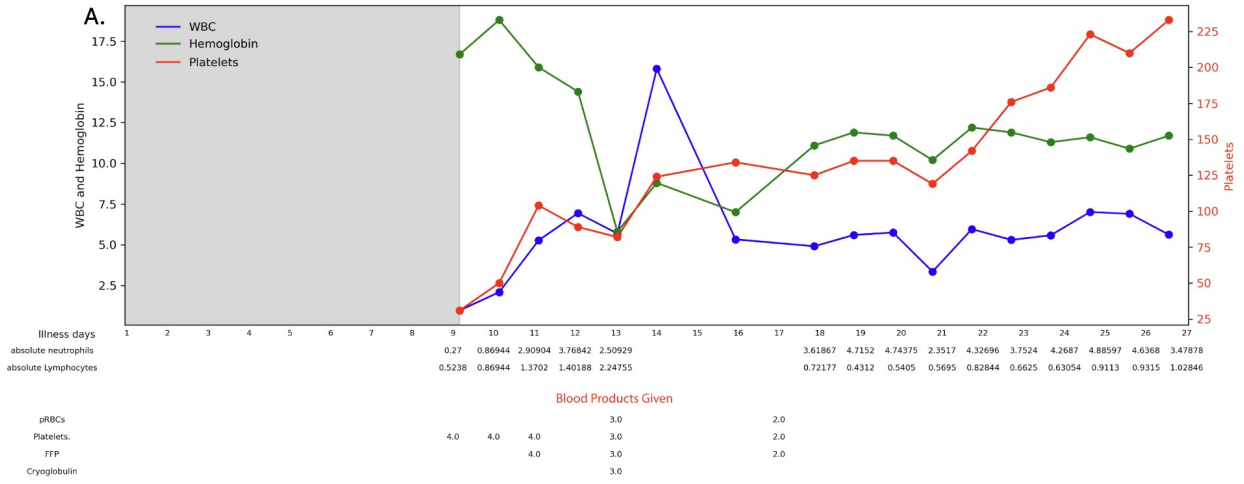
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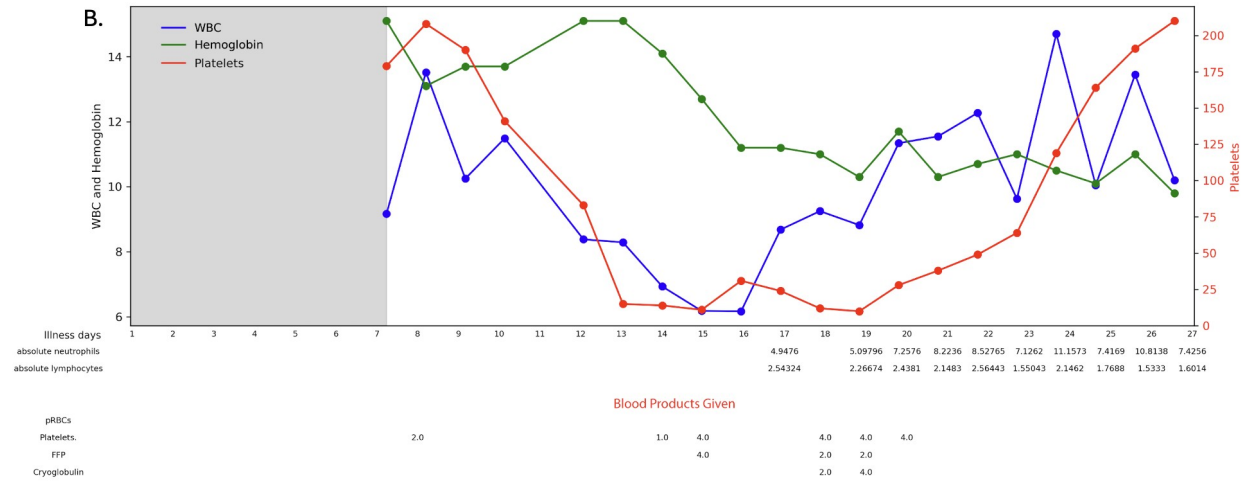
Figure 1. Laboratory results during acute Marburg virus disease. **A (Patient 1) and B (Patient 2)**. White blood cell count, haemoglobin, platelet count, and administered blood products. **C (Patient 1) and D (Patient 2)**. AST, ALT, GGT, and Alkaline phosphatase. **E (Patient 1) and F (Patient 2)**. Creatinine and albumin. **G (Patient 1) and H (Patient 2)**. C-reactive protein.

