HHS Public Access

Author manuscript

Clin Obstet Gynecol. Author manuscript; available in PMC 2019 March 01.

Published in final edited form as:

Clin Obstet Gynecol. 2018 March ; 61(1): 186–196. doi:10.1097/GRF.0000000000000332.

Ebola Infection in Pregnancy: A Global Perspective and Lessons Learned

Lisa B. Haddad, MD MS MPH[1], **John Horton, MD**[1], **Bruce S. Ribner, MD MPH**[2], and **Denise J. Jamieson, MD MPH**[1]

[1]Department of Gynecology and Obstetrics, Emory University School of Medicine, Atlanta, GA, USA

[2]Division of Infectious Diseases, Department of Medicine, Emory University School of Medicine, Atlanta, GA, USA

Abstract

The 2014-2016 Ebola outbreak primarily based in 3 West African countries, had far-reaching global effects. Importantly, the crisis highlighted large gaps in reproductive health services in affected countries and inadequate healthcare system preparedness for obstetrical patients in the setting of highly contagious infectious diseases. We aim to review Ebola virus effects with a focus on the obstetrical implications in the context of this recent Ebola outbreak, discuss the lessons learned following this outbreak and propose current measures specific to obstetrics that should be considered in preparation for the next concerning emergent infectious disease.

Keywords

Ebola; obstetrics; pregnancy; haemorrhagic fever

Background

Although Ebola virus was first discovered more than 40 years ago, it remained a relatively obscure pathogen until 2014 when it became widely known, including within the obstetrics and gynecology community. Prior to 2014, Ebola virus was associated with small, relatively limited disease outbreaks in rural Africa. However, in 2014–2016, West Africa experienced the largest outbreak of Ebola virus disease (EVD) in history, with more than 28,000 people infected and 11,000 deaths[1]. Although the vast majority of cases occurred in 3 West African countries (Guinea, Sierra Leone, and Liberia), 7 additional countries, including the United States, reported local transmission. In the United States, four people were diagnosed with Ebola virus infection with one of them dying from EVD[1].

Ebola virus, first discovered in 1976 in Yambuku, Democratic Republic of Congo, along the Ebola River, is a zoonotic RNA virus and a member of the Filoviridae family. There are five

Corresponding Author: Lisa B. Haddad, Department of Gynecology and Obstetrics, Emory school of Medicine, 49 Jesse Hill Jr. Drive, Glenn Building, Atlanta, GA 30303, Telephone: 404-778-1385, lisa.haddad@emory.edu.

None of the authors have any relevant financial disclosures or conflicts of interest to report

known species of ebolaviruses with the Zaire ebolavirus the cause of the 2014-2016 West Africa EVD outbreak[2]. The virus is easily transmitted from person-to-person through direct contact with blood or body fluids, including through unsafe burial practices and through breast milk and sexual contact with semen. It is unknown if sexual transmission from women occurs. In addition, transmission can also occur from contact with contaminated objects such as needles or syringes and contact with infected animals including ingestion of infected meat[2].

The Ebola outbreak of 2014-2016 in West Africa had profound and lasting effects. In addition to the terrible tragedy of such widespread morbidity and mortality, overall gaps in reproductive health services in affected countries in West Africa became apparent[3]. It highlighted the importance of screening for travel history to avoid importation of disease. Because Ebola is highly transmissible, it also brought into focus the importance of infection control strategies, particularly in labor and delivery settings where blood and body fluid contamination is common. Ebola caused a shift in our global perspective of disease and had many lasting effects. Our goal is to review Ebola virus effects with a focus on the obstetrical implications in the context of this recent Ebola outbreak. Further aims are to discuss the lessons learned following this outbreak and current measures specific to obstetrics that should be considered in preparation for the next concerning emergent infectious disease.

Clinical Course of Ebola Virus Disease

Signs and symptoms of EVD include fever, severe headache, muscle pain, abdominal pain, diarrhea, vomiting, and unexplained hemorrhage. While classically individuals present with a febrile gastrointestinal illness, up to 18% of confirmed cases may present without fever[4]. Symptoms during the initial course of EVD may be non-specific and mirror the symptoms from infections endemic to the same region. The incubation period from exposure to the development of symptoms is 2-21 days with an average of about 7 days[5]. A diagnosis of EVD is initially based on clinical presentation in the context of potential exposure history, either recent travel or potential Ebola virus exposure. Laboratory testing via reverse transcriptase polymerase chain reaction (RT-PCR) of blood or oral swabs to detect Ebola virus RNA may be positive within the first 24 hours after symptom onset, however such positivity can be delayed for up to 72 hours after symptom onset[6]. Enzyme linked immunosorbent assay (ELISA) can also be performed to detect Ebola Virus specific IgM or IgG, with antibodies developing as early as 2 days and 6 days after symptom development and persisting for up to 6 months and 10 years for IgM and IgG, respectively[6–10]. Prolonged detection of Ebola virus has been demonstrated in certain body fluids including semen and vaginal secretions.

