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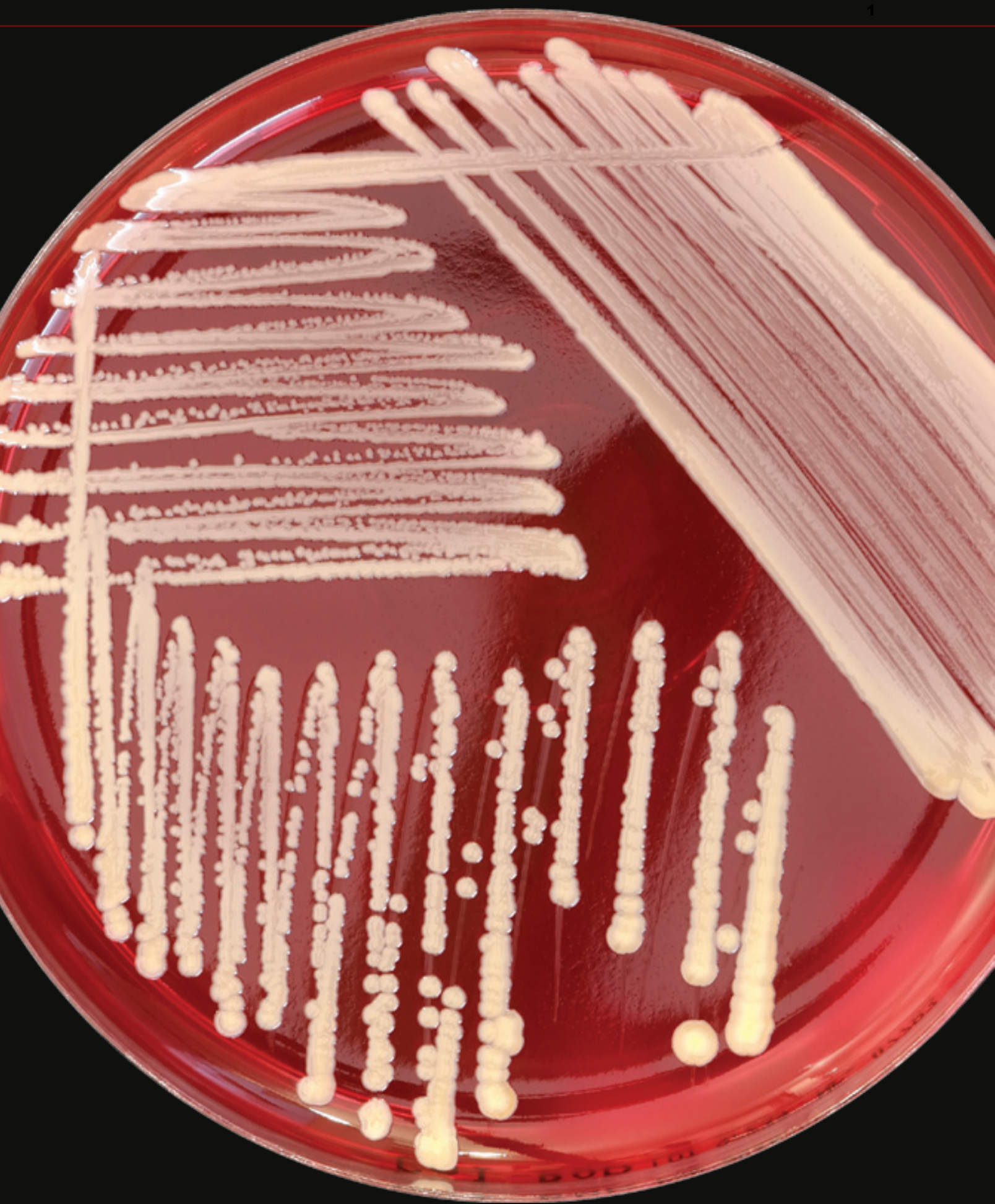
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The Rise of MRSA

Jessica Cantrell, CST

In 1928, Scottish bacteriologist Alexander Fleming accidentally discovered penicillin's miraculous ability to kill *Staphylococcus* germs. Pathologist Howard Florey learned how to isolate penicillin for widespread use and created the first broad-spectrum antibiotic in 1940.³ Penicillin-resistant strains of staph were widespread by the late 1950s. In 1961, the first case of Methicillin-resistant *Staphylococcus aureus*, or MRSA, appeared in a British hospital, just two years after Methicillin was first used to treat *Staphylococcus aureus* infections.⁵ The first reported case of MRSA in the United States came in 1968.⁷ Since those fledgling years in the discovery of antibiotics, bacteria have increasingly adapted and developed new strains that are able to resist a large variety of medicinal attacks, old or new, that have been created in an effort to restrain the increasing number of infectious diseases that exist today.

