

Produced by the National Institute of Allergy and Infectious Diseases (NIAID), this digitally-colored scanning electron micrograph (SEM) depicts numerous filamentous Ebola virus particles (blue) budding from a chronically-infected VERO E6 cell (yellow-green). Photo credit: NIAID

Dealing with Infectious Disease

Are You (and Your Operating Room) Prepared to Handle the Ebola Virus?

KEN WARNOCK, CST, CRCST

The Ebola virus disease (EVD) has been on the minds of most Americans and, in particular, the minds of every US healthcare worker. Even though few people have been treated for Ebola in the United States as a result of the most recent – and largest outbreak of Ebola – the infections of two nurses who cared for a patient and subsequently became infected with the Ebola virus, raised the level of concern to near-panic levels in late fall.

The likelihood of a patient with the Ebola virus requiring surgical intervention is extremely remote. In fact, of the patients treated thus far in the United States with Ebola, not one has required surgical intervention. However, it is crucial that surgical departments be prepared for an Ebola-infected patient who requires surgical intervention.

HISTORY OF FILOVIRUSES AND EBOLA

The Ebola virus is considered a filovirus, a single-strand ribonucleic acid (RNA) virus. The first identified outbreak of infection with a filovirus dates to 1967 and involved a shipment of monkeys from Africa to Europe. Twenty-five people working with the monkeys and/or their tissues became sickened with an aggressive form of hemorrhagic fever. An additional six people – who were either medical providers caring for those infected, or close family members of the original patients – also contracted the infection.¹ This strain of virus was coined Marburg hemorrhagic fever virus, based on the region where the infection was first identified in Germany. The mortality rate from this outbreak was 23%.

LEARNING OBJECTIVES

- ▲ Learn about the history of the Ebola virus
- ▲ List the steps of donning enhanced personal protective equipment
- ▲ Review the steps of removing PPE for infectious disease cases
- ▲ Recall the signs and symptoms of EVD
- ▲ Evaluate the steps needed to prepare the OR for a patient with Ebola

A second case of Marburg fever was identified in a traveler to Zimbabwe in 1976. A fellow traveler and a nurse who were with the index patient also developed the infection during the patient's care in South Africa. One of these patients died, which increased the mortality rate to 33% for this outbreak.

The first reported outbreak of what would become known as Ebola hemorrhagic fever was identified in 1976 when 318 people became ill in a region of Zaire (formerly the Democratic Republic of Congo), where the Ebola River served as the watershed for the area. This outbreak was, at the time, the largest outbreak of hemorrhagic fever. Investigators from the Centers for Disease Control (CDC) traveled to the region to investigate and help contain the

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spread of infection. Despite their best efforts, the outbreak had a mortality rate of 88%. A concurrent outbreak in neighboring Sudan sickened 284 people and had a resulting mortality rate of 53%. According to the World Health Organization (WHO), mortality rates associated with Ebola range from 25% to 90% with an average mortality rate of approximately 50%.²

Analysis of the Zaire and Sudanese outbreaks determined they were caused by two different strains of what has become known as the Ebola virus, and are now referred to as Ebola (Zaire) and Ebola (Sudan). Initially, it was thought the Marburg and Ebola viruses belonged to a family of viruses known as rhabdoviruses. Subsequent analysis determined that these two viruses established a new family, Filoviridae.^{1,3} Currently, there are five known strains that result in EVD. Zaire ebolavirus (ZEBOV), Sudan ebolavirus (SEBOV), Tai Forest ebolavirus (formerly known as Ivory Coast ebolavirus or ICEBOV), Reston ebolavirus (REBOV) and Bundibugyo ebolavirus (BEBOV). Of these, the current epidemic involving ZEBOV is the most virulent.³

EVD has been extremely challenging to investigators, as identifying the sources of infection, reservoirs, natural hosts and vectors and exact routes of transmission have been difficult to ascertain.¹ This has been consistent across each of the EVD outbreaks that have occurred since the 1970s.

More recent research suggests that some species of bats may serve as a natural reservoir for filoviruses although this is still being investigated.^{1, 2, 4} (**In late December 2014, scientists reported that a bat-filled tree in Meliandou, Guinea, was most likely the host for most-recent Ebola epidemic. A two-year old boy was likely infected by playing in a hollow tree that was home to a colony of insectivorous free-tailed bats. That boy, as well as his mother, sister and grandmother, died last year after suffering mysterious symptoms, which were later linked to the Ebola virus.*²³)

In the case regarding the death of a patient in Dallas, Texas, and the subsequent infections of two nurses who provided care for the patient, a specific route of transmission from the primary patient to the two nurses has not been identified. Public health investigators have speculated that the nurses accidentally contaminated themselves while removing contaminated personal protective equipment (PPE).

With no FDA-approved treatments, vaccines or post-exposure prophylaxis (PEP) yet available, the one element that has effectively limited each of the outbreaks is the implementation of strict infection control processes. Surgical personnel, in particular, are already well-prepared to donning and doffing PPE safely and effectively.^{7, 9, 11, 16, 18, 19}

SIGNS AND SYMPTOMS OF EBOLA VIRUS (EBV) INFECTION

Following exposure to EBV, a patient may demonstrate no symptoms for as many as three weeks. Generally, infected patients demonstrate symptoms between eight to 12 days following exposure; however, the range from infection to onset of symptoms is two to about 21 days. It has not been determined how many individuals may be exposed without demonstrating symptoms of infection as no studies exist regarding subclinical (asymptomatic) infection. A patient with an active infection tends to become at an increased risk for transmitting infection, especially when EVD is in the advanced stages. In the cases of the two nurses treating the Dallas patient, it is believed the exposure leading to their infections occurred later in the course of his treatment. Early stages of symptomatic EBV infection are nonspecific and may appear similar to influenza. These symptoms are also consistent with many other viral prodromal phases of



A US healthcare worker donning enhanced personal protective equipment while preparing to help civilians in West Africa.