Following the initial phase of illness, patients often progress to severe disease and may develop hypovolemia, oliguria, transaminitis, hypoalbuminemia, elevated creatinine, leukopenia, thrombocytopenia, and multi-organ failure. Although EVD is considered a hemorrhagic disease, less than half of patients will have abnormal bleeding. The overall mortality rate is high but depends on the medical setting; those who receive intensive medical care have better survival rates. The overall mortality rate is estimated to be 34-74 based on data from the 2014-2016 West African outbreak[4,5,11], however among EVD

patients managed in Europe and the United states, the overall mortality rate was 18.5%[12]. People who recover from Ebola infection develop antibodies that may last 10 years or longer.

Treatment for Ebola includes primarily supportive care to maintain plasma volume and blood pressure including liberal use of blood products, correction of electrolyte imbalances or coagulopathy and maintaining adequate oxygenation. Patients may require 5-10 L of more of intravenous or oral fluid per day to maintain circulating blood volume[13]. Secondary infections are also common and should be aggressively managed. In malaria endemic regions, malaria treatment should be considered. Clinical management must prioritize prompt isolation and effective infection control measures including standard, contact and droplet precautions[3]. Unfortunately, there are no effective therapeutic agents or vaccines that are currently FDA approved to treat or prevent Ebola virus disease. Several investigational therapeutic agents have recently been evaluated, though no agents have yet been identified with proven substantial clinical efficacy against Ebola. For example, a randomized clinical trial of ZMapp, a mixture of three investigational monoclonal antibodies, was conducted during the outbreak and concluded that although ZMapp may have had some beneficial effect the results did not reach the a priori threshold for efficacy[14]. Although numerous vaccine candidates are in clinical development, there are currently no licensed vaccines and there remains a critical need for a safe and effective vaccine that can be used for future outbreaks[15]. Unfortunately, pregnant women have been excluded from most, if not all, vaccine trials.

Pregnancy among women with Ebola Virus Disease

Accurate information regarding the specific impact of EVD during pregnancy is limited due to the paucity of data. There is no evidence of increased susceptibility during pregnancy from prior outbreaks and very few pregnant women have been reported in the literature[3]. However, surveillance systems in past outbreaks, including during the West African outbreak, did not carefully and routinely collect pregnancy status information. Therefore, little is known about attack rates in pregnancy. Women may be at greater risk of exposure as they may more commonly be acting in a care role tending to the ill. Due the sheer scale of the public health needs and limited resources, the response to the 2014-2016 outbreak focused primarily on preventing transmission while surveillance capacity was limited.

The clinical presentation and disease course of EVD appears to be similar among pregnant and non-pregnant women, however data are limited. An increased risk for severe disease and death among pregnant women compared to non-pregnant women has been reported in prior outbreaks with maternal mortality estimated at about 90%. Although there is some evidence that mortality rates in pregnant women in the recent outbreak were lower[16] than reported in prior outbreaks, there were very few pregnancy outcomes reported. There is limited information regarding specific care and treatment recommendations for pregnant women. Thus supportive care recommendations should be similar to that for the non-pregnant women with primarily supportive care focusing on hydration to replace expected losses from mainly gastrointestinal sources of diarrhea and vomiting. Avoidance of secondary infections is critical, particularly during pregnancy when alterations in immunity may occur.

The perinatal mortality rate among infants of Ebola-infected women is very high with very few infants surviving past the neonatal period. However, since nearly all reports of pregnancy outcomes are from those receiving care in resource-limited settings, it is unknown if the survival rate would be substantially better if infants received intensive medical treatment. Neonates have been included in some use of investigational interventions but the results were used in rescue scenarios that cannot be used to create treatment protocols.

Recommendations for Management of the Pregnant Ebola Patient

Pregnant EVD patients should be considered a substantial risk for fluid contamination as spontaneous rupture of membranes, uterine bleeding, and labor are unpredictable. During labor and delivery, high risks associated with potential massive fluid and blood exposure increases the importance of infection control measures specific to the obstetrical setting[17]. Given these risks of transmission and the limited capacity for effective preventive strategies during the recent outbreak, there is some anecdotal evidence that OB wards were serving as amplification points for the Ebola virus[3,18].

Strategies for management of spontaneous abortion and fetal demise including manual vacuum aspiration, dilation and evacuation or induction need to be available in centers caring for the EVD patients. Expectant management should be standard of care. There are no specific guidelines concerning fetal monitoring though consideration of clinical response should be included in any decision to monitor. As neonatal mortality has been extremely high[3,19] the role for routine fetal surveillance and active obstetrical management is unclear and must be balanced by concerns for transmission to health care workers. Importantly, recommendations for fetal assessment and obstetrical management in high-resource settings may differ if more favorable infant outcomes are anticipated[19].