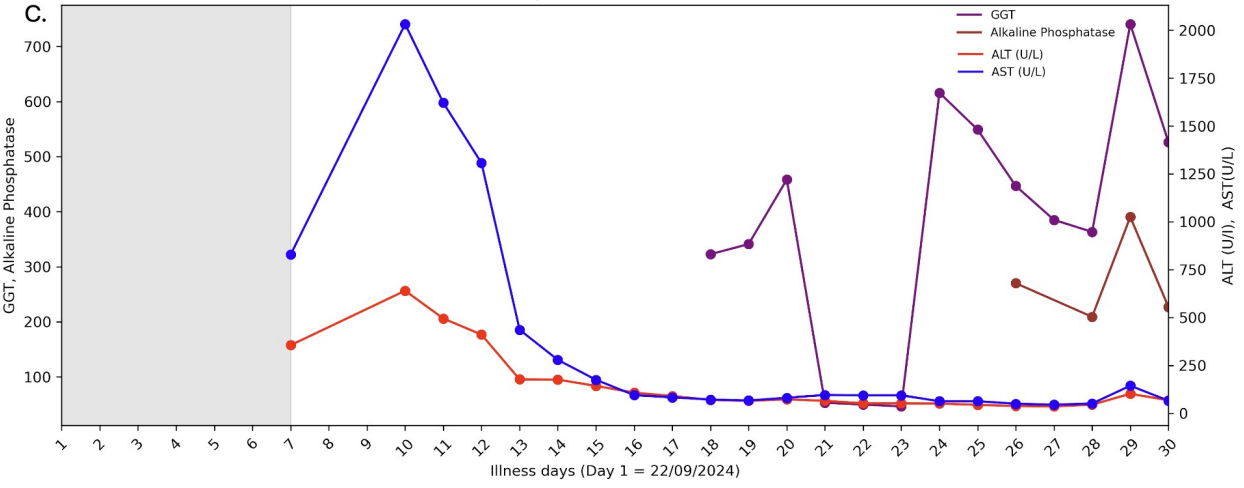
Figure 2. Chest radiographs during acute Marburg virus disease. A. Patient 1. B Patient 2

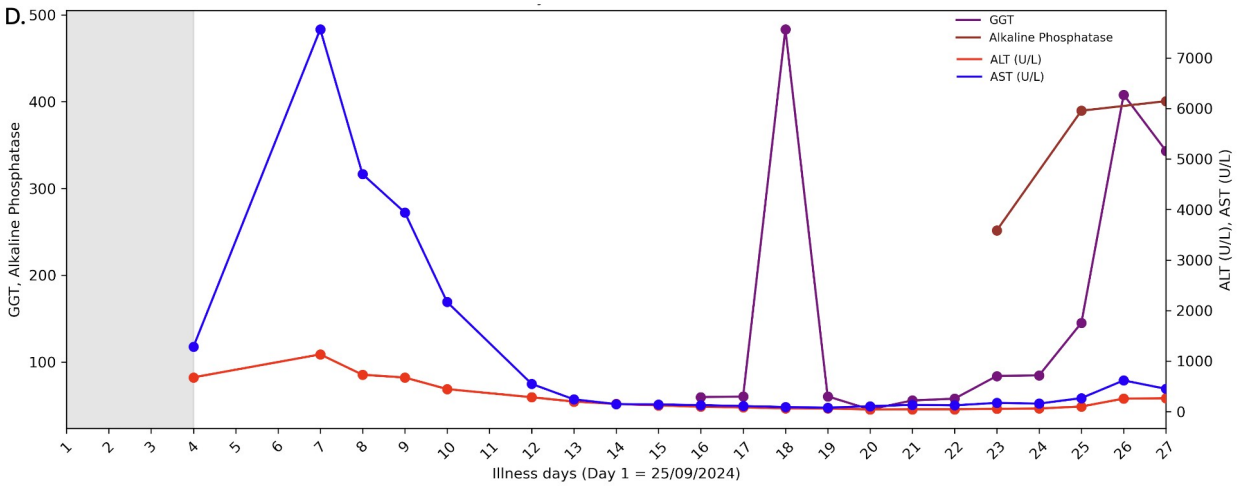
Figure 3. National Marburg Treatment Center Intensive Care Unit.