Photo credit: Nahid Bhadelia, CDC

Donning and Doffing of PPE

Editor's Note: *The following is the author's recommendations for donning and doffing PPE. The suggestions presented here have not been formally adopted by any agency or organization. The following suggested steps for donning and doffing of PPE vary from existing recommendations of the Centers for Disease Control and Prevention (CDC) and other agencies but are geared, specifically, for staff members working in the surgical environment. These steps have been drafted by the author, based on the CDC recommended guidelines, and have been trialed by the author to determine the feasibility of following this process to provide adequate safety for surgical patients and to reduce the risk of contamination or exposure of the surgical team members. Surgical personnel should check with their facilities' protocols for donning and doffing of PPE.*

The first pair of gloves should be donned using an open-gloving technique prior to donning the surgical gown. The rationale for this is that the knitted cuffs of a surgical gown are not waterproof and having the glove under the cuff will protect from strike-through contamination at this vulnerable point of the surgical gown. The gown will be donned and the second pair of sterile gloves will be donned as per usual aseptic practice. Some healthcare workers may advocate for the use of a triple-gloving technique; however, this is discouraged as it limits tactile sensation, dexterity and since this is an unusual technique, poses a risk for cross-contamination while removing this third pair of gloves. For unsterile team members, the inner and outer gloves can be taped to the gown sleeve using regular duct tape to seal the gown sleeve and the glove opening. If doing this, it is important to leave a tab at the free end of the tape to allow for easier removal with gloved hands.

Donning of enhanced PPE:

1. OR personnel will don disposable scrub tops and pants.
2. OR personnel will remove all jewelry, including: Earrings, bracelets, necklaces, finger rings and wrist watches. Pagers, cellphones and other electronic devices are to be left outside of the actual procedure room.
3. OR personnel will don standard shoe covers over shoes.
4. OR personnel will don hair covers and a surgical mask (if wearing an enclosed hood with PAPR) or N95 respirator mask (if using a face shield).
5. Unsterile team members:
 - a. Don a pair of waterproof booties (or boots) that extend to above mid-calf (may be omitted if wearing coveralls with one-piece shoe covers).
 - b. If using PAPR, don the head frame and test for function. If not using PAPR, a hair cover that completely covers hair, ears and neck must be worn.
 - c. If using PAPR, don a disposable hood to ensure flaps extend down to the shoulders and mid-chest.
 - d. Perform hand hygiene.
 - e. Don a pair of surgical-grade gloves ensuring adequate fit.
 - f. Don coveralls or a surgical gown that is rated for Level 4 protection per ASTM F1671.
 - g. Don a second pair of surgical-grade gloves ensuring adequate fit. NOTE: Duct tape may be used to secure the glove cuff to the gown making certain to leave a, "tab" of tape for easy removal at the end of the procedure.
 - h. Don a full face-shield (if not wearing PAPR with enclosed hood).
6. Sterile team members:
 - a. Don a pair of waterproof booties (or boots) that extend to above mid-calf.
 - b. Don PAPR head-frame and test for function. If not using PAPR, a hair cover must be worn that is of a style that completely covers the hair, ears and neck. If not wearing PAPR, eye protection AND a full face-shield must be worn along with an N95 respirator mask.
 - c. Perform hand hygiene.
 - d. Don a pair of sterile, surgical-grade, gloves using the open-gloving technique.
 - e. Don the sterile surgical head covering for the PAPR using aseptic technique.
 - f. Don a surgical gown that is rated for Level 4 protection per ASTM F1671.
 - g. Don a second pair of sterile, surgical-grade, gloves ensuring the glove extends beyond the knitted cuff of the gown.

Removal of PPE is the riskiest point for cross-contamination of the healthcare worker. Due to this risk of cross-contamination, direct observation of the healthcare worker is required. A step-by-step checklist has been formulated for the safety of healthcare workers.¹⁰ A specially-trained observer must be present to ensure the proper donning and doffing of enhanced PPE to identify and address any breaks in technique. Doffing of PPE should be performed in an anteroom outside of the actual procedure room. An alternative is to have a temporary enclosed area set up by the facilities department within the room near the exit door or immediately outside the room provided emergency egress pathways are not obstructed. PPE is to be removed in a slow methodical fashion to protect the safety of the healthcare worker. This step-by-step process is directed by the observer. The checklists formulated by the CDC, and others, are generally designed for routine patient care involving a patient with EVD and are not specific for OR personnel. The guidelines below vary from the current CDC recommendations as they flow in the order that surgical technologists have been trained to use through surgical technology programs across the country. Here is a link to the official CDC recommended guidelines for donning and doffing of PPE: <http://www.cdc.gov/vhf/ebola/hcp/procedures-for-ppe.html>