Vaginal delivery should include full body personal protective equipment (PPE) and be mindful of the extreme exposure to body fluids and feces. As much as possible, artificial rupture of membranes should be avoided and cervical exams minimized. Surgical delivery of neonate via cesarean delivery should be carefully weighed with consideration of healthcare worker exposure and should only occur in centers with expertise in the management of patients with Ebola. Pain control should be offered and given with close coordination with anesthesia providing available options. Neuraxial anesthesia may represent high rates of complications as EVD may lead to thrombocytopenia[20]. Little data exists on whether delivery improves or worsens morbidity though case reports demonstrate that some patients survived EVD after expectant management of intrauterine fetal death[21,22]. Further, these case reports of successful management of pregnant Ebola patients demonstrate that women can be cared for and delivered without infection to healthcare workers. In one case[22], initial symptoms were mild without fever highlighting the importance of vigilance for signs and symptoms in pregnant women, which often may overlap with symptoms of pregnancy. Additionally, this mother continued her course without hemorrhagic symptoms similar to two other reported cases[21], highlighting that not all women with Ebola during the high-risk pregnancy period will have these severe complications. Fetal and placental tissues have been Ebola RT-PCR positive even after maternal recovery and clearance of viremia[22]. Similarly, the virus may continue to be present in vaginal secretions and amniotic fluid even after

maternal blood clearance of the virus[21,22], thus infection control measures with appropriate personal protective equipment by trained staff along with proper management and disposal of fetal remains is imperative even after resolution of maternal symptoms.

Other maternal and infant health issues

Beyond the specific concerns regarding care of the pregnant Ebola patient, the Ebola outbreak impacted reproductive aged women in other ways. Women are often the caregivers, thus given the risks of exposure in the care of the Ebola patient, during the recent outbreak, there were reports of women being disproportionately infected[23]. As contaminated needles have been associated with the spread of Ebola, women may be reluctant to receive contraceptive injections thus increasing their risk for unintended pregnancy. Further, these fears may also lead to reduction in vaccination rates increasing the risks of other infectious diseases.

Further, during the Ebola crisis there were unclear recommendations regarding breast-feeding among mothers with suspected or confirmed Ebola. While Ebola may be transmitted through breast-feeding, many of these women are in low-resource settings where breast-feeding is considered the optimal method of infant feeding. In some settings there may not be safe alternatives to breast-feeding, where non-breast fed infants have increased risks of death from starvation or other infections. Further complicating the issue, infants exposed to the sick mothers may act as vectors passing on the virus to new caregivers when their mother becomes symptomatic. Given the unclear recommendations and little data on clearance of the virus from breast-milk, decisions regarding feeding need to be individualized.

Ebola survivors – Issues relating to future pregnancies

There are an estimated 17,000 EVD survivors worldwide including over 5000 women of reproductive age (WHO 2016). Ebola survivors have reported major barriers to resuming normal lives after clinical improvement[24,25], such as emotional distress, discrimination, health issues, loss of possessions, and difficulty regaining their livelihoods. Unfortunately, for women of reproductive age, many questions regarding the impact of EVD on future pregnancies remain.

Importantly Ebola virus can be found in immune privileged sites, such as ocular fluid, semen and cerebrospinal fluid, for many months post-infection, thus the potential risk of Ebola virus, including risks of sexual transmission, maternal to child transmission, and risks of healthcare related transmissions may persist long after resolution of maternal symptoms. The length of viral persistence in bodily fluids remains poorly defined. For example, there is evidence of Ebola viral RNA persisting up to 21 days in vaginal secretions after maternal blood viral clearance[26]; given the paucity of data the maximal length of viral persistence among pregnant and non-pregnant women in vaginal secretions is unclear.

It is not known if EVD can impact future pregnancies in terms of increasing the risks of spontaneous abortion, stillbirth, birth defects or poor obstetrical outcomes. Case reports however on healthy outcomes following EVD have been reported. For example, Kamali described the delivery of a healthy baby to an EVD survivor who became pregnant 22 weeks

after clearance of viremia[17]. While these limited data suggest that healthy outcomes are possible, we are unable to advise on the actual risks or length of time after infection when pregnancy may be safest. Given the concerns for persistent viremia, women with prior EVD should be managed as a high-risk pregnancy with a plan for delivery following strict infection control measures.

Learning from Ebola – Opportunities for Global and US systems and response efforts, hospitals and the OB/GYN provider

In the aftermath of the recent Ebola outbreak, there are still many unanswered questions and an urgency to improve healthcare systems to reduce the impact of future outbreaks. Further progress in less invasive diagnostic testing could decrease the potential for healthcare worker exposure, improve treatment response, and decrease the time patients under investigation are sequestered given the confounding symptomatology of pregnant patients.

Global: Systems-level recommendations and opportunities

The recent West-African Ebola outbreak exposed the challenges for reproductive care during emergent infectious disease outbreaks. With 8% of the doctors, nurses and midwives in Liberia infected and dying due to Ebola, the impact of the healthcare system is still significant[27]. With reduced access to healthcare in affected countries, over 10,000 lives were lost to other health conditions such as TB, malaria and HIV[28]. The already overburdened healthcare systems deteriorated with reports of lack of access to obstetric care for uninfected pregnant women, lack of trust in the healthcare system and an overall increase in births by unskilled birth attendants[29]. Further, while global efforts aimed to increase the capacity for care though Ebola Treatment Units (ETUs), these centers had minimal OB care available, with limited or no capacity for cesarean deliveries or manual vacuum aspiration. The lack of pregnancy specific data available highlights the need for surveillance efforts to recognize pregnancy and tracking outcomes as well as closely evaluating obstetrical units as potential amplification points. In the absence of appropriate monitoring and surveillance activities that recognize pregnancy and follow reproductive aged women who are survivors, we are unable to appropriately develop recommendations for the management of pregnant women as to the timing and management of future pregnancies to optimize outcomes[30].

