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Exploring the Pathophysiological Concepts of Ebola Virus

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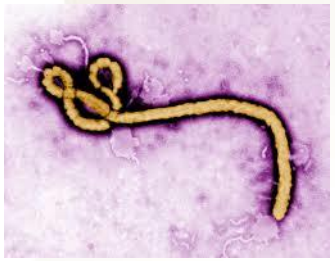
Introduction

The increase and ease of globalization along with emerging infectious diseases puts populations at a higher risk for contracting infections capable of causing severe morbidity and mortality. Viral infections are a common source of illness worldwide, and the severity of illness can depend on many factors such as the type of virus, the host's natural defense, and the availability of resources and treatments. Ebola has been a hot topic in the news lately as a result of the recent 2014 outbreak in West Africa that eventually found its way into the United States. According to Bray and Chertow (2015) "As of June 28, 2015, the cumulative number of probable, suspected, and laboratory-confirmed cases attributed to Ebola virus is 27,550, including 11,235 deaths." Ebola was first discovered in 1976 near the Ebola River within the Congo region of Africa (CDC, 2015). The Ebola virus is a member of the filoviridae family. Five different species have been identified, four of which are known to cause disease in humans (CDC, 2015). The Ebola virus has historically been termed Ebola hemorrhagic fever, however this term is no longer widely accepted due to fact that only about 1/3 of patients who contract Ebola develop hemorrhaging (Rougeron, Feldmann, Grard, Becker & Leroy, 2014). Rapid action and containment along with a touch of luck prevented a possible epidemic in the United States, but does not mean we are immune to another potential threat in the future. Additionally, our country has been in a war for well over a decade with seemingly no end in sight. The aftermath of September 11th, 2001 lingers on, and the reality of continued terrorism remains a fear for the majority of Americans. We have come to understand that many of these terrorists who plan to do harm to our nation live in our communities. This reality makes the threat of terrorism even more frightening, and bioterrorism is no exception. While the debate remains, the recent outbreak of Ebola has many bioterrorism experts concerned over the possibility of 'weaponizing' the highly infectious agent, which would undoubtedly wreak havoc on our nation. While the news has seemed to steer away from talking about Ebola, we must not let our guard down. As health care professionals, we should familiarize ourselves with pathophysiologic concepts regarding Ebola should an epidemic occur.

Pathophysiological Processes

The Ebola virus is a member of the filoviridae family. Five distinctive species of ebolavirus have been identified, four of which are known to cause disease in humans (Martines, Ng, Greer, Rollin, and Zaki, 2014). The specific species known to cause disease in humans are Zaire, Sudan, Ivory Coast, and Bundibugyo (Bray & Chertow, 2014). Bah et al. (2015) report that the Zaire ebolavirus (EBOV) was the cause of the most recent West African outbreak and carries the highest human mortality rate among the five known species, with up to 90% of cases being fatal. Ebola is a filamentous, enveloped, single-stranded, negative-sense RNA virus (Martines, et al., 2014). According to Jarrett (2014), just ten Ebola microbes are needed to successfully transmit the virus from human to human, proving it to be highly capable of infectivity. "Outbreaks typically originate with introduction of the virus into humans from a wild animal reservoir, with subsequent human-to-human transmission, often fueled by nosocomial amplification in resource-poor settings" (Bah, et al., 2015, p. 40). Ebola can be spread by direct contact with various infected animal species including primates and bats, however the virus is not spread via the airborne route (CDC, 2014). Fruit bats are considered to be reservoirs of Ebola virus. After the initial transmission from animal to human, Ebola spreads "via direct contact (through broken skin or mucous membranes) with the blood, secretions, organs or other bodily fluids of infected people, and with surfaces and materials contaminated with these fluids" (Nault, 2014).

Once the virus enters the body, it can quickly invade and affect nearly all cell types including epithelial cells, dendritic cells, monocytes, hepatocytes and endothelial cells (Bray & Chertow, 2015). Macrophages and monocytes are thought to be the first cells to be infected, causing the release of pro-inflammatory cytokines (Rougeron, et al., 2014). While lymphocytes are not directly infected, apoptosis of this cell type is commonly seen with this disease leading to a deficient adaptive immune response (Feldmann & Geisbert, 2011). The virus invades the host through damaged skin or mucous membranes and attaches to the host's receptor cell where it then penetrates the cell through endocytosis, uncoats itself, and is then transcribed into positive-strain mRNA (Jarrett, 2014). The rapid replication of the virus within the host's receptor cell leads to cellular necrosis with subsequent release of a large number of new viral particles into the surrounding space (Bray & Chertow, 2015). "In cases of severe infection, there is a massive release of pro-inflammatory mediators and vasoactive substances, which promotes inflammation and coagulation but renders the immune system unable to effectively prevent systemic spread of the virus." In late stages of the disease, infected macrophages release tissue factor causing disseminated intravascular coagulation (Rougeron, et al., 2014). The multiplied virions now in the extracellular fluid are then able to travel to various organ systems including the liver, spleen, kidneys, and bone marrow where they are capable of causing end-organ damage and destruction ultimately leading to shock and death.