Doffing of enhanced PPE

1. Removal of personal protective equipment (PPE) will begin AFTER the patient has left the actual operating room (OR).
2. Doffing of PPE should be done in a specific area and all PPE on all team members is to be sprayed, or wiped down, using an, "EPA-registered" and hospital-approved disinfectant prior to entering the area for doffing.
3. Doffing of PPE is to be directly observed by a trained observer.
4. One person at a time is to remove PPE to avoid cross-contamination.
5. Sterile team members will doff their PPE first.
6. Sterile team members:
 - a. All PPE is to be wiped down, or sprayed, with a hospital-approved disinfectant and inspected for holes or tears prior to beginning the doffing process.
 - b. Unsnap and/or untie the surgical gown.
 - c. The outer gloves are removed one at a time using the following process:
 1. Wipe gloves with hospital-approved disinfectant.
 2. Grasp the palm of one glove with the second hand and gently pull down toward the finger tips, remove and discard.
 3. Grasp the palm of the second outer glove and gently pull down toward fingers, remove and discard.
 4. Wipe gloves with hospital-approved disinfectant or alcohol-based hand-rub (ABHR).
 - d. Beginning at the shoulders, roll the gown down over the arms ensuring the outside of the gown does not contact any exposed skin or clothing. The gown is rolled up and placed in a trash receptacle.
 - e. Remove PAPR hood by grasping hood at top/rear of head and pulling over the head using caution to avoid contaminating the head, face or arms. If PAPR was not worn, the face-shield is grasped at the bottom and lifted up and away from the face.
 - f. Remove the waterproof booties, or boots, one at a time using caution to avoid contaminating the arms. Disposable booties are discarded in the trash while reusable boots may be placed in a container for decontamination.
 - g. Wipe gloves with hospital-approved disinfectant or ABHR.
 - h. Remove PAPR head-frame and components using caution to avoid contaminating the arms or face and place in appropriate container for decontamination, or;
 - i. Remove goggles and discard or place in appropriate container for decontamination.
 - j. Wipe gloves with hospital-approved disinfectant or ABHR.
 - k. Remove shoe covers one at a time by grasping outside of shoe cover and pulling down and toward the toe of the shoe and discard using caution to avoid contaminating the arms.
 - l. The inner gloves are removed one at a time using the following process:
 1. Wipe gloves with hospital-approved disinfectant or ABHR.
 2. Grasp the palm of one glove with the second hand and gently pull down toward the finger tips, remove and discard.
 3. Slide the index finger of the ungloved hand under the cuff of the gloved hand, push down and toward the fingers, remove and discard.
 4. Wipe hands with alcohol-based hand-rub (ABHR).
 - m. Apply clean pair of gloves.
 - n. Carefully untie surgical mask and remove and discard.
 - o. Wipe gloves with hospital-approved disinfectant or ABHR.
 - p. Carefully remove hair cover and discard.
 - q. Remove gloves as described above and discard.
 - r. Wipe hands with alcohol-based hand rub (ABHR).
7. Unsterile team members:
 - a. All PPE is to be wiped down, or sprayed, with a hospital-approved disinfectant and inspected for holes or tears prior to beginning the doffing process.
 - b. Unsnap and/or untie the surgical gown. See process below for coveralls.
 - c. The outer gloves are removed one at a time using the following process:
 1. Wipe gloves with hospital-approved disinfectant.
 2. If duct-tape was used to seal the glove and sleeve pull tab to remove tape using care to make certain not to tear the sleeve.
 3. Grasp the palm of one glove with the second hand and gently pull down toward the finger tips, remove and discard.
 4. Grasp the palm of the second outer glove and gently pull down toward fingers, remove and discard.
 5. Wipe inner gloves with hospital-approved disinfectant or alcohol-based hand rub (ABHR).
 6. NOTE: Gently roll tape into a ball in order to discard into waste receptacle.
 - d. Beginning at the shoulders, roll the gown down over the arms ensuring the outside of the gown does not contact any exposed skin or clothing. The gown is rolled up and placed in a trash receptacle.
 - e. Remove PAPR hood by grasping hood at top/rear of head and pulling over the head using caution to avoid contaminating the head, face or arms. If PAPR was not worn, the face-shield is grasped at the bottom and lifted up and away from the face.
 - f. Remove the waterproof booties, or boots, one at a time using caution to avoid contaminating the arms. Disposable booties are discarded in the trash while reusable boots may be placed in a container for decontamination.
 - g. Wipe gloves with hospital-approved disinfectant or ABHR.

- h. Remove PAPR head-frame and components using caution to avoid contaminating the arms or face and place in appropriate container for decontamination, or;
 - i. Remove goggles and discard or place in appropriate container for decontamination.
 - j. Wipe gloves with hospital-approved disinfectant or ABHR.
 - k. Remove shoe covers one at a time by grasping outside of shoe cover and pulling down and toward the toe of the shoe and discard using caution to avoid contaminating the arms.
 - 1. The inner gloves are removed one at a time using the following process:
 - 1. Wipe gloves with hospital-approved disinfectant or ABHR.
 - 2. Grasp the palm of one glove with the second hand and gently pull down toward the finger tips, remove and discard.
 - 3. Slide the index finger of the ungloved hand under the cuff of the gloved hand, push down and toward the fingers, remove and discard.
 - 4. Wipe hands with alcohol-based hand-rub (ABHR).
 - m. Apply clean pair of gloves.
 - n. Carefully untie surgical mask and remove and discard.
 - o. Wipe gloves with hospital-approved disinfectant or ABHR.
 - p. Carefully remove hair cover and discard.
 - q. Remove gloves using the process described above.
 - r. Wipe hands with alcohol-based hand rub (ABHR).
8. Removal of PPE including coveralls:
- a. All PPE is to be wiped down, or sprayed, with a hospital-approved disinfectant and inspected for holes or tears prior to beginning the doffing process.
 - b. The outer gloves are removed one at a time using the following process:
 - 1. Wipe gloves with hospital-approved disinfectant.
 - 2. If duct-tape was used to seal the glove and sleeve pull tab to remove tape using care to make certain not to tear the sleeve.
 - 3. Grasp the palm of one glove with the second hand and gently pull down toward the finger tips, remove and discard.
 - 4. Grasp the palm of the second outer glove and gently pull down toward fingers, remove and discard.
 - 5. Wipe inner gloves with hospital-approved disinfectant or alcohol-based hand rub (ABHR).
 - 6. NOTE: Gently roll tape into a ball in order to discard into waste receptacle.
 - c. A number of commercially-available coveralls have zippers that zip up the front or the back of the coverall. Care, or assistance from the trained observer, must be exercised in order to prevent contamination of scrubs. Completely unzip coveralls prior to removal. Roll coverall down using care to avoid contaminating skin or scrubs. Step out of coveralls onto clean surface. Carefully roll coveralls up and discard in appropriate trash receptacle.
 - d. Remove PAPR hood by grasping hood at top/rear of head and pulling over the head using caution to avoid contaminating the head, face or arms. If PAPR was not worn, the face-shield is grasped at the bottom and lifted up and away from the face.
 - e. Wipe gloves with hospital-approved disinfectant or ABHR.
 - f. Remove PAPR head-frame and components using caution to avoid contaminating the arms or face and place in appropriate container for decontamination, or;
 - g. Remove goggles and discard or place in appropriate container for decontamination.
 - h. Wipe gloves with hospital-approved disinfectant or ABHR.
 - i. Remove shoe covers one at a time by grasping outside of shoe cover and pulling down and toward the toe of the shoe and discard using caution to avoid contaminating the arms.
 - j. The inner gloves are removed one at a time using the following process:
 - 1. Wipe gloves with hospital-approved disinfectant or ABHR.
 - 2. Grasp the palm of one glove with the second hand and gently pull down toward the finger tips, remove and discard.
 - 3. Slide the index finger of the ungloved hand under the cuff of the gloved hand, push down and toward the fingers, remove and discard.
 - 4. Wipe hands with alcohol-based hand-rub (ABHR).
 - k. Apply clean pair of gloves.
 - m. Carefully untie surgical mask and remove and discard.
 - n. Wipe gloves with hospital-approved disinfectant or ABHR.
 - o. Carefully remove hair cover and discard.
 - p. Remove gloves using the process described above.
 - q. Wipe hands with alcohol-based hand rub (ABHR).