Figure 1. Laboratory Parameters

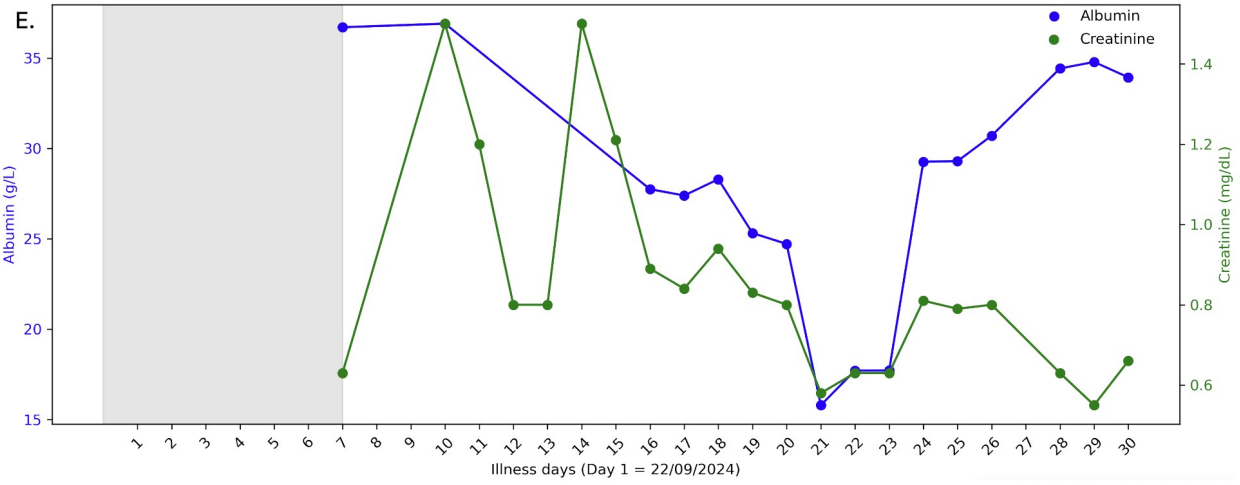




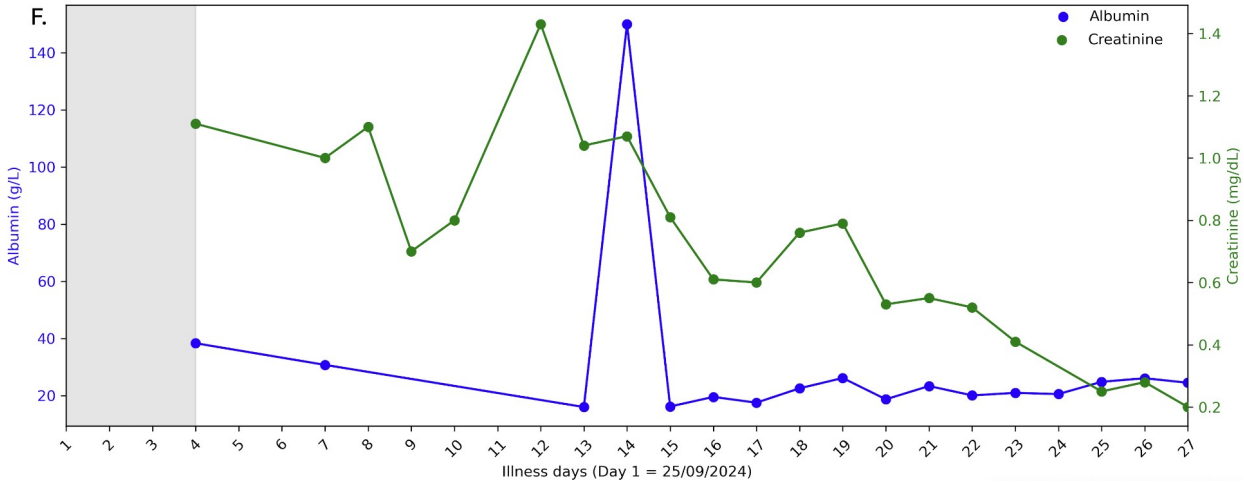



D.
GGT
Alkaline Phosphatase
ALT (U/L)
AST (U/L)
GGT, Alkaline Phosphatase
ALT (U/L), AST (U/L)
Illness days (Day 1 = 25/09/2024)

355


E.
Albumin
Creatinine