The crisis highlighted the need to strengthen the current healthcare systems in these developing countries to provide opportunities for future prevention of similar outbreaks and improving healthcare outcomes from EVD and other potential emerging infectious diseases.

There is a need for better global preparedness, specifically for pregnant women. As over 5000 reproductive aged women were infected during the West African outbreak, the clear lack of attention to obstetric care in the setting of Ebola merits attention with the development of guidelines in preparation for future outbreaks to include care of infected and uninfected pregnant women.

Further, future responses to emerging infectious disease outbreaks can leverage experience to aid in the development of successful response strategies. For example, Uganda was

successful in rapid containment of the virus through a multipronged approach due to high political support and effective coordination through national and district task forces, an active surveillance program, community mobilization using village health teams and other community resources, effective laboratory systems, effective case management and collaboration with partners.[31] These coordinated efforts must integrate management of obstetrical patients.

United States: national and health care systems recommendations and opportunities

During the West African Ebola outbreak, awareness of Ebola virus increased and efforts to increase preparedness among providers the United States became a priority. For OB GYNs, recommended guidance in the setting of the Ebola outbreak[3] emphasized the importance of asking all patients about travel histories and potential high-risk exposures, and increasing awareness of key signs and symptoms of Ebola. During outbreak, many healthcare providers and hospitals began routine assessment of recent travel to West Africa, with many systems continuing to assess travel history after the resolution of the outbreak.

Addressing patient care in low resource settings during active outbreaks, compared to high-resource settings with sporadic travel associated cases, limited local transmission, such as the United States, need to clearly have different approaches responses employed for management. The Centers of Disease Control and Prevention with the U.S. Department of Health and Human services released recommendations for screening and appropriate management with triaging suspected EVD patients in March of 2015[32]. The development of a tiered approach was recommended with front-line health care facilities, Ebola assessment hospitals and Ebola treatment hospitals. In the case where you have a patient who has suspicion for EVD in a high resource setting with low disease prevalence, it is imperative that the healthcare system be alerted to avoid potential exposure and transmission and clear protocols be in place to reduce the risk of transmission and optimize the care of the patient. Patients under investigation (PUIs) should be immediately isolated with strict infection control procedures implemented to prevent spread. During the Ebola outbreak, CDC developed extensive monitoring systems to follow individuals exposed to Ebola. Once the diagnosis is confirmed, pregnant patients should be cared for in an Ebola Treatment Center[3].

While this approach is pragmatic with hospitals strengthening their capacity for providing the level of care within their tier, evaluation of the success of multiple Ebola treatment centers should be considered. The original US response to the threat of domestic EVD outbreak included 55 Ebola Treatment Centers spread throughout the nation[32]. These had varying degrees of preparation for the obstetric population, as there was little guidance for care of the fetus and laboring patient. Experts and stakeholders have suggested that efforts should focus on building upon this tiered hospital approach with developing a few regional centers[32] ideally in geographic regions with a high number of expatriates and travellers that are well prepared to respond to Ebola or other highly contagious emerging pathogens. We believe that these centers must have capacity to care for the obstetric population and can continue to maintain women’s health unit readiness for highly contagious diseases. Given

the money and investment in developing these centers, focused efforts on fewer centers of excellence is more appropriate. This allows for highly trained staff with preparatory experience and improved coordination of care. As there were initially three U.S. biocontainment units (Emory University Hospital, National Institutes of Health Clinical Center and Nebraska Medicine), improving the capacity within these centers may be appropriate. Notably, obstetrical care within these centers must be planned for within the emergency response systems. Response planning for a laboring patient with EVD is an important part of any Ebola Treatment Center though not all centers may have the capability to accommodate. Thusly public health officials should be involved to insure transfer to the appropriate facility. Should outbreaks become more expansive, adjustment of the model with these centers of excellence is possible with expansion of these centers or adding centers as needed.

For success of these Ebola Treatment Centers, there is a need for recurrent education of staff regarding full body PPE as well as patient treatment in the setting of contagious diseases. Staff fear and concerns need to be addressed with education to reinforce safe practices and conduct for when actual clinical scenarios occur. Simulation can be used to practice care and find points of confusion concerning care, especially in this setting, as very few patients with Ebola were ever cared for in United States and none of them pregnant. The specific organism should not be the focus of preparation rather modes of disease transmission.