infection. They include malaise, joint and muscle aches, nausea, vomiting, headache and diarrhea. Arriving at a diagnosis of EVD requires clinicians to rule out more common ailments including influenza, malaria and dengue. A patient with EVD is not considered to be infectious to others until he or she begins to demonstrate symptoms of infection, such as a fever. Prompt recognition of symptoms, coupled with a thorough travel and personal contact history, is critical in order to ensure early isolation of the infected patient.

Current guidelines recommend screening any patient presenting with a fever of greater than 100.4 degrees Fahrenheit for a travel history within the prior three weeks to areas with endemic EVD.^{4, 5, 11, 12, 18, 19} This travel history applies to the patient and the patient's close contacts. Any patient with a positive travel history and with an elevated temperature should be isolated pending further evaluation and assess-

Treatment for EVD is supportive and palliative. In the advanced state, vomiting, diarrhea and hemorrhage can result in significant fluid loss. Maintaining adequate fluid replacement is critical for patient survival. EVD affects coagulation processes and leads to lymphocytopenia resulting in severe immune depression. Leukopenia with neutrophilia, including an increased quantity of immature cells, and thrombocytopenia are common laboratory findings. Because the Ebola virus' RNA levels may be too low in the patient's blood at the time of initial presentation, a negative result on a RT-PCR requires a second test to be conducted approximately three days after the negative result while the patient remains in isolation until the second test results come in. Generally, lab results are available within 24 hours of the lab receiving the specimen.

While fever, arthralgia, myalgia, vomiting and diarrhea

Emergency surgical intervention always poses particular challenges for the OR team. OR staff members that provide such care must be properly trained and have sufficient practice in the donning and doffing of specific PPE that would be used in providing surgical care for a patient with EVD.

ment to rule out EVD. The patient should be placed in a private room with a private restroom and the door to the hallway should be kept closed. Contact and droplet isolation precautions should be implemented with airborne isolation precautions if the patient is coughing, sneezing or vomiting.

Diagnostic testing for the presence of the Ebola virus consists of reverse-transcriptase polymerase chain-reaction (RT-PCR) and is performed by the CDC or, if available, through state health department laboratories. Special transportation requirements may be required for transporting laboratory specimens for Ebola testing. Additional testing would include complete blood count (CBC) with differential white blood cell (WBC) count, electrolyte levels, prothrombin time (PT), partial thromboplastin time (PTT), fibrinogen levels and complete metabolic panel (CMP). A Type and Screen (T & S) or Type and Cross-match (T & C) also may be considered. Whenever a patient presents with a history or symptoms consistent with EVD, the hospital's Infection Control Department should be notified immediately. The department will provide guidance and serve as a communications link between the hospital, the CDC and local and state health departments.

are common early symptoms of EVD, later symptoms may include pharyngitis, bleeding, cerebral edema, rash, bruising, conjunctival hemorrhage, acute kidney injury (AKI), liver dysfunction, pancreatitis and septic shock. As the Ebola virus attacks macrophages and an immune response is mounted, laboratory testing will identify high levels of various inflammatory markers. It is believed that it is the immune response, more than the virus itself, triggers the subsequent immune system failure and kidney and liver injury. Disseminated intravascular coagulopathy (DIC) is common in the later stages of EVD and treatment with heparin has not proven conclusively beneficial for these patients.

A significant number of patients with EVD will require hemodialysis, which poses additional concerns and risks for staff members inserting lines and performing continuous renal replacement therapy (CRRT). A right internal jugular (IJ) line placement for CRRT is recommended followed by a femoral vein location rather than left IJ or subclavian vein placement.¹³ The reasons for acute kidney injury (AKI) may be a result of fluid overload, hyponatremia

mia, hypokalemia or as a result of the virus itself. It may also be a result of medication toxicities. Electrolyte and fluid balances must be carefully monitored in patients with EVD. As a result of the risk of bleeding in these patients, systemic anticoagulation therapy may be contraindicated. Alternative methods of preventing clots in the hemodialysis filtering mechanism may need to be employed.

RISKS OF EXPOSURE AND LIKELIHOOD OF INFECTION

Because infection with hemorrhagic fever viruses are associated with high mortality rates, there has been a heightened concern for healthcare workers caring for a patient with EVD. As of October 8, 2014, the CDC reported that 401 healthcare workers caring for EVD patients in West Africa have contracted the Ebola virus, and of these, 232 have died. (However, the CDC does not provide a total number of healthcare providers that were providing care and we cannot identify the relative risk (RR) of exposure or infection on the basis of this information.) In the United States, there were at least 50 known healthcare workers that provided care to the primary patient in Dallas. The two nurses who provided care to the patient and became infected with the Ebola virus and survived. Several other patients, including the two nurses who were secondarily infected, were successfully treated with no other healthcare workers becoming infected. It is noteworthy that no one who came into contact with the primary Dallas patient before he was placed into isolation became infected. That included nearly 60 additional individuals who were exposed to this patient including adults and children where he was visiting prior to his admission, Emergency Department (ED) personnel who originally evaluated and discharged him and Emergency Medical Technicians (EMT's) and ED personnel who cared for him when he returned to the ED.