The term “staph infection” is a relatively common phrase that can be heard from the workplace to almost any health care facility in the country. It refers to an infection caused by *Staphylococcus aureus*, a Gram-positive, aerobic bacteria that colonizes in the nose and on the skin of 25% to 30% of the population.⁶ While this colonization is typically asymptomatic, approximately 1% of *S aureus* carriers develop MRSA.⁷ Methicillin-resistant *Staphylococcus aureus* typically forms as skin infections such as boils, abscesses, or pustules, but also has the potential to be much more severe and possibly fatal. It is resistant to not only Methicillin, but also more common antibiotics such as amoxicillin, penicillin and other antibiotics in the beta-lactams family.⁶ MRSA can be differentiated into two different categories: Hospital-Acquired MRSA (HA-MRSA) and Community-Acquired MRSA (CA-MRSA). While MRSA is typically found most often in health

LEARNING OBJECTIVES

- ▲ Learn about the different strains of MRSA
- ▲ Identify the differences of the two strains
- ▲ Review how each type of MRSA strain can be acquired
- ▲ Examine the treatment for patients that acquire either strain of MRSA
- ▲ Determine what groups are most susceptible to acquiring *Staphylococcus aureus*



Courtesy CDC Magnified 20,000X, this colorized scanning electron micrograph (SEM) depicts a grouping of methicillin resistant *Staphylococcus aureus* (MRSA) bacteria

care settings, it has been noted that the number of CA-MRSA incidents have increased during the past decade as well significant differences between the two strains.¹ For instance, CA-MRSA seems to be more sensitive to a wider range of drugs than HA-MRSA. HA-MRSA, however, seems to be the strain of MRSA that affects the most victims. A study conducted in 2005 by the US Centers for Disease Control and Prevention stated that the majority of the estimated 94,360 cases of MRSA were hospital-acquired, which supports the belief that the HA-MRSA strain is potentially more resilient than the CA-MRSA strain.²

Due to the speed at which the bacteria multiply as well as its ability to adapt to its environment quickly, MRSA can occur at any location, and it can occur anywhere on a person's body and affect anybody. It is typically transmitted through an area of broken or open skin, but it has also been known to cause infections on areas of skin that lack any kind of wound.⁶ With HA-MRSA, the infection is spread when a colonized individual comes into contact with a patient who

has had surgery or who has a weak immune system. People at risk also include patients who have come into contact with inanimate objects or surfaces contaminated with the body fluids of someone who carries MRSA in their system, patients who have had to stay in ICU, and patients who have indwelling catheters. CA-MRSA can be transmitted much quicker; all it takes is for one colonized individual to come into contact with a crowd to start a crisis if the proper precautions are not taken. This category of MRSA is transmitted usually due to poor hygiene, overcrowded living conditions, skin-to-skin contact, and the sharing of personal items such as towels or razors. Certain groups remain at risk to CA-MRSA because of the aforementioned transmission risks, such as young children, the elderly, the homeless, athletes, prison inmates, day-care workers, tattoo recipients and drug abusers.¹

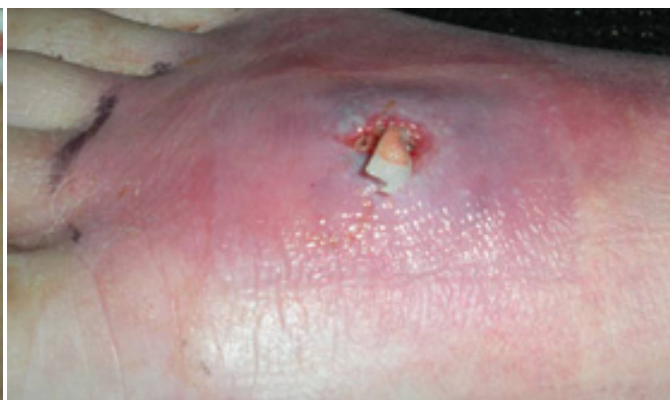
PATHOGENESIS

Colonization, primarily through the anterior nares of the nasal region or through other parts of the body such as the groin, rectum, or axilla, is an important factor in the development of MRSA. It has been suggested that by destroying the colonization in the nose, the colonization in other areas of the body will disappear as well. Skin-to-skin contact is another major route to infection, as well as skin-to-surface contact. With HA-MRSA, this includes contact with medical equipment and workstations, and with CA-MRSA, personal items such as soap and towels are implicated as sources of infection.¹

Resistance to antibiotics in certain staphylococci strains seem to appear for different reasons. It has been suggested in one report that resistance is created through the transfer of the *mecA* gene between the different strains of the bacteria. The gene chromosomally encodes the strain with a high-level resistance to Methicillin and other beta-lactams



Gregory Moran, MD A cutaneous abscess located on the back, caused by MRSA



Major Kirk Waibel, MD A cutaneous abscess on the foot post packing, which had been caused by methicillin-resistant *Staphylococcus aureus* bacteria, or MRSA



Gregory Moran, MD A cutaneous abscess, which had been caused by methicillin-resistant *Staphylococcus aureus* bacteria



Gregory Moran, MD A cutaneous abscess on the hand, caused by MRSA

by using altered penicillin-binding proteins.⁶ Another way in which resistance develops is through the overuse of antibiotics. When antibiotics are used inappropriately, such as when they are taken for a viral illness or when they are not taken as prescribed by a physician, it increases the risk of the bacteria mutating and becoming resistant to that form of antibiotic.