During the recent EVD outbreak two cases of local transmission within the United States provided a significant reminder of the importance of patient screening and infection control training[33]. In 2014 a patient and traveler from Liberia, a known EVD epidemic site, presented to a Texas hospital with fever (37.8°C – 39.4°C) and complaints of abdominal pain and headache. He was discharged with treatment for sinusitis presenting again three days later for continued fever, abdominal pain, and new onset of diarrhea with subsequent diagnosis of EVD. An investigation by CDC found 21 healthcare workers with exposure to the patient or body fluid without the use of complete protective equipment and 10 patients that had been transported in the same emergency vehicle without proper decontamination procedures. Following the care of this patient with EVD, two nurses who stated using PPE and reported no exposure were found to be positive for Ebola virus. The primary patient died thirteen days after first presentation though both cases of local transmission were treated and survived.

This highlights an overarching need to improve infection control protocols and practices within routine care at all health facilities[34,35]. These procedures are both intended to prevent the health-care provider from getting sick as well as transmitting the infection to other patients. Obstetric care and procedures are laden with potential bodily fluid exposure and, given the often fast-paced nature of obstetrical care, strict adherence to standard precautions should be met at every procedure and delivery. Infection control procedures must assume that all blood, bodily fluids, secretions, excretions (except sweat), non-intact skin, and mucous membranes might contains transmissible infection[35]. Use of personal protective equipment (PPE) including gloves, fluid impervious gowns, shoe covers and shielding of mucous membranes and eyes are minimum requirements. Standard precautions must include: appropriate hand hygiene, PPE, respiratory hygiene and cough etiquette, safe

injection practices, and safe handling of potentially contaminated equipment or surfaces[36]. Additional recommendations for labor and delivery include eye protection and facemasks and double layers of gloves for procedures[35]. The use of standard PPE should be protocol driven and enforced at every facility. These procedures must be followed in all situations, regardless if the case is suspected or confirmed. Though outbreaks of highly infectious diseases are rare, daily prevention techniques can prepare healthcare workers and facilities from the spread of contaminants and disease. More common conditions can highlight potential dangers, such as a sharps exposure to bodily fluid with Hepatitis C carries a seroconversion rate of 1.8%[37]. Training should include identification of exposure level and the appropriate PPE response needed. Further, minimizing the number of individuals exposed to highly infectious individuals is imperative. Trainees and less experienced providers should not be involved with direct patient care. Any individuals not directly involved in patient care should be adequately protected and if possible isolated from areas of exposure risk.

Health care facilities need a plan and protocol for highly communicable diseases like Ebola that is appropriate for the level of care they will provide. For example, most centers will focus on isolation and basic infectious control procedures where centers of excellence will need higher level protocols for management of patients, particularly developing procedures for management of pregnant women[34]. It is imperative that focus is placed on obstetrical units as a setting for disease exposure. This focus demands an increased need for awareness and vigilance as standard of care. Further, labor and delivery units act as a patient access point and should use screening guidelines for travel and assessment of possible infection[38]. Individuals that screen positive and considered a person under investigation (PUI) should be assessed in a facility that can provide obstetric and neonatal care.

U.S. provider level recommendations and opportunities

While the goal is to create system-based practices to reduce individual provider exposure, there is an imperative for individual OB/GYNs to have a minimal base of information to reduce personal risk, delays in care and the spread of infections. Providers can directly work to improving system capacity, however they cannot rely on systems for knowledge, screening and personal safety. For example, in the case of Ebola, an OB/GYN must be aware of any new outbreaks that may occur, continue to screen women for recent travel within the past 3 weeks to high-risk regions or high-risk exposures and know signs and symptoms of Ebola.

Overall OB/GYNs must stay aware of current outbreaks of any highly contagious infectious disease, risk factors for these infections and the symptoms associated with the infection. During the recent outbreak CDC responded to clinical inquiries from throughout the country, however a majority had no initial signs or symptoms consistent with Ebola or epidemiologic factors, such as travel of having contact with an Ebola patient placing them at risk. While it is imperative to actively identify and isolate any persons meeting criteria for a PUIs, recognizing the important risk factors for Ebola is imperative as misallocation as a PUI may delay appropriate medical evaluation and treatment for other conditions[39]. Importantly, pregnancy has common confounding symptomatology including, nausea, diarrhea, and

abdominal pain, that can challenge standard criteria for diagnoses of infections. Signs or symptoms consistent with Ebola in a pregnant woman should trigger immediate coordination of obstetric and infectious disease consultation.

Strict adherence to standard infectious precautions should be followed for all obstetrical patients. As most facilities will not have the capacity to directly provide the high-level are for these patients, appropriate testing, isolation and transfer procedures need to be followed. For the actual care of these women, It should be limited to the most prepared settings and most highly trained providers. Obstetricians caring for these women should consider risks to woman and potential benefits to neonate when determining obstetric management of pregnant women with emerging infectious diseases, particularly decisions about mode of delivery. In many cases there may be no data on obstetric outcomes from settings with highly developed healthcare systems, thus extrapolation from existing data may not be appropriate.