Albumin (g/L)
Creatinine (mg/dL)
Illness days (Day 1 = 22/09/2024)

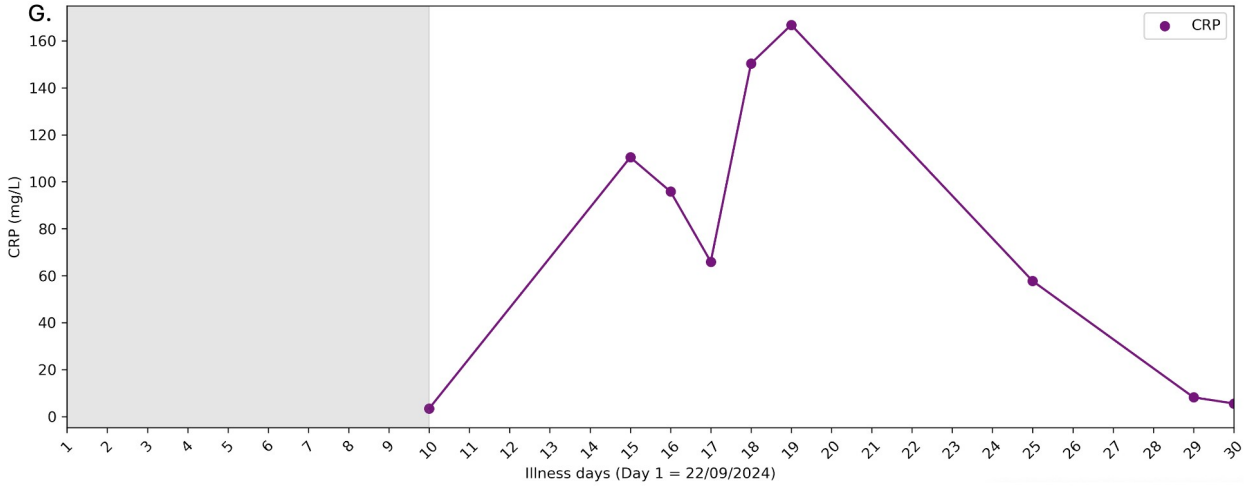
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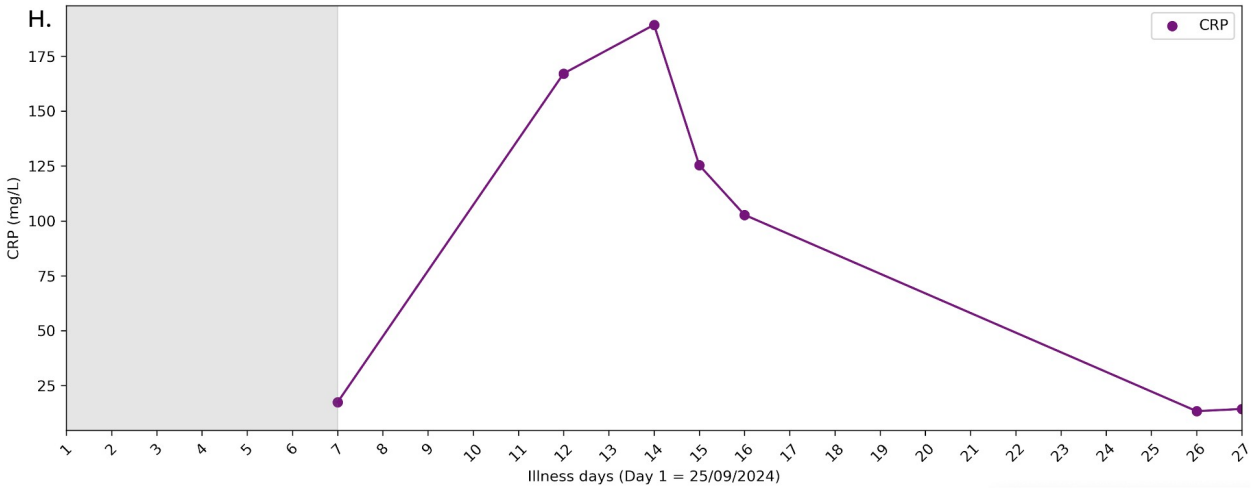
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Figure 2. Chest Radiography