While there are several strains of MRSA that are virulent and significant sources of infection, one clone of the bacteria, the USA300, appears to be considered the main CA-MRSA strain. This clone contains genes and toxins that can lead to several skin and soft tissue infections.¹ If MRSA, especially this clone in particular, is left untreated, it can cause toxic shock syndrome, necrotizing pneumonia, endocarditis, scalded skin syndrome, gastroenteritis and osteomyelitis.⁷

CLINICAL/LABORATORY DIAGNOSIS

This bacteria is most commonly suspected when a skin infection is displayed in the form of abscesses, boils, or carbuncles. The patient may also complain of a painful “spider bite” which may ultimately be a MRSA infection. In order to be certain that a clinical diagnosis of MRSA is correct, a culture must be obtained from the infection site of the patient, and then sent to a microbiology lab for further testing.⁶ The cultures may be obtained from different sites based on the location of the infection. Sputum would be obtained if the symptom is pneumonia, while a biopsy of skin or a sample of drainage may be obtained from a skin infection.

Different tests may be used to screen for MRSA, especially typical broth-based and agar-based tests. However, the Clinical and Laboratory Standards Institute now recommends the use of the cefoxitin disk screen test, the latex agglutination test for PBP2a (the penicillin-binding protein), or a plate containing 6 µg/ml of oxacillin in Mueller-Hinton agar sup-

plemented with NaCl.⁶ The results for these tests are positive for MRSA if the bacteria prove to be resistant to oxacillin or cefoxitin.

PREVENTION CONTROL

Once MRSA begins to spread it is notoriously difficult to control. If caught early, the localized MRSA (which usually appears as a skin infection) can be treated by lancing and draining, and keeping the area dry and covered. An oral dosage of vancomycin may be given if necessary. If the condition has been allowed to worsen and the symptoms are severe, a variety of antibiotics may be given intravenously, such as vancomycin, daptomycin, tigecycline, or linezolid.²

As death can possibly result from exposure to MRSA, it is important to take measures to prevent and/or control the risk of outbreaks. The first and easiest step in the prevention and control of this bacteria is simply to maintain good hygiene: keep hands washed, always shower after exercising, and keep cuts, scrapes, and wounds clean and covered with bandages until completely healed. This is especially important in certain environments that involve a multitude of close contact with others, such as athletic locker rooms, schools, gyms, and health-care settings. Sharing personal items, including towels, razors, and clothing, should be avoided. Clothing and towels should be machine-washed using bleach and hot water if possible, as well as dried in a machine as opposed to air-drying.⁵

If a skin infection is suspected to be MRSA, patients should mention this to their physician in an effort to avoid contact with other patients who could potentially acquire the bacteria through contact. This also helps with the ability to track MRSA strains by healthcare providers who are attempting to control the spread of the bacteria. Patients can also help fight the spread of MRSA by monitoring their own

Taking Actions to Reduce HA-MRSA Infections

AST staff

Multiple hospitals across the US have taken steps to reduce hospital-acquired MRSA colonization and infection. Many centers have had success at decreasing the number of cases due to enacting preventative measures. From daily monitoring of clinical cultures for recovery of MRSA, surveillance of high-risk patients, ensuring all precautions for colonized or infected patients, using barrier protections for placement of central venous catheters, installing and using alcohol hand rubs and a hospital-wide dedication to hand hygiene, all these elements help reduce the exposure and spread of MRSA infections. The VA Pittsburgh Health System and the University of Pittsburgh Medical Center Presbyterian used a “bundle” of interventions and saw a 70% decrease in MRSA infections in one patient care unit over a four-year period.¹

Due to aggressive approaches to control the spread of MRSA infections, data from the CDC’s National Health Safety Network shows an “11% decrease in incidence of hospital-acquired invasive MRSA infections from 2005-2006” and a “44% decrease in central line-associated MRSA bloodstream infections from 2001 to 2007.”²

THE ROLE OF LEADERSHIP

Initiatives work best when everyone is onboard, including hospital leadership. Leaders in the health arena need to be committed to enforcing, reviewing and implementing infection reduction policies. They also need to be willing to engage everyone on their clinical staff in acknowledging that the MRSA problem is serious and empower the front-line teams to get the job done. It is also important for leadership to understand that in order to begin a control program funds will need to be allocated to up-front resources. However, in return, by controlling MRSA infection issues, the hospital will save money in the long run. By setting up and utilizing MRSA infection precautions, hospitals can save from \$20,000 to \$462,000.¹

COMPONENTS OF CARE

As a part of the 5 Million Lives Campaign, established by the Institute for Healthcare Improvement, a guide on how to reduce MRSA infections was created. In the guide, the IHI

came up with five components of care that organizations should follow when adopting a MRSA-reduction initiative.