Conclusion

In the aftermath of the recent Ebola outbreak, we have to prioritize preparedness for the next potential infectious outbreak. Globally, we must improve the healthcare infrastructure and capacity of the healthcare systems to rapidly respond to these highly contagious infections with high-mortality rates. There is an imperative to increase United States health care facility readiness to respond to the next emerging infectious disease outbreak. Systems must be in place for early identification, evaluation, isolation and treatment with the goals of improving outcomes while reducing the spread of these infections. These systems both globally and in the U.S. must recognize and prioritize obstetrical care, as these are overlooked high-risk settings. Attention to effective travel screening and infection control procedures is essential in all settings. Obstetricians need to be aware of any outbreaks and involved in the discussions on health-system responses and help to develop appropriate plans for care of the sick pregnant patient.

Acknowledgments

Funding: Dr. Haddad’s effort was supported by the NICHD (1K23HD078153-01A1).

References

1. CDC. Ebola Outbreak in West Africa – Case Counts. 2014; 2016 https://www.cdc.gov/vhf/ebola/outbreaks/2014-west-africa/case-counts.html. Accessed August 25, 2017.
2. World Healh Organization (WHO). Ebola virus disease Fact Sheet. 2017. http://www.who.int/mediacentre/factsheets/fs103/en/. Accessed August 25, 2017
3. Jamieson DJ, Uyeki TM, Callaghan WM, Meaney-Delman D, Rasmussen SA. What obstetrician-gynecologists should know about Ebola: a perspective from the Centers for Disease Control and Prevention. Obstet Gynecol. Nov; 2014 124(5):1005–1010. [PubMed: 25203368]
4. Qin E, Bi J, Zhao M, Wang Y, Guo T, Yan T, Li Z, Sun J, Zhang J, Chen S, Wu Y, Li J, Zhong Y. Clinical Features of Patients With Ebola Virus Disease in Sierra Leone. Clin Infect Dis. Aug 15; 2015 61(4):491–495. [PubMed: 25995207]
5. W. H. O. Ebola Response Team. Aylward B, Barboza P, Bawo L, Bertherat E, Bilivogui P, Blake I, Brennan R, Briand S, Chakauya JM, Chitala K, Conteh RM, Cori A, Croisier A, Dangou JM, Diallo B, Donnelly CA, Dye C, Eckmanns T, Ferguson NM, Formenty P, Fuhrer C, Fukuda K, Garske T,

Gasasira A, Gbanyan S, Graaff P, Heleze E, Jambai A, Jombart T, Kasolo F, Kadiobo AM, Keita S, Kertesz D, Kone M, Lane C, Markoff J, Massaquoi M, Mills H, Mulba JM, Musa E, Myhre J, Nasidi A, Nilles E, Nouvellet P, Nshimirimana D, Nuttall I, Nyenswah T, Olu O, Pendergast S, Perea W, Polonsky J, Riley S, Ronveaux O, Sakoba K, Santhana Gopala Krishnan R, Senga M, Shuaib F, Van Kerkhove MD, Vaz R, Wijekoon Kannangarage N, Yoti Z. Ebola virus disease in West Africa–the first 9 months of the epidemic and forward projections. N Engl J Med. Oct 16; 2014 371(16):1481–1495. [PubMed: 25244186]