A retrospective look at past outbreaks has shown that direct physical contact with a patient with EVD poses a risk for transmission. There is no evidence that a single household contact – who did not have direct physical contact with an Ebola patient – has then subsequently contracted the Ebola virus infection.⁵ A closer look at index (primary) cases and their household contacts shows that direct contact, especially in advanced stages of illness, conferred the highest risk for secondary infections.^{4, 5, 9, 11, 12}

Based on the recent experience in the United States, it would appear the risk of exposure to the Ebola virus is very low and the risk of infection from caring for a patient with EVD is extremely low. This, of course, presumes

the proper use of PPE.^{7, 10, 14, 15, 16, 17} The proper use of PPE includes wearing the appropriate attire, and removing it correctly every time. The CDC has amended its recommendations for PPE when caring for a patient with EVD, and the American College of Surgeons (ACS) also has published recommendations for surgical personnel when providing care for surgical patients with EVD.^{6, 16, 17}

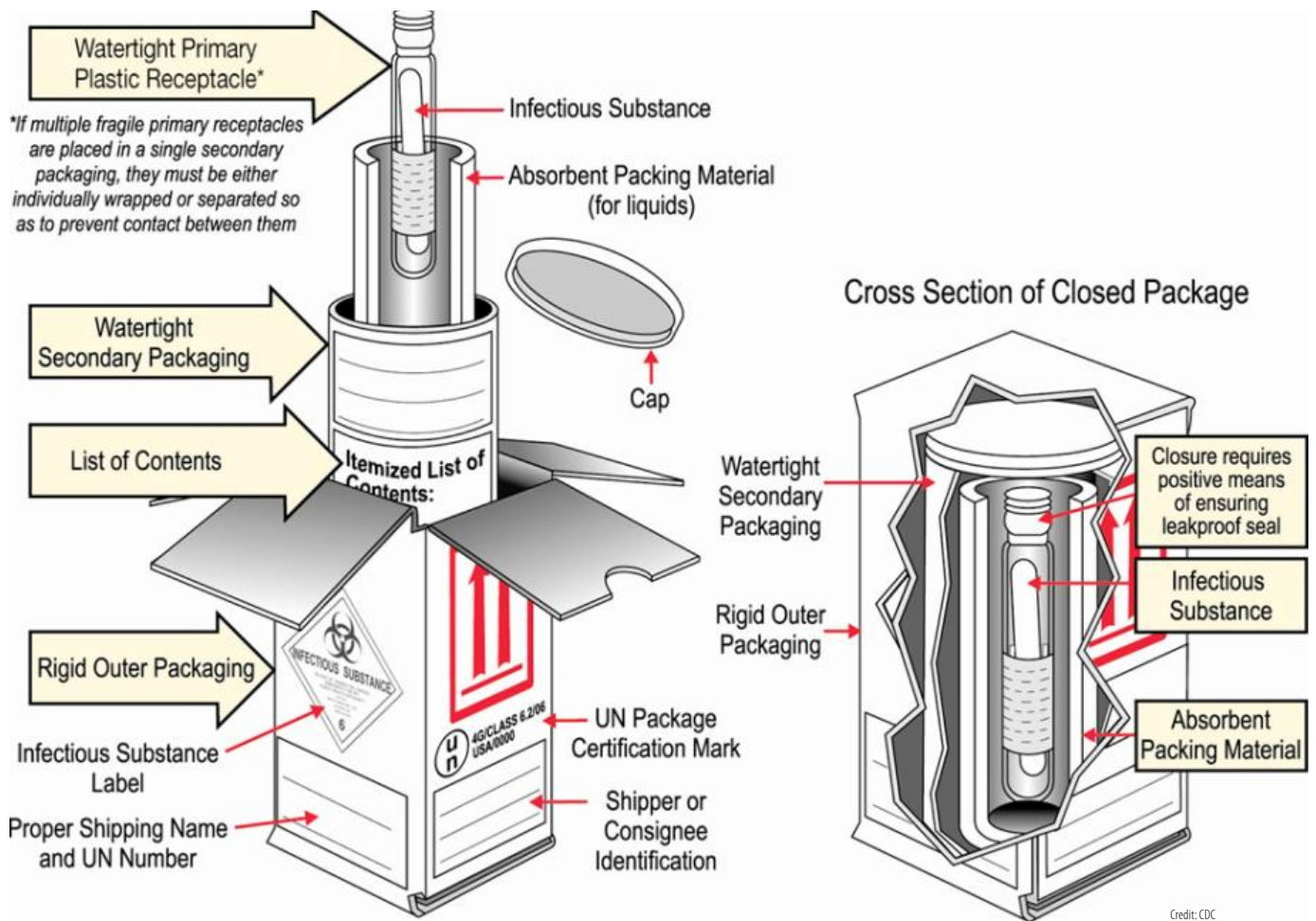
WHY DOES THE OR NEED TO BE PREPARED FOR EBOLA?

Developed nations, such as the United States, will employ very intensive interventions that are consistent with an increased likelihood of healthcare worker (HCW) exposure to infectious particles. With the exception of this most recent outbreak, no patient with EVD has been treated outside of the continent of Africa. As of November 1, 2014, patients with the confirmed Ebola virus infection have been cared for in the United States and Europe.

As the outbreak continues to evolve, it is likely that additional patients may present in the US, Europe or on other continents. While care for patients with EVD is generally supportive or palliative, it is quite possible that a patient with EVD may require surgical intervention. Examples include a female patient needing to deliver a child, a patient who develops appendicitis, a patient with cerebral edema needing a craniotomy or a patient needing an arteriovenous fistula for renal dialysis.

It would be unethical to not be prepared to provide surgical care for a patient infected with the Ebola virus just as it was unethical to fail to provide care for a patient infected with the Human Immunodeficiency Virus (HIV) or with Acquired Immunodeficiency Syndrome (AIDS) in the 1980s. It is critical that healthcare facilities be able to protect their staffs as they provide high-quality care to every patient.