1. Hand hygiene
2. Decontamination of the environment and equipment
3. Active surveillance
4. Contact precautions for infected and colonized patients
5. Device bundles (Central Line Bundle and Ventilator Bundle)

HAND HYGIENE

Although the nose harbors the MRSA colonization, hospitalized patients often have high concentrations for MRSA on their skin and other body parts and since patients tend to contaminate their surroundings, MRSA may be lurking for days on hospital furniture. Health care workers have been shown to have MRSA on their hands when working in settings where the infection is epidemic. Transient contamination is believed to be the most frequent mode in which the infection is transferred from patient to health care worker. Cleaning hands before and after contact with MRSA patients or their immediate environment is critical in reducing transmission even when wearing gloves. Health care workers hands can be contaminated during glove removal. The IHI reports that dedicated hand hygiene remains under 50% at many hospitals derailing any effort to thwart MRSA infections.

The IHI released these components as part of the hand hygiene intervention for all health care centers to use when trying to get all staff to comply with hand washing.

- Demonstrate knowledge by training clinical staff with the key element of hand hygiene
- Demonstrate competence by training staff to use appropriate technique when cleansing their hands
- Enable staff by making alcohol-based hand gel and gloves available and easy to access
- Verify competency by monitoring correct glove usage

DECONTAMINATION

MRSA can survive for days on surfaces touched by infected patients so decontaminating their rooms or any area where an infected patient has been needs to be sterilized. Regularly cleaning and disinfection is also necessary and should be a priority for all health care settings. Leadership plays a key role in ensuring that these actions take place and providing education to all those involved in sterilizing so that everyone is well aware of the stakes in the MRSA control effort. Education for all staff, environment and clinical, needs to be available and checklists need to be used every time to verify that every area has been sterilized. The IHI recommends that those checklists be available for each cleaning and there should be areas to document any high-touch areas. Specific equipment should be dedicated for patients on isolation and leadership should use issue immediate feedback regarding cleaning and proper technique.

ACTIVE SURVEILLANCE

Since colonized patients are the main reason transmission occurs health care workers need to ensure correct and swift implementation of control measures to reduce infection rates. Active surveillance testing of the anterior nares will identify 80% of MRSA-colonized patients. By using a combination of screening specimens from the anterior nares and wounds, the percentage of identifying infected patients rises to 92%.¹ Some patients will go undetected if the infected area is not tested, such as the rectum. The IHI advises hospitals to begin collecting specimens on admission-only patients and measure compliance of the first test. If the first test is higher than 90%, call for the second test. Staff should be notified immediately when a patient tests positive for MRSA so that all precautions can be implemented.

CONTACT PRECAUTIONS FOR INFECTED AND COLONIZED PATIENTS

Although the anterior nares are the most common area for MRSA, patients can be infected in a number of body sites. Contact precautions are meant to break up the ways in which MRSA can be transmitted. Gloves, handing washing and alcohol wipes all help in reducing the spread of the infection as patients can contaminate their gowns, hospital room and the like. Each hospital needs to come up with a plan and adhere to all precautions to ensure the proper barrier techniques are used every time an infected patient is in their hospital. Adequate supplies should be easy to access and constantly restocked. Patients should be educated about

hand hygiene and encouraged to comply with the hospital's protocol. When a patient cannot be placed in a private room, visual cues should be used for anything that crosses into the common area.

DEVICE BUNDLES

"Patients with invasive devices, such as central lines and ventilators, are at greater risk for developing hospital-acquired infections."¹ These patients are also at a greater risk of MRSA bloodstream infections and pneumonia. Bundles have helped many hospitals reduce or eliminate device-related infections. By combining the Central Line Bundle and Ventilator Bundle, hospitals can work toward greatly reducing MRSA infections.

When reducing MRSA infections is a hospital's goal, everyone needs to be aware of the plan and leadership needs to take an active role in enforcing each of the steps. If a hospital only focuses on one of the components, they will fail to address the problem at hand. Each component requires commitment, continuing education and direction offered by leadership so that each employee may be aware and dedicated to ensure that they and their hospital are giving each patient the quality care.