6. 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. Nov 27; 2014 371(22):2054–2057. [PubMed: 25372854]
7. Rowe AK, Bertolli J, Khan AS, Mukunu R, Muyembe-Tamfum JJ, Bressler D, Williams AJ, Peters CJ, Rodriguez L, Feldmann H, Nichol ST, Rollin PE, Ksiazek TG. Clinical, virologic, and immunologic follow-up of convalescent Ebola hemorrhagic fever patients and their household contacts, Kikwit, Democratic Republic of the Congo. Commission de Lutte contre les Epidemies a Kikwit. J Infect Dis. Feb; 1999 179(Suppl 1):S28–35. [PubMed: 9988162]
8. Ksiazek TG, Rollin PE, Williams AJ, Bressler DS, Martin ML, Swanepoel R, Burt FJ, Leman PA, Khan AS, Rowe AK, Mukunu R, Sanchez A, Peters CJ. Clinical virology of Ebola hemorrhagic fever (EHF): virus, virus antigen, and IgG and IgM antibody findings among EHF patients in Kikwit, Democratic Republic of the Congo, 1995. J Infect Dis. Feb; 1999 179(Suppl 1):S177–187. [PubMed: 9988182]
9. Ansari AA. Clinical features and pathobiology of Ebolavirus infection. J Autoimmun. Dec.2014 55:1–9. [PubMed: 25260583]
10. Martinez VP, Bellomo CM, Iglesias AA. Laboratory preparation for the diagnosis of Ebola virus disease in Argentina. Medicina (B Aires). 2014; 74(6):506–507. [PubMed: 25555017]
11. Yan T, Mu J, Qin E, Wang Y, Liu L, Wu D, Jia H, Li Z, Guo T, Wang X, Qin Y, Li Y, Chen S, Zhang Y, Zhang J, Wu Y, Wang S, Li J. Clinical characteristics of 154 patients suspected of having Ebola virus disease in the Ebola holding center of Jui Government Hospital in Sierra Leone during the 2014 Ebola outbreak. Eur J Clin Microbiol Infect Dis. Oct; 2015 34(10):2089–2095. [PubMed: 26223324]
12. Uyeki TM, Mehta AK, Davey RT Jr, Liddell AM, Wolf T, Vetter P, Schmiedel S, Grunewald T, Jacobs M, Arribas JR, Evans L, Hewlett AL, Brantsaeter AB, Ippolito G, Rapp C, Hoepelman AI, Gutman J, Working Group of the USECNoCMoEVDPitUS, Europe. Clinical Management of Ebola Virus Disease in the United States and Europe. N Engl J Med. Feb 18; 2016 374(7):636–646. [PubMed: 26886522]
13. Bebell LM, Riley LE. Ebola virus disease and Marburg disease in pregnancy: a review and management considerations for filovirus infection. Obstet Gynecol. Jun; 2015 125(6):1293–1298. [PubMed: 26000499]
14. Group PIW, Multi-National PIIST. Davey RT Jr, Dodd L, Proschan MA, Neaton J, Neuhaus Nordwall J, Koopmeiners JS, Beigel J, Tierney J, Lane HC, Fauci AS, Massaquoi MBF, Sahr F, Malvy D. A Randomized, Controlled Trial of ZMapp for Ebola Virus Infection. N Engl J Med. Oct 13; 2016 375(15):1448–1456. [PubMed: 27732819]
15. Venkatraman N, Silman D, Folegatti PM, Hill AVS. Vaccines against Ebola virus. Vaccine. Aug 02.2017
16. Bebell LM, Oduyebo T, Riley LE. Ebola virus disease and pregnancy: A review of the current knowledge of Ebola virus pathogenesis, maternal, and neonatal outcomes. Birth Defects Res. Mar 15; 2017 109(5):353–362. [PubMed: 28398679]
17. Kamali A, Jamieson DJ, Kpaduwa J, Schrier S, Kim M, Green NM, Stroher U, Muehlenbachs A, Bell M, Rollin PE, Mascola L. Pregnancy, Labor, and Delivery after Ebola Virus Disease and Implications for Infection Control in Obstetric Services, United States. Emerg Infect Dis. Jul.2016 22(7)
18. Gostin LO, Lucey D, Phelan A. The Ebola epidemic: a global health emergency. JAMA. Sep 17; 2014 312(11):1095–1096. [PubMed: 25111044]
19. Nelson JM, Griese SE, Goodman AB, Peacock G. Live neonates born to mothers with Ebola virus disease: a review of the literature. J Perinatol. Jun; 2016 36(6):411–414. [PubMed: 26658125]