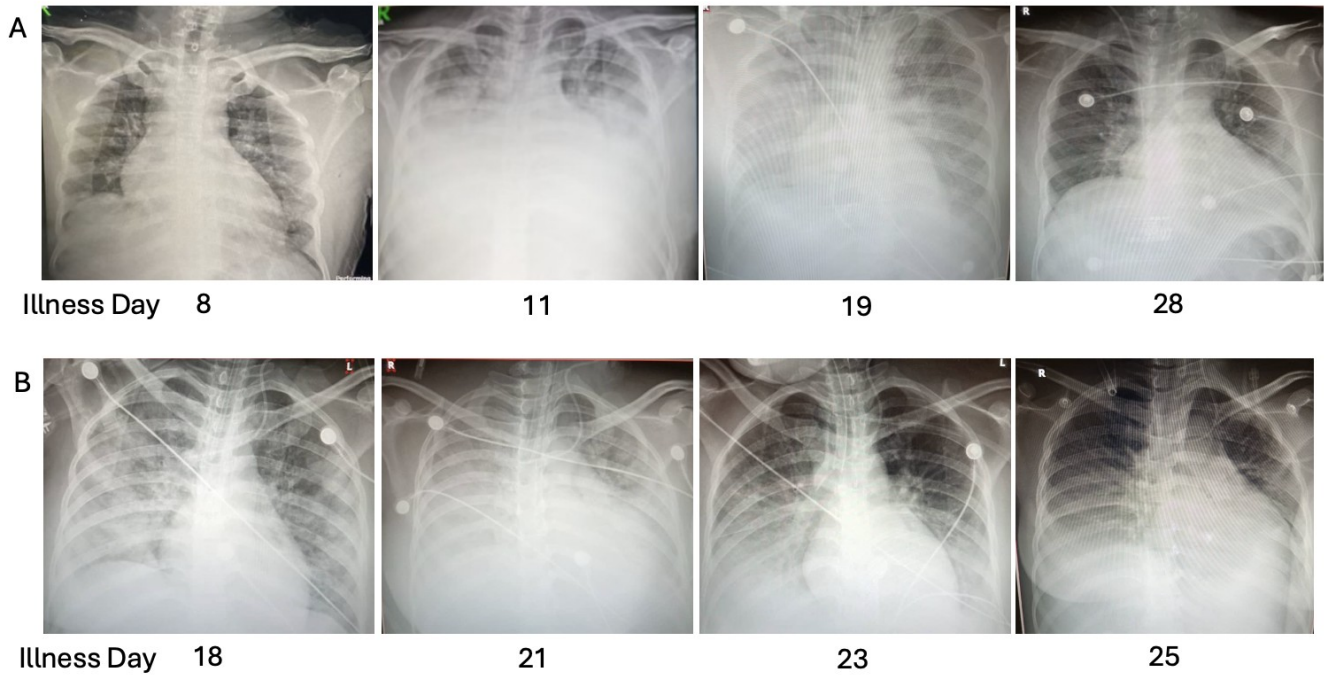


Figure 3. National Marburg Treatment Center Intensive Care Unit



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Supplemental Material

Supplemental Methods

Study Design and Setting

This retrospective case series was conducted to describe the clinical course, management, and outcomes of two critically ill patients with RT-PCR confirmed Marburg virus disease (MVD). Both patients were admitted to the National MVD Treatment Centre Intensive Care Unit.

Case Identification and Data Collection

The cases were identified through laboratory confirmation of Marburg virus infection via reverse transcription polymerase chain reaction (RT-PCR) performed on blood samples at the National Reference Laboratory. Data were retrospectively extracted from medical records, including demographic characteristics, clinical presentation, laboratory findings, imaging results, supportive care interventions, and outcomes.

Clinical and Laboratory Assessments

Baseline laboratory investigations included complete blood count, serum biochemistry, liver and renal function tests, and inflammatory markers. Imaging studies, including chest radiography and abdominal CT, were conducted based on clinical indications. Secondary infections were diagnosed through microbiological cultures and molecular diagnostics.

Appendix I

Search Strategy and Selection Criteria

Date of search: May 07, 2025
1967- present; No language filters; no age filters; exclude non-primary literature
Duplicates removed via EndNote x8 (Clarivate); Citations screened in Covidence (Covidence.org)