As of November 1, 2014, most ORs in the United States, while technologically able to provide surgical intervention for a patient with EVD, lack sufficient PPE for staff members and may not have the specific surgical drapes, gowns, masks, respirators and other items that are currently recommended by CDC and ACS. It does appear that many hospitals are working on addressing this issue, which has resulted in many of the recommended items being on back order from the manufacturer. Examples include N95 respirator masks, Level 4 protective gowns and drapes as well as fully-enclosed protective suits.^{14, 15} A worthwhile cause would be for each state to designate a facility that would provide dedicated treatment for patients with EVD. In Ohio, a preliminary plan has been presented that involves the rotation of respon-



sibilities among several hospitals in a region.⁸

The CDC is also creating a plan to identify specific hospitals that would bear responsibility for treating patients presenting with Ebola-like symptoms. Stemming from the result of the two nurses who acquired the infection while caring for the Dallas patient, the CDC has promised to send a support team to any hospital in the US that has a patient that presents symptoms consistent with the Ebola virus infection so that they can lead an effective and safe response in caring for the patient.

Because a patient with Ebola is not to be scheduled for elective surgery, any surgical intervention would be considered urgent or emergent. Emergency surgical intervention always poses particular challenges for the OR team. OR staff members that provide such care must be properly trained and have sufficient practice in the donning and doffing of specific PPE that would be used in providing surgical care for a patient with EVD. Staff must also be able to correctly put on and remove these critical components of PPE with-

out contaminating themselves.

PREPARING THE OR FOR A PATIENT WITH EBOLA

As with any surgical procedure, the OR staff must prepare the room for the arrival of the patient. For a patient with Ebola, this requires more than simply putting on appropriate PPE. In addition to the supplies and instrumentation required for the surgical procedure, the circulator and the scrub must consider the nature of the patient and perform appropriate preoperative planning. One consideration is that once the procedure begins, the circulator will not be able to leave the room to obtain additional supplies or equipment.

In preparing the room for an Ebola patient's arrival, it is important to remove any unnecessary equipment. Everything in the room will need to be terminally decontaminated before it can be used again. This is a similar process that is used when a patient appears to have an infection of a prion-based illness such as Creutzfeldt-Jakob Disease. Only the supplies necessary for the procedure should be exposed

in the room. Additional supplies, if necessary, will need to be passed into the room from the clean core entrance. When preparing the room it is important to clearly identify the clean entryway versus the “dirty” exit which all items (used case cart, trash, linen, patient stretcher) and personnel involved in the procedure will exit the room after the surgical procedure. This is important to prepare a decontamination area for personnel to remove PPE after the procedure.

Current guidelines require the use of gowns and drapes that are rated for Level 4 protection from strike-through contamination. This applies to surgical gowns, hoods and draping materials.

The transport stretcher should ideally remain in the room to avoid the risk of unprotected staff members who may come into contact with the stretcher while the surgical procedure is in progress. Since the individual operating rooms are under positive pressure, there should be no entry into, or out of, the room once the patient has entered the room.

Staff members need to consider that surgical instrumentation and equipment that cannot be sterilized using steam sterilization methods should not be used since low-temperature methods of sterilization have not been validated to determine their effectiveness against the Ebola virus. Likewise, items that cannot be immersed in disinfectant solutions used in the Central Sterile Processing Department (CSPD) cannot be used. The CSPD staff will need to be alerted that a surgical patient with EVD is being cared for to allow them time to make necessary preparations to receive the case cart and items used during the surgical procedure.

A patient with EVD requiring surgical intervention should be transported directly to the operating room; however, some facilities may have a negative-pressure isolation room where a stable patient may be transported prior to surgery. This is not a desirable practice, however, as the number of healthcare workers should be limited to reduce exposure of the disease.

Since Ebola patients are generally not medically stable and are prone to excessive blood loss, renal failure and hypovolemic shock, the surgical technique used must be performed efficiently to minimize the time spent on the table. Meticulous hemostasis would be required to minimize blood loss.

INTRAOPERATIVE CARE OF THE PATIENT WITH EVD

Care of the surgical patient infected with the Ebola virus is carried out in a similar manner as it would be performed for any other surgical patient. Strict, hands-free passing techniques should be used to decrease the risks associated with injury from a scalpel blade or needle. No recapping of hypodermic needles should be permitted. ACS recommends the use of electrosurgical devices instead of scalpels and the use of endoscopic versus open surgical techniques.⁶

Strict input and output (I & O) must be monitored due to risks of fluid overload, renal compromise, hemorrhage and disseminated intravascular coagulopathy (DIC). Monitoring of blood loss is critical as these patients are generally hemodynamically unstable. The use of blood-scavenging devices has not been validated as a useful adjunct in these patients and should not be used. Strict hemostasis must be obtained to reduce blood loss and topical coagulants may assist in obtaining adequate hemostasis. The patient must be monitored for disseminated intravascular coagulopathy (DIC), which is a common complication of the Ebola virus. Although heparin is commonly indicated for the treatment, and reversal of DIC, its usefulness in a patient with EVD has not been widely studied or validated.

Primary wound closure is desirable in these patients to avoid the need to return the patient for a delayed primary closure (DPC) later. Wound dressings should be used to contain serosanguinous drainage.

POSTOPERATIVE ACTIVITIES

At the end of a surgical procedure, the patient, if intubated, should be transported directly back to the intensive care unit (ICU). Depending on a facility's practice, a non-ventilated patient may be transported to an isolation room in the post-anesthesia care unit (PACU); however, in order to limit the potential number of healthcare workers it may be prudent to transport this patient directly back to the intensive care unit. Because the surgical team members (sterile and unsterile team members) are considered “contaminated,” it may be worthwhile to have a separate transport team standing by outside of the room to deliver the patient to PACU or back to the ICU. This team might include the ICU nurses who will be providing post-operative care and a Certified Registered Nurse Anesthetist (CRNA). These staff members will need to be attired in CDC-recommended PPE and must remain outside of the procedure room at all times.