Above: Colorized transmission electron micrograph (TEM) representing an Ebola virus virion.
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Case Study

J.M is a 34-year-old E.R nurse who is employed at a large metropolitan hospital in Columbus, Ohio. J.M cared for a middle-aged man approximately one week ago who embarked on a mission trip to West Africa educating the community on the prevention of sexually transmitted infections (STI's). This patient's health rapidly declined and he ultimately expired in the hospital for reasons that are currently being investigated by the coroner. The patient was placed under strict isolation, however he was not in isolation while under the care of J.M. J.M now presents to the urgent care with complaints of generalized weakness, fatigue, myalgia, abdominal pain, diarrhea and vomiting that began approximately 3 days ago and her symptoms have progressively worsened. She states that the flu has been going around at work.

Above: Map of West Africa depicting the # of days since the last confirmed case of Ebola virus as of July 12, 2015. © WHO, 2015

J.M was a previously healthy, well-developed individual with no past medical or surgical history. J.M is a nonsmoker, drinks alcohol only on occasion, and denies illicit drug use. Vitals signs are blood pressure 98/52, heart rate 124 beats/minute, respiratory rate 34 breaths/minute, temperature 102.4° F, oxygen saturation 96% on room air. Physical exam reveals J.M is alert, oriented x 3. She appears to be in moderate distress. She is tachypneic and diaphoretic. Lungs are clear to auscultation bilaterally, no use of accessory muscles. She has a moist cough. Cardiovascular exam reveals RRR with no clicks, rubs, or murmurs noted, no JVD, and she has no peripheral edema. Bowel sounds are hyperactive. Abdomen is soft, nontender. No organomegaly is detected. At the urgent care, rapid strep test was negative. CBC and chem 7 is unremarkable. Portable chest x-ray reveals no infiltrates or atelectasis. Due to the fact that she recently cared for an individual who became critically ill shortly after returning from an international trip, she is sent to the nearest emergency department for further testing and care. J.M is immediately placed in negative pressure isolation. A polymerase chain reaction (PCR) assay is conducted at the hospital and is positive.

Clinical Manifestations

Ebola virus has an incubation period of 2 to 21 days, but generally causes sudden symptoms an average of 6 to 12 days post exposure (Bray & Chertow, 2015). Early symptoms are nonspecific and include flu-like symptoms such as fever, chills, and general malaise (Martines, et al., 2015). These early symptoms are often difficult to distinguish between other viral infections making it challenging to diagnose early. As the disease progresses, gastrointestinal symptoms such as anorexia, nausea, vomiting, and diarrhea become apparent along with the development of a rash, cough, and jaundice (Feldmann & Gesibert, 2011). Patients can also experience an altered level of consciousness and seizure activity along with a diffuse erythematous rash (Bray & Chertow, 2015). These symptoms generally indicate that the virus has affected multiple organ systems. Hemorrhagic signs and symptoms are only seen approximately one third of infected patients, is often considered the fatal stage of the disease course, and manifests as mucous membrane bleeding, epistaxis, and hematemesis (Rougeron, et al., 2014). "The systemic virus spread and replication, the general dysregulation of the host immune response, the coagulation abnormalities, the impairment of the vascular system, and hypotension all together finally result in shock and multiorgan failure" (Feldmann & Geisbert, 2011, p. 853).

Nursing Implications

The medical community, including nurses and advanced practice nurses are frontline clinicians that need to be properly educated to better understand the pathogenesis of the Ebola virus. This understanding leads to better care for patients and can prevent further spread of the disease should an outbreak occur. With terror threats becoming increasingly frequent, the nursing community must not rule out Ebola as a potential disease agent of warfare targeted at Americans. Additionally, Ebola should be considered a diagnosis in patients presenting with signs of infection that have recently traveled internationally or been exposed to someone with the virus (Martines, et al., 2015). Highly infectious diseases such as Ebola require the highest level of clinical preparedness to adequately triage and prevent a possible pandemic. Working closely with local, state, and federal government healthcare agencies can aid in the prevention and contamination of an outbreak. The research conducted by Bah, et al. (2015), found that age was the greatest predictor of outcome in those with Ebola virus. The study of 37 patients revealed the mean age of survivors who were diagnosed with the Ebola virus in Conakry, Guinea was 26 compared to the older mean age of 45 among nonsurvivors (Bah, et al., 2015). While treating others is important, perhaps the most crucial aspect of infectious disease outbreaks capable to producing widespread illness such as Ebola that the medical community must consider is protecting oneself. Anyone suspected of having Ebola ought to be immediately isolated, and those caring for the individual must adhere to strict protocols such as being fully covered with protective clothing and a respirator, in addition to properly washing hands and carefully cleaning and disinfecting potentially infected surfaces and equipment (Pringle, 2015).

Conclusion

Clearly, the Ebola virus is capable of producing widespread morbidity and mortality. While the recent outbreak of Ebola virus that penetrated American cities was terrifying and had the capability of causing an epidemic, the medical community and healthcare organizations learned a great deal about the disease. This newfound respect for Ebola has sparked a desire for better treatment options including the development of a vaccine, leading to not only better health for Americans, but also better outcomes for those in poor and underserved countries in Africa. Moreover, with continued terror threats against the United States, we should not rule out the possibility of Ebola being used as a biological weapon.

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