20. Missair A, Marino MJ, Vu CN, Gutierrez J, Missair A, Osman B, Gebhard RE. Anesthetic Implications of Ebola Patient Management: A Review of the Literature and Policies. Anesth Analg. Sep; 2015 121(3):810–821. [PubMed: 25551317]
21. Baggi FM, Taybi A, Kurth A, Van Herp M, Di Caro A, Wolfel R, Gunther S, Decroo T, Declerck H, Jonckheere S. Management of pregnant women infected with Ebola virus in a treatment centre in Guinea, June 2014. Euro Surveill. Dec 11.2014 19(49)
22. Oduyebo T, Pineda D, Lamin M, Leung A, Corbett C, Jamieson DJ. A Pregnant Patient With Ebola Virus Disease. Obstet Gynecol. Dec; 2015 126(6):1273–1275. [PubMed: 26375715]
23. United Nations Radio. UNICEF: women most affected Ebola outbreak in W. Africa. http://www.unmultimedia.org/radio/english/2014/07/unicef-women-most-affected-ebola-outbreak-in-w-africa/-.U_IMwnYpDcs. Accessed August 18, 2014
24. Lee-Kwan SH, DeLuca N, Adams M, Dalling M, Drevlow E, Gassama G, Davies T, Centers for Disease C, Prevention. Support services for survivors of ebola virus disease - Sierra Leone, 2014. MMWR Morb Mortal Wkly Rep. Dec 19; 2014 63(50):1205–1206. [PubMed: 25522090]
25. Davtyan M, Brown B, Folayan MO. Addressing Ebola-related Stigma: Lessons Learned from HIV/AIDS. Glob Health Action. Dec.2014 7(1):26058. [PubMed: 25382685]
26. Rodriguez LL, De Roo A, Guimard Y, Trappier SG, Sanchez A, Bressler D, Williams AJ, Rowe AK, Bertolli J, Khan AS, Ksiazek TG, Peters CJ, Nichol ST. Persistence and genetic stability of Ebola virus during the outbreak in Kikwit, Democratic Republic of the Congo, 1995. J Infect Dis. Feb; 1999 179(Suppl 1):S170–176. [PubMed: 9988181]
27. Evans DK, Goldstein M, Popova A. Health-care worker mortality and the legacy of the Ebola epidemic. Lancet Glob Health. Aug; 2015 3(8):e439–440. [PubMed: 26163833]
28. Parpia AS, Ndeffo-Mbah ML, Wenzel NS, Galvani AP. Effects of Response to 2014-2015 Ebola Outbreak on Deaths from Malaria, HIV/AIDS, and Tuberculosis, West Africa. Emerg Infect Dis. Mar; 2016 22(3):433–441. [PubMed: 26886846]
29. Shannon FQ 2nd, Horace-Kwemi E, Najjemba R, Owiti P, Edwards J, Shringarpure K, Bhat P, Kateh FN. Effects of the 2014 Ebola outbreak on antenatal care and delivery outcomes in Liberia: a nationwide analysis. Public Health Action. Jun 21; 2017 7(Suppl 1):S88–S93. [PubMed: 28744445]
30. Tambo E, Ugwu EC, Ngogang JY. Need of surveillance response systems to combat Ebola outbreaks and other emerging infectious diseases in African countries. Infect Dis Poverty. 2014; 3:29. [PubMed: 25120913]
31. Mbonye AK, Wamala JF, Nanyunja M, Opio A, Makumbi I, Aceng JR. Ebola viral hemorrhagic disease outbreak in West Africa- lessons from Uganda. Afr Health Sci. Sep; 2014 14(3):495–501. [PubMed: 25352864]
32. Koonin LM, Jamieson DJ, Jernigan JA, Van Beneden CA, Kosmos C, Harvey MC, Pietz H, Bertolli J, Perz JF, Whitney CG, Halpin AS, Daley WR, Pesik N, Margolis GS, Tumpey A, Tappero J, Damon I, Centers for Disease C, Prevention. Systems for rapidly detecting and treating persons with ebola virus disease–United States. MMWR Morb Mortal Wkly Rep. Mar 06; 2015 64(8): 222–225. [PubMed: 25742383]
33. Chevalier MS, Chung W, Smith J, Weil LM, Hughes SM, Joyner SN, Hall E, Srinath D, Ritch J, Thathiah P, Threadgill H, Cervantes D, Lakey DL, Centers for Disease C, Prevention. Ebola virus disease cluster in the United States–Dallas County, Texas, 2014. MMWR Morb Mortal Wkly Rep. Nov 21; 2014 63(46):1087–1088. [PubMed: 25412069]
34. Meaney-Delman D, Koonin LM, Jamieson DJ. US hospital preparedness for obstetrics patients with possible Ebola. Am J Obstet Gynecol. Apr; 2015 212(4):417–419. [PubMed: 25656019]
35. Olson CK, Iwamoto M, Perkins KM, Polen KN, Hageman J, Meaney-Delman D, Igbinosa II, Khan S, Honein MA, Bell M, Rasmussen SA, Jamieson DJ. Preventing Transmission of Zika Virus in Labor and Delivery Settings Through Implementation of Standard Precautions - United States, 2016. MMWR Morb Mortal Wkly Rep. Mar 25; 2016 65(11):290–292. [PubMed: 27010422]
36. Siegel JD, Rhinehart E, Jackson M, Chiarello L, Health Care Infection Control Practices Advisory C. 2007 Guideline for Isolation Precautions: Preventing Transmission of Infectious Agents in Health Care Settings. Am J Infect Control. Dec; 2007 35(10 Suppl 2):S65–164. [PubMed: 18068815]

37. Egro FM, Nwaiwu CA, Smith S, Harper JD, Spiess AM. Seroconversion rates among health care workers exposed to hepatitis C virus-contaminated body fluids: The University of Pittsburgh 13-year experience. Am J Infect Control. Apr 24.2017

38. Minkoff H, Ecker J. Physicians' obligations to patients infected with Ebola: echoes of acquired immune deficiency syndrome. Am J Obstet Gynecol. Apr; 2015 212(4):456 e451–454. [PubMed: 25530596]

39. Karwowski MP, Meites E, Fullerton KE, Stroher U, Lowe L, Rayfield M, Blau DM, Knust B, Gindler J, Van Beneden C, Bialek SR, Mead P, Oster AM, Centers for Disease C, Prevention. Clinical inquiries regarding Ebola virus disease received by CDC–United States, July 9-November 15, 2014. MMWR Morb Mortal Wkly Rep. Dec 12; 2014 63(49):1175–1179. [PubMed: 25503923]

Recommendations and lessons learned from Ebola

Global Response

- Strengthen existing healthcare systems
- Surveillance systems need to include pregnancy status
- Build provider base with skill set in providing pregnancy care in emergency infectious disease responses
- Response systems must have appropriate plan for management of pregnant women, including capacity for miscarriage management and cesarean deliveries.
- Develop capacity for testing that reduces healthcare exposure, e.g. oral swabs

United States Healthcare System Response

- Appropriate protocols for screening and management need to be in place in all healthcare settings
- Standard infection control procedures should be carefully followed
- A tiered approach should be followed with development few regional centers of excellence for the management of highly infectious diseases.
- Plan for management of infectious cases need to include plans for the obstetric patient
- Ensure appropriate training of personnel
- Minimize number of providers exposed

OB/GYN Provider Response

- Screen all patients for recent travel history
- Be aware of global epidemics and symptoms of high-risk infections
- Practice appropriate infection control procedures and know hospital protocols