PubMed (pubmed.ncbi.nlm.nih.gov)- 146 results
("Filoviridae Infections"[Mesh] OR "Marburg Virus Disease"[Mesh] OR "Hemorrhagic Fever, Ebola"[MeSH] OR "Marburgvirus"[MeSH] OR "Ebolavirus"[MeSH] OR filovir*[tw] OR "marburg virus"[tw] OR "marburg fever"[tiab:~3] OR marburgvirus[tw] OR ebola[tw] OR ebolavirus[tw] OR MARV[tw] OR EBOV[tw] OR ZEBOV[tw]) AND ("Intensive Care Units"[Mesh] OR "intensive care"[tw] OR "Critical Care"[Mesh] OR "Critical Care Nursing"[Mesh] OR "Critical Illness"[Mesh] OR "critical care"[tw] OR neurocritical[tw] OR "critical condition"[tw] OR "critically ill"[tw] OR "critical illness*"[tw] OR ICU[tw] OR ICUS[tw] OR CICU[tw] OR SICU[tw] OR MICU[tw] OR intensivist*[tw] OR "hemorrhagic shock"[tw] OR "haemorrhagic shock"[tw] OR "cytokine storm"[tw] OR hypox*[tw] OR "acute kidney injury"[tw] OR "kidney failure"[tw] OR "Renal Replacement Therapy"[MeSH] OR "renal replacement"[tw] OR dialysis[tw] OR dialyz*[tw] OR hemodial*[tw] OR haemodial*[tw] OR hypox*[tw] OR "respiratory failure"[tw] OR "ventilation failure"[tw] OR "mechanical ventilation"[tw] OR hypotens*[tw] OR vasopressor*[tw] OR vasoactive[tw] OR "volume deplet*"[tw] OR "metabolic acidosis"[tw] OR "Multiple Organ Failure"[MeSH] OR multisystem[ti] OR "multi-system"[ti] OR multiorgan[ti] OR "multi-organ"[ti] OR "multiple organ"[ti] OR "end-organ"[ti] OR "life-threatening"[ti]) NOT ((animal[Filter] NOT humans[Filter]) OR animal*[tiab] OR "nonhuman primate*"[tiab] OR macaque[tiab] OR "covid-19"[ti] OR "sars-cov-2"[ti]) NOT (review[Filter])