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use of antibiotics. There are a few simple guidelines that can be followed to fight antibiotic-resistance:

1. Avoid asking for antibiotics without knowing the exact reason for illness.
2. If antibiotics are prescribed, take the dosage exactly as directed. This includes finishing the entire prescription instead of stopping as soon as the symptoms clear up. This prevents the resistant bacteria from multiplying and becoming more resistant.
3. Do not take someone else's antibiotic.²

MRSA, as well as antibiotic-resistant bacteria in general, has become a major problem not only in the US, but the world. Public awareness and good hygiene are crucial to controlling outbreaks and potentially saving lives.



ABOUT THE AUTHOR

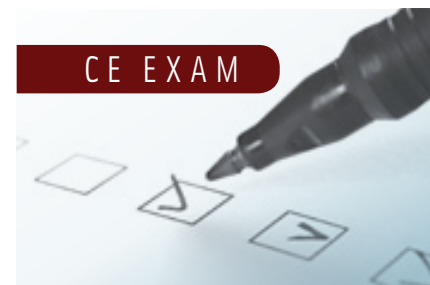
Jessica Cantrell, CST, graduated from the surgical technology program at Ashland Community and Technical College in Ashland, Kentucky, in 2011. She immediately began working at Cabell Huntington Hospital in Huntington, West

Virginia, as an anesthesia tech after graduation. Jessica was invited and participated in item writing for the National Board of Surgical Technologists and Surgical Assistants for practice exams. She is currently pursuing her Bachelor's degree in ecology/evolutionary science at Marshall University, and hopes to obtain a Master's degree in Physician Assistant Studies. She is supported by her fiancé and two daughters.

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The Spread of the Superbug

AST STAFF

As technology continues to allow scientists to make medical advances that once were considered difficult, new threats to public health are rising. Superbugs are deadly bacteria that spread easily and can potentially be untreatable. A newer family of superbugs named carbapenem-resistant Enterobacteriaceae, known as CRE, has spread across hospitals throughout the United States in 2013, and again has topped The Center for Disease Control and Prevention's (CDC) top five health concerns for the new year.¹

HISTORY OF SUPERBUGS

Antimicrobial resistance in bacteria is nothing new. The concern dates back more than 50 years ago as bacterial resistance started to appear in cases of *Staph aureus* infections in the 1950s. Methicillin was introduced in 1960 and just a year later, methicillin-resistance *Staph aureus* or MRSA, was beginning to be seen.⁴ Since then, there have been different strains of superbugs.

MRSA, most commonly known and one of the original superbugs, has been followed by a slew of other superbugs that all have one thing in common: resistance to antibiotics. A group of six hospital-borne pathogens, known as ESKAPE (Enterococcus, Staphylococcus, Klebsiella, Acinetobacter, Pseudomonas and Enterobacter) were present in hospitals starting 20 years ago.⁶ Because there have been so many antibiotics used to treat these strains, they have been trained to resist these drugs. This group of bacteria invades through hospital equipment such as surgical implants and central lines making the affected patient susceptible to infection.

LEARNING OBJECTIVES

- ▲ Identify how superbug CRE spreads
- ▲ Learn about the history of superbugs in American society
- ▲ List five of the scariest superbugs in history
- ▲ Review AST's standard for hand hygiene
- ▲ Summarize the best ways to prevent superbugs from spreading

There are also food-borne bugs that have become drug resistant, partially due to farm animals being fed antibiotics to promote growth.⁶ Escherichia Coli and Salmonella are two of these types of strains. Super gonorrhea and chlamydia are also a part of the superbug family as individuals either opt to not seek treatment of these conditions, which leads to a series of problems, or because they have had STD infections treated with antibiotics in the past and now these new strains require more than just a few pills.

Tuberculosis was once curable with antibiotics. Much like the others in the superbug family, it is now resisting antibiotic treatments. This condition is a global threat, killing 1.34 million people each year. Since people can easily travel between countries, TB is being spread faster than ever and is difficult to treat. According to the World Health Organization in 2010, 650,000 out of 12 million TB cases were drug resistant.⁶

CRE is a new family of germs and evades some of the strongest antibiotics, according to the CDC.⁶ This factor makes these infections almost untreatable. The CDC says in the last year, “one in 25 acute-care facilities reported at least one case of hospital-acquired CRE.” (CRE) In a CDC report, 42 states in the US have had at least one report of a particular strain of CRE. These germs tend to be found in the human digestive system and have adapted to resist all forms of antibiotics. This particular strain of CRE has intensified as reports on this strain have increased from 2% to 10% through the past decade in the US.³

The superbug tends to affect those who already are ill, have been in the hospital for a while or are elderly. “In 2001, only 1.2% of the common family of bacteria, Entero-

Antimicrobial resistance in bacteria is nothing new. The concern dates back more than 50 years ago as bacterial resistance started to appear in cases of Staphylococcus aureus infections in the 1950s.