It has been suggested that a tarp should be laid on the floor by the exit doorway and sprayed with an EPA-registered, hospital-approved disinfectant, which would allow



Bio safety officer, Kristie Yeakle, evaluates two students as they sanitize their personal protective equipment during a training session October 24, 2014, at the San Antonio Military Medical Center in San Antonio, Texas. The students are part of a 30-person team designated for "prepare to deploy" status in the event of an Ebola crisis in the US.

Photo credit: U.S. DoD, Army Sgt. 1st Class Tyrone C. Marshall, Jr

the stretcher wheels to be disinfected as it is wheeled out of the room. All hard surfaces of the stretcher should be disinfected immediately prior to the stretcher being wheeled out of the room.

Sharps safety must continue to be a priority after wound closure to prevent accidental injury to other staff members. Linens and trash are to be placed in sealed, leak-proof and puncture-proof containers that are to be wiped down with an approved disinfectant prior to being removed from the room. Suction canisters shall be sealed and placed in leak-proof, puncture-proof containers to be discarded. Specimens must be handled according to a facility's policy. However, no specimens obtained from a patient with EVD should be transported using a pneumatic tube system.

Instruments must be free of blood and tissue. Unlike with instruments used on a patient with CJD, surgical instruments used in a patient with EVD do not need to be soaked in sodium hypochlorite or sodium hydroxide. Instruments may be kept moist using a towel kept damp with sterile water. Instruments should not be sent to the

CSPD in a basin of water as this poses a risk for contamination from spilling or splashing. Instruments and other items to be transported to the CSPD must be contained in an enclosed case cart that has been wiped down with a hospital-approved disinfectant. As with the stretcher, the cart wheels may be disinfected by rolling them over the tarp that has been sprayed down with disinfectant. The OR staff members must personally deliver the case cart to the decontamination area to ensure that no one accidentally comes into contact with the cart or its contents prior to being decontaminated and disinfected by the CSPD staff members. The cart cannot be left in a holding area with other case carts awaiting decontamination.

It is important to note that following infection with the Ebola virus, patients are counselled about potentially being able to transmit Ebola virus infection for a period of time after they are considered cured. This varies based on specific tissues and body fluids; however, a patient who has recently recovered from EVD should be considered as having an active illness for at least two to four weeks post-recovery.

ENHANCED PPE FOR EBOLA

The initial guidelines offered by the CDC were identical to the standard precautions recommended for the treatment of any patient receiving care for an infectious illness. But after the Dallas-based nurses became infected with the virus, the CDC modified these recommendations to include leaving no exposed skin and ensuring proper training and evaluation of staff members to ensure that PPE is consistently donned, and doffed, properly.^{7,9,10} At about the same time, ACS published guidelines for the use of specific, enhanced, PPE for caring for a surgical patient with EVD.^{6,7,10} In addition, North Shore Long Island Jewish (LIJ) Health System drafted guidance that has been made available to those involved in the preparation of their own facilities for the care of patients with EVD.¹⁹

Specific items of PPE that are considered include:

- Level 4 surgical gowns or coveralls that extend to at least the mid-calf
- Hoods with flaps that extend to at least the shoulders and mid-chest
- Double gloves
- Water-proof booties or boots that extend above mid-calf
- N95 respirator mask or powered-airway particulate respirator (PAPR)
- Full face-shield (unless incorporated into hood)

Surgical technologists are well versed in the application and removal of PPE including gowns, masks, eye protection and gloves.^{20,21} It must be noted that hair covers and shoe covers are not considered to be PPE, which is why special hoods and waterproof shoe coverings must be worn. Other members of the surgical team including RN circulators, anesthesia providers, surgeons, residents, aides or attendants, X-ray personnel, etc, are not as familiar with the proper donning and doffing of regular PPE, let alone donning and doffing enhanced PPE. Even experienced scrub personnel, may not regularly use enhanced PPE and may not be comfortable with donning and doffing of hoods, air-exchange devices, water-proof booties and the like.^{18,19,20,21} It is important to note that the guidance prepared by the CDC, and other agencies including WHO, are geared toward regular patient care activities involving a patient with EVD and are not specific for operating room personnel or CSPD staff members.

SPECIFIC RISKS FOR OR PERSONNEL DONNING AND DOFFING OF PPE

One concern raised regarding the use of enhanced PPE is the increased risk of cross-contamination while removing items of protective gear they are not familiar with wearing. For this reason, it is important that all surgical staff mem-

bers who participate in the surgical care of a patient with EVD be thoroughly trained, and routinely practice, the proper steps in donning and doffing of this protective gear.

Current guidelines require the use of gowns and drapes that are rated for Level 4 protection from strike-through contamination. This applies to surgical gowns, hoods and draping materials. Gowns and drapes that meet the Association for the Advancement of Medical Instrumentation (AAMI) standard will be labeled as such and will include a film lining as opposed to being fabric-reinforced.^{14,15} Additionally, those participating in direct-patient care activities are recommended to wear a N95 respirator or, if aerosolization is a risk, a powered-airway purifying respirator (PAPR).^{7,9,10} A PAPR is similar to devices worn in many total joint procedures; however, the PAPR uses a high-efficiency particulate absorption (HEPA) filtering mechanism. They are both battery powered. The PAPR may be mounted to the head frame under a hood or worn on a belt.

For non-sterile team members, a fully-enclosed one piece suit or a coverall with a separate hood that covers the entire head and face and has flaps that extend to at least the shoulders is acceptable. Coveralls with separate hoods are preferred as they reduce the risk of cross-contamination during the removal process. If this is not available, surgical gowns with a Level 4 rating are used. For sterile team members, there is a challenge as there are no one piece suits that can be donned using aseptic technique. CDC and ACS guidelines recommend double gloving for all patient care activities involving a patient with EVD.

While it is generally unlikely that a surgical patient with Ebola will require surgical intervention, it is critical that surgical teams in developed nations be prepared for this possibility. It is important for surgical team members to be properly trained and routinely practice in case there is the need to provide care to a patient infected with the Ebola virus.