Embase (Elsevier)- 205 results
('filovirus infection'/exp/mj OR 'filovirus infection':ti,ab,kw OR 'marburg hemorrhagic fever'/exp/mj OR 'marburg hemorrhagic fever':ti,ab,kw OR 'ebola hemorrhagic fever'/exp/mj OR 'ebola hemorrhagic fever':ti,ab,kw OR 'marburgvirus'/exp/mj OR 'ebolavirus'/exp/mj OR 'filovir*':ti,ab,kw OR 'marburg virus':ti,ab,kw OR ((marburg NEAR/3 fever):ti,ab,kw) OR 'marburgvirus':ti,ab,kw OR 'ebola':ti,ab,kw OR 'ebolavirus':ti,ab,kw OR 'marv':ti,ab,kw OR 'ebov':ti,ab,kw OR 'zebov':ti,ab,kw) AND ('intensive care unit'/exp/mj OR 'intensive care unit':ti,ab,kw OR 'intensive care'/exp/mj OR 'intensive care':ti,ab,kw OR 'intensive care nursing'/exp/mj OR 'intensive care nursing':ti,ab,kw OR 'critical illness'/exp/mj OR 'critical care':ti,ab,kw OR 'neurocritical':ti,ab,kw OR 'critical condition':ti,ab,kw OR 'critically ill patient'/exp/mj OR 'critically ill':ti,ab,kw OR 'critical illness*':ti,ab,kw OR 'icu':ti,ab,kw OR 'icus':ti,ab,kw OR 'cicu':ti,ab,kw OR 'sicu':ti,ab,kw OR 'micu':ti,ab,kw OR 'intensivist*':ti,ab,kw OR 'hemorrhagic shock':ti,ab,kw OR 'haemorrhagic shock':ti,ab,kw OR 'cytokine storm':ti,ab,kw OR 'acute kidney injury':ti,ab,kw OR 'kidney failure':ti,ab,kw OR 'renal replacement therapy'/exp/mj OR 'renal replacement therapy':ti,ab,kw OR 'renal replacement':ti,ab,kw OR 'dialysis':ti,ab,kw OR

'dialyz*':ti,ab,kw OR 'hemodial*':ti,ab,kw OR 'haemodial*':ti,ab,kw OR 'hypox*':ti,ab,kw OR 'respiratory failure':ti,ab,kw OR 'ventilation failure':ti,ab,kw OR 'mechanical ventilation':ti,ab,kw OR 'hypotens*':ti,ab,kw OR 'vasopressor*':ti,ab,kw OR 'vasoactive':ti,ab,kw OR 'volume deplet*':ti,ab,kw OR 'metabolic acidosis':ti,ab,kw OR 'multiple organ failure'/exp/mj OR 'multiple organ failure':ti,ab,kw OR 'multisystem':ti OR 'multi-system':ti OR 'multiorgan':ti OR 'multi-organ':ti OR 'multiple organ':ti OR 'end-organ':ti OR 'life-threatening':ti) NOT ([animals]/lim NOT [humans]/lim OR 'animal*':ti,ab,kw OR 'nonhuman primate*':ti,ab,kw OR 'macaque':ti,ab,kw OR 'covid-19':ti OR 'sars-cov-2':ti OR 'review'/it OR [cochrane review]/lim OR [systematic review]/lim OR [meta analysis]/lim)