CASE STUDY

According to the CDC, it worked with the state of Florida to stop a year-long CRE outbreak. The outbreak took place in a long-term acute care facility. Improvements were made to a variety of techniques to help control and then reduce the infection. Gown and glove use improved; Staff, equipment and rooms were dedicated to CRE-infected patients; and the staff underwent training in an effort to reduce the spread of the disease. After a year, the percentage of patients who got CRE at the facility decreased from 44% to 0.¹

bacteriaceae, were resistant to carbapenem antibiotics – the strongest class available. By 2011, that figure had jumped to 4.2%.² Almost all of CRE infections occur to patients receiving serious medical care and as many as half of the patients who get bloodstream infections from CRE die from the infection.¹

These deadly antibiotic-resistant superbugs are cause for alarm is if nothing is done to stop their spread. These bacteria have the ability to share its resistance genes with other bacteria making far more common bacteria, such as E coli, possibly untreatable. Since there is a small chance that an effective drug would be developed and produced in the next several years to kill CRE, the issue becomes that of a major public concern.²

PREVENTION

The best way to combat CRE and other superbugs is to get everyone on the same page about taking preventative measures. The CDC has issued a public campaign directed at hospitals, healthcare providers and patients to help curb the spread of this infectious superbug.

Hospitals need to take great care in detecting if any of their patients have CRE and take precautions such as wearing gloves and gowns; dedicating separate rooms, machinery and staff for those who are infected; removing invasive devices, such as catheters, as soon as possible; and making sure that even basics such as hand washing is done properly and followed by everyone.²

Doctors should pause before prescribing antibiotics to make sure that the condition(s) a patient has will be appropriately fought by an antibiotic. Patients also need to think twice before asking his or her doctor to prescribe antibiotics as now many common illnesses such as ear infections and sinus infections often go away without them. These two

HOW CRE SPREADS¹

- Lots of germs abound, a couple of which are CRE
- Antibiotics are used and kill off good germs, leaving the couple of CRE germs behind
- CRE continues to grow, expanding from a couple to many
- CRE germs share their genetic defenses to make other bacteria resistant

HAND HYGIENE

The following is taken from AST's Standard of Practice for Hand Hygiene. For more and other AST Standards of Practice, visit www.ast.org.

Proper care and hygiene of the fingernails, hands and arms by the surgical team members is essential to promoting surgical conscience, providing quality surgical care to the patient, and ensuring a positive outcome for the patient.⁷

STANDARD OF PRACTICE I

The surgical team members should practice on a daily basis effective hand and fingernail hygiene.

1. Effective hand hygiene should be practiced on a daily basis to remove dirt, skin oil, debris and transient microorganisms to prevent transmission to the patient.
 - A. Indications for hand washing include the following:
 - B. Hands are visibly dirty or contaminated, or visibly contaminated with blood or body fluids
 - C. Anytime the possibility existed of contact with blood or body fluids
 - D. When entering the surgical suite at the beginning of a day or shift
 - E. Prior to having direct contact with a patient and between patients
 - F. Immediately after the removal of gloves
 - G. Before and after eating
 - H. Immediately after using the restroom
 2. Hand hygiene includes daily skin care by using hand lotions or creams to minimize the occurrence of irritant contact dermatitis, dry and cracked skin associated with repeated handwashing.
 - A. Manufacturers of hand lotions and creams should be consulted regarding any effects their product(s) may have on the persistent effects of antimicrobial soaps being used in the healthcare facility in order to choose the proper lotion or cream.
 - B. Lotions and creams should be selected based on compatibility with gloves.
3. The skin of surgical team members should be healthy and intact. Cuts, abrasions, open sores and hangnails provide a portal of exit and entry of microorganisms, thereby providing risk of exposure to surgical personnel and patients.
 2. Artificial fingernails should not be worn by surgical team members.
 - A. Artificial fingernails are more likely to harbor greater numbers of microorganisms, as compared to the natural fingernail, even after handwashing. Personnel wearing artificial nails have been epidemiologically connected in outbreaks of infection.
 - B. Fungal growth can occur between the natural fingernail, and the artificial fingernail due to moisture, and products used to apply the artificial fingernail.
 3. Studies have established that there is no increase in microbial growth related to wearing freshly applied nail polish. However, it is recommended that fingernail polish should not be worn by surgical personnel.
 - A. Chipped fingernail polish may support microbial growth on the fingernails.
 - B. Data does indicate that chipped nail polish or polish that has been worn for more than four days does harbor greater numbers of bacteria.
 4. The relationship between long fingernails and surgical site infections has not been established. However, it is known fingernails that extend beyond the fingertips are more difficult to clean and keep clean, and therefore could contribute to an increase in the potential for harboring greater numbers of microorganisms.
 - A. Fingernails that extend beyond the fingertips add to the potential for scratching patients during patient care, transfer and transport to and from the surgical suite and OR, and while positioning the patient.
 - B. Fingernails that extend beyond the fingertips increase the risk of tearing or puncturing gloves.
 - C. It is recommended that the natural nail tips be kept less than ¼-inch long and not significantly extend past the fingertips.