ABOUT THE AUTHOR

Ken Warnock received his training as a surgical technologist in the US Navy. He has nearly 30 years of experience working as a surgical technologist, surgical first assistant, preceptor, educator and manager.

He currently works as a shift supervisor in Central Sterile Processing at Oakwood Hospital-Dearborn, in Michigan, and is an adjunct faculty member at Macomb Community College in Clinton Township, Michigan. Ken has authored previous articles for *The Surgical Technologist*, including: "Terrorism and Its Impact on the Practice of Surgery" (May 2002), and "Preventing Surgical Errors" (June 2003). He also was a contributing author for "Fuller's Surgical Technology Principles and Practice" 4th Edition (2010).

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Dealing with Infectious Disease – Ebola

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1. What animal was involved in the first identified outbreak of the filovirus?
 - a. Cow
 - b. Bat
 - c. Monkey
 - d. Goat
2. The strain of the Marburg hemorrhagic fever virus was coined based on the region it was first identified. What region was it?
 - a. France
 - b. West Africa
 - c. Liberia
 - d. Germany
3. The second case of Marburg fever was identified in a traveler to _____.
 - a. West Africa
 - b. France
 - c. Zaire
 - d. Zimbabwe
4. The first reported outbreak of Ebola hemorrhagic fever was identified in a region of _____.
 - a. Sudan
 - b. Zaire
 - c. Zimbabwe
 - d. Ivy Coast
5. How many people became ill in the first reported outbreak of Ebola?
 - a. 441
 - b. 318
 - c. 368
 - d. 225
6. The mortality rate of the first reported outbreak of Ebola was _____.
 - a. 88%
 - b. 78%
 - c. 100%
 - d. 94%
7. Ebola symptoms are similar to what illness?
 - a. Strep
 - b. Sinus infection
 - c. Influenza
 - d. Common cold
8. If wearing a face shield, it should be grasped from the _____ and lifted away from the face when doffing.
 - a. Bottom
 - b. Top
 - c. Side
 - d. All of the above
9. In the early stages of the EVD, what symptom typically occurs?
 - a. Fever
 - b. Constipation
 - c. Bleeding
 - d. Bruising
10. How many healthcare workers had died of Ebola after giving care in West Africa as of October 8, 2014?
 - a. 232
 - b. 334
 - c. 401
 - d. 441
11. Based on recent events in the US, the risk of exposure to the Ebola virus is:
 - a. High
 - b. Moderate
 - c. Low
 - d. Extremely low
12. The first reported case in the US was treated in which city?
 - a. Omaha
 - b. Dallas
 - c. Chicago
 - d. Orlando

DEALING WITH INFECTIOUS DISEASE – EBOLA

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13. How many Dallas-based nurses contracted the disease after caring for the initial patient?
- 2
 - 5
 - 10
 - 15
14. The first identified outbreak of infection with a filovirus dates to _____.
- 1976
 - 1967
 - 1987
 - 1966
15. Which of the following is not considered to be PPE?
- Level 4 surgical gown
 - Coveralls
 - Double gloves
 - Shoe covers
16. According to the author, the first pair of gloves should be donned prior to the _____.
- Overalls
 - Hood
 - Shoe covers
 - Gown
17. Which technique is discouraged because it limits tactile sensation?
- Double gloving
 - Triple gloving
 - Double shoe covers
 - Wearing an enclosed hood
18. If a PAPR is used, (a) disposable _____ should be worn.
- Shoe covers
 - Hair covers
 - Hood
 - Gloves
19. Sterile team members should wear a pair of _____ that extend at least to the mid-calf.
- Boots
 - Waterproof booties
 - Waterproof wool socks
 - Either a or b
20. Which level of gown should be used in infectious disease cases?
- Level 4
 - Level 5
 - Level 3
 - Level 6
21. Where should doffing of PPE occur?
- At the OR table
 - In the hallway
 - In an anteroom outside of the OR
 - Outside the facilities' grounds
22. Currently, there are how many known strains that result in EVD?
- 4
 - 5
 - 6
 - 7
23. Shoe covers should be removed by pulling them toward the toe of the shoe and discarded using caution to avoid contaminating the _____.
- Shoes
 - Hands
 - Arms
 - Legs
24. To remove the inner gloves, the _____ of the ungloved hand should slide under the cuff and push down.
- Ring finger
 - Index finger
 - Pinkie finger
 - Thumb
25. Recently, what animal do scientists believe the largest-known outbreak is traced to?
- Monkeys
 - Dogs
 - Boars
 - Bats
26. Coveralls with separate _____ are preferred as they reduce cross-contamination during the removal process.
- Hoods
 - Flaps
 - Gloves
 - Boots
27. Generally, infected patients demonstrate symptoms between _____ days following exposure.
- 6-12
 - 8-10
 - 8-12
 - 10-12
28. The range of infection is from _____ days.
- 2-10
 - 1-21
 - 1-22
 - 2-21
29. Current guidelines recommend screening any patient presenting with a fever of greater than _____ degrees Fahrenheit.
- 101.1
 - 100.4
 - 102.4
 - 104.4
30. Contact and droplet isolation precautions should be implemented with airborne isolation precautions if the patient is _____.
- Coughing
 - Sneezing
 - Vomiting
 - All of the above
31. According to the World Health Organization, mortality rates associated with Ebola range from _____.
- 25%-90%
 - 20%-90%
 - 50%-90%
 - 50%-80%
32. The current epidemic involving _____ is the most virulent.
- ICEBOV
 - BEBOV
 - ZEBOV
 - SEBOV
33. In early October 2014, the CDC reported that _____ healthcare workers caring for EVD patients in West Africa has contracted the disease.
- 232
 - 334
 - 401
 - 441
34. When testing for EVD, leukopenia with _____ is a common laboratory finding.
- Neutrophilia
 - Lymphocytopenia
 - Thromboplastin
 - Prothrombin
35. A significant number of patients with EVD will require _____.
- Renal replacement therapy
 - Right internal jugular therapy
 - Hemodialysis
 - Subclavian vein placement