Scopus (Elsevier)- 295
No reviews, no book chapters
TITLE-ABS-KEY (filovir* OR "marburg virus" OR "marburg fever" OR marburgvirus OR ebola OR ebolavirus OR marv OR ebov OR zebov) AND (TITLE-ABS-KEY ("intensive care" OR "critical care" OR neurocritical OR "critical condition" OR "critically ill" OR "critical illness*" OR "ICU" OR "ICUS" OR "CICU" OR "SICU" OR "MICU" OR intensivist* OR "hemorrhagic shock" OR "haemorrhagic shock" OR "cytokine storm" OR hypox* OR "acute kidney injury" OR "kidney failure" OR "renal replacement" OR dialysis OR dialyz* OR hemodial* OR haemodial* OR hypox* OR "respiratory failure" OR "ventilation failure" OR "mechanical ventilation" OR hypotens* OR vasopressor* OR vasoactive OR "volume deplet*" OR "metabolic acidosis") OR TITLE (multisystem OR "multi-system" OR multiorgan OR "multi-organ" OR "multiple organ" OR "end-organ" OR "life-threatening")) AND NOT TITLE (animal* OR "nonhuman primate*" OR macaque OR "covid-19" OR "sars-cov-2") AND (EXCLUDE (EXACTKEYWORD , "Nonhuman") OR EXCLUDE (EXACTKEYWORD , "Veterinary") OR EXCLUDE (EXACTKEYWORD , "Animal Experiment") OR EXCLUDE (EXACTKEYWORD , "Animals") OR EXCLUDE (EXACTKEYWORD , "Animal") OR EXCLUDE (EXACTKEYWORD , "Animal Model")) AND (EXCLUDE (DOCTYPE , "re") OR EXCLUDE (DOCTYPE , "ch"))

Global Health (Ebsco)- 122
No books
((SU "Filoviridae" OR SU "Ebola haemorrhagic fever" OR SU "Ebolavirus" OR SU "Marburg virus disease" OR SU "Marburgvirus" OR TI(filovir* OR "marburg virus" OR (marburg N3 fever) OR marburgvirus OR ebola OR ebolavirus OR MARV OR EBOV OR ZEBOV) OR AB(filovir* OR "marburg virus" OR (marburg N3 fever) OR marburgvirus OR ebola OR ebolavirus OR MARV OR EBOV OR ZEBOV))) AND ((SU "Intensive Care" OR SU "Intensive Care Units" OR SU "Renal Failure" OR SU "Acidosis" OR SU "Shock" OR TI(“intensive care” OR "critical care" OR neurocritical OR "critical condition" OR "critically ill" OR "critical illness*" OR ICU OR ICUS OR CICU OR SICU OR MICU OR intensivist* OR "hemorrhagic shock" OR "haemorrhagic shock" OR "cytokine storm" OR hypox* OR "acute kidney injury" OR "kidney failure" OR "renal replacement" OR dialysis OR dialyz* OR hemodial* OR haemodial* OR hypox* OR "respiratory failure" OR "ventilation failure" OR "mechanical ventilation" OR hypotens* OR vasopressor* OR vasoactive OR "volume deplet*" OR "metabolic acidosis" OR multisystem OR "multi-system" OR multiorgan OR "multi-organ" OR "multiple organ" OR "end-organ" OR "life-threatening") OR AB(“intensive care” OR "critical care" OR neurocritical OR "critical condition" OR "critically ill" OR "critical illness*"

OR ICU OR ICUS OR CICU OR SICU OR MICU OR intensivist* OR "hemorrhagic shock" OR "haemorrhagic shock" OR "cytokine storm" OR hypox* OR "acute kidney injury" OR "kidney failure" OR "renal replacement" OR dialysis OR dialyz* OR hemodial* OR haemodial* OR hypox* OR "respiratory failure" OR "ventilation failure" OR "mechanical ventilation" OR hypotens* OR vasopressor* OR vasoactive OR "volume deplet*" OR "metabolic acidosis")))
NOT (TI(animal* OR "nonhuman primate*" OR macaque OR "covid-19" OR "sars-cov-2"))

Critical Care for Filoviruses