STANDARD OF PRACTICE II

Fingernails should be natural and polish-free. Fingernails should be short, debris-free, and not extend past the tips of the fingers.

1. The subungual area of the fingernail harbors high concentrations of bacteria, particularly coagulase-negative *staphylococci*, gram-negative rods, *Corynebacteria*, and yeasts. The subungual area should be cleansed with particular attention, using a disposable fingernail cleaner and/or fingernail brush under running water.

STANDARD OF PRACTICE III

The reinforcement of hand and fingernail hygiene should be constantly emphasized with surgical technology students and peers.

1. Hand and fingernail hygiene begins in the classroom, lab and clinical rotation, and should be constantly emphasized to the student.
2. Education and promotion of hand and fingernail hygiene have been targeted as the primary factors in gaining compliance by health-care workers.

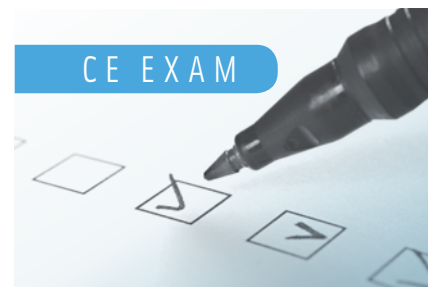


aspects may help lessen one's resistance to antibiotic drugs.

In 2012, the CDC shared its CRE toolkit as a way to help facilities and individuals partake in measures that can help reduce the chance of CRE appearing. Actions include proper hand hygiene, educational programs and training and CRE screening initiatives.

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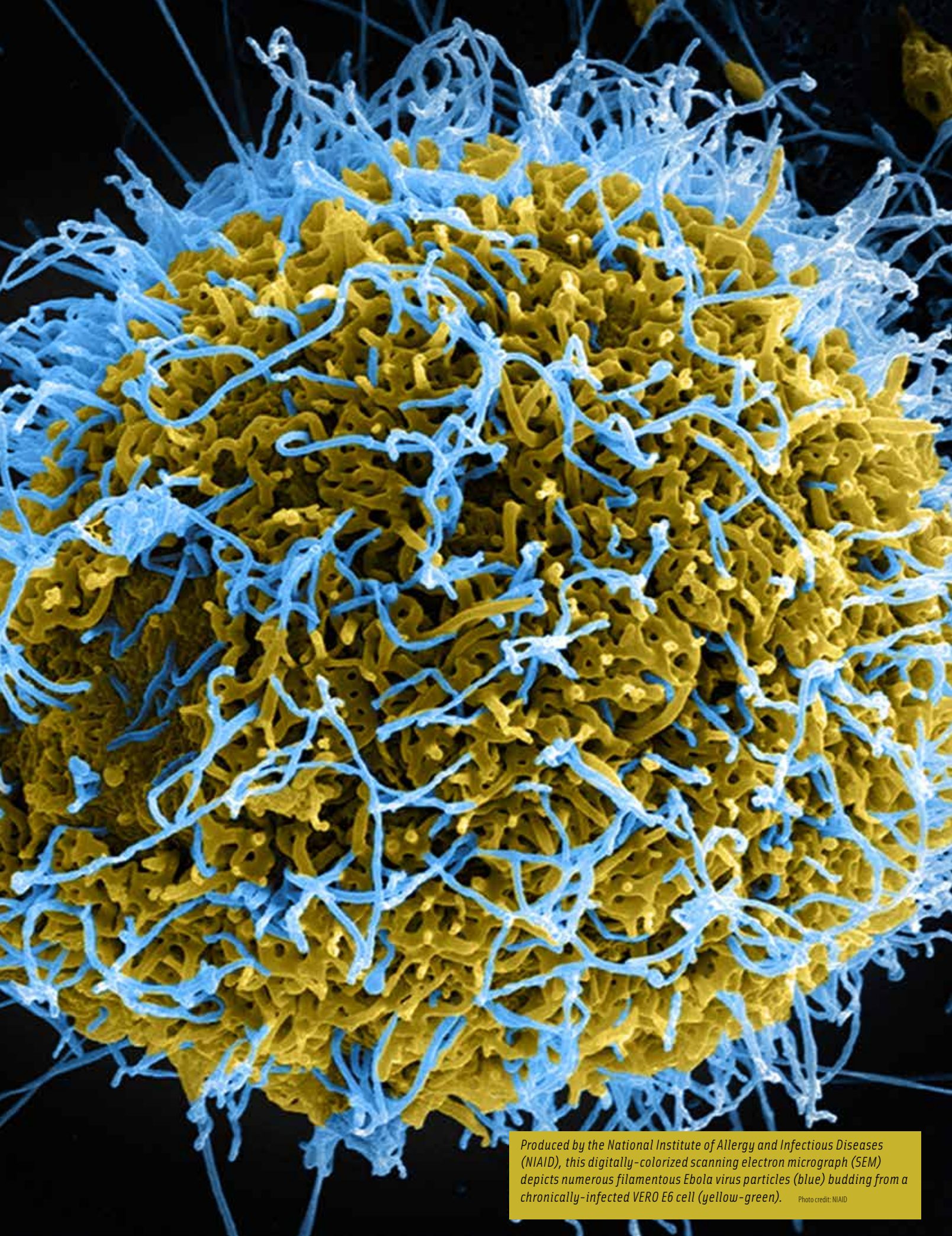
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Produced by the National Institute of Allergy and Infectious Diseases (NIAID), this digitally-colored scanning electron micrograph (SEM) depicts numerous filamentous Ebola virus particles (blue) budding from a chronically-infected VERO E6 cell (yellow-green).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

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.

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}

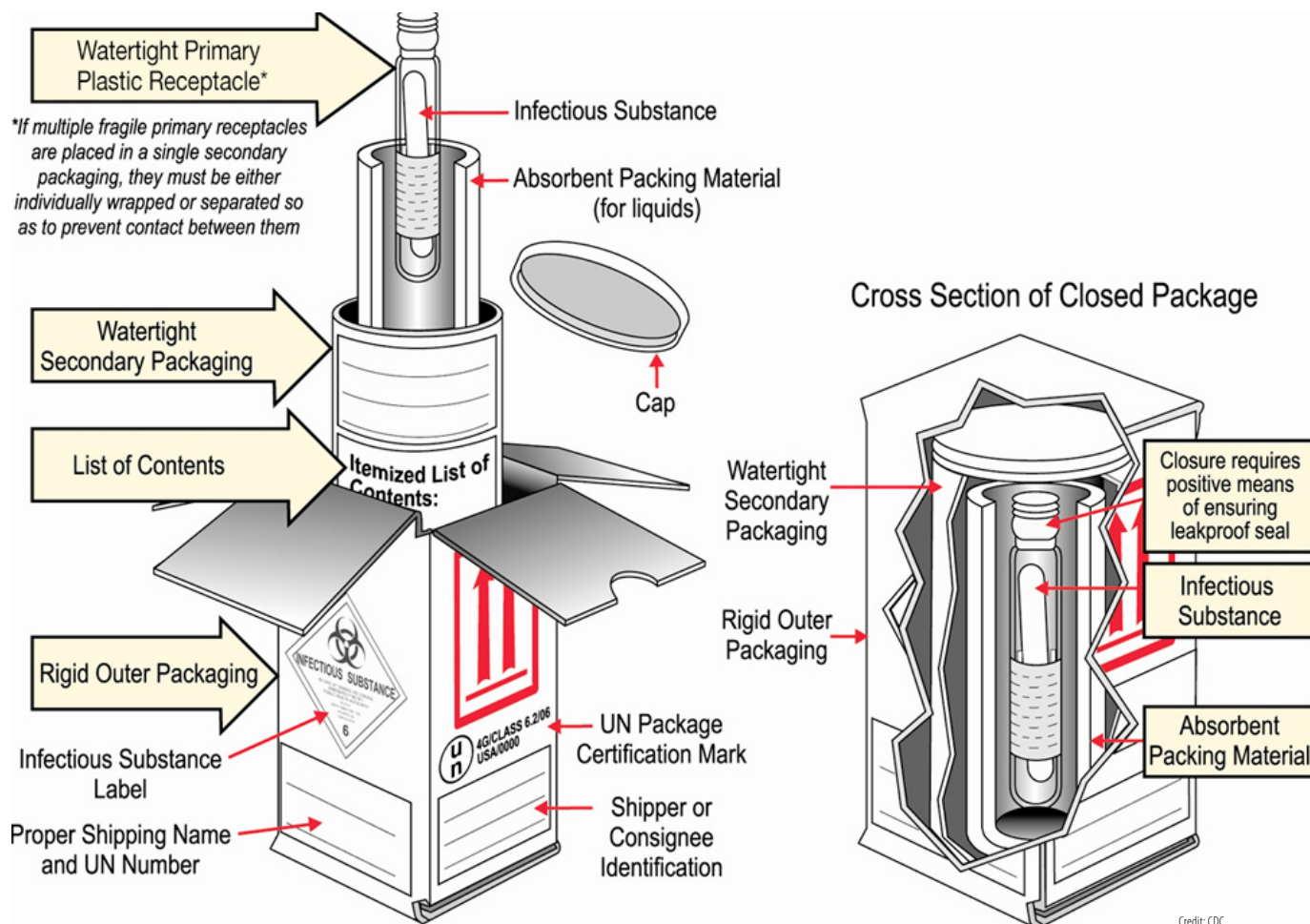
WHY DOES THE OR NEED TO BE PREPARED FOR EBOLA?

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.



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