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Performance of Bedside Diagnostic Ultrasound in an Ebola Isolation Unit: The Emory University Hospital Experience

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Abstract

OBJECTIVE—Individuals with Ebola virus disease, a contagious and potentially lethal infection, are now being treated in specialized units in the United States. We describe Emory University's initial experience, current operating procedures, and ongoing planning with diagnostic ultrasound in the isolation unit.

CONCLUSION—Ultrasound use has been limited to date. Future planning considerations include deciding what types of ultrasound studies will be performed, which personnel will acquire the images, and which ultrasound machine will be used.

Keywords

Ebola; infectious diseases; isolation; ultrasound

The current outbreak of Ebola virus disease (EVD) began in West Africa in December 2013 and is the most widespread and deadliest to date [1, 2]. As of December 2014, more than 20,000 cases have been documented in West Africa and more than 7000 individuals have died as a result of EVD [3]. Additionally, two American health care workers infected with the Ebola virus in West Africa were successfully treated at Emory University Hospital (Atlanta, GA) and were the first known patients with EVD treated in the United States [4]. The Emory University Hospital isolation unit was designed to support the research laboratories and field epidemiologists at the Centers for Disease Control and Prevention (CDC) [5]. Two similar facilities are located at the National Institutes of Health (Bethesda,

MD) and the Nebraska Medical Center (Omaha, NE). Since the current Ebola outbreak began, the CDC has designated an additional 32 hospitals as Ebola Treatment Centers [6]. Ebola Treatment Centers are defined as institutions prepared to treat individuals with EVD for the duration of their illness [6].

Because patients being treated for known EVD are confined to isolation units, imaging is generally limited to portable methods, including portable radiography and ultrasound. Our institution's experience with portable radiography has been described previously [7, 8]. The purpose of this article is to describe our institution's initial experience, current standard operating procedures, and ongoing planning with diagnostic ultrasound in the isolation unit. The article begins with a general overview of the pathophysiology of EVD and concludes with some considerations for radiology departments preparing for the potential ultrasound imaging of individuals with EVD.

Ebola Virus Disease

The Ebola virus was first identified in Africa in 1976 and first reported in 1977 [9]. The disease that results from Ebola virus infection was initially termed “Ebola hemorrhagic fever” but has since been changed to “Ebola virus disease” because most individuals infected with the Ebola virus do not develop bleeding complications.

High fever, body aches, and malaise are often the first symptoms of EVD [10]. By days 3–5, patients typically develop nausea, vomiting, and diarrhea [10]. The resultant large-volume fluid losses and electrolyte imbalances, if untreated, result in multiorgan failure, cardiac arrhythmia, and death [10]. In resource-limited environments, the disease can progress rapidly, with most deaths occurring between days 7 and 12 in the current outbreak [10].

Presently, the mainstays of treatment are supportive care, including fluid and electrolyte replacement [10]. In resource-poor environments, such as parts of West Africa, supportive care may be limited to oral rehydration. IV fluids and close electrolyte monitoring and replacement are necessary for many patients. In the United States, patients with EVD have been supported with mechanical ventilation and renal replacement therapy [11]. The role of diagnostic imaging in the evaluation and treatment of individuals with EVD is yet to be defined.

In addition to supporting individuals with EVD, preventing disease spread to healthy individuals is also critical. Ebola transmission occurs when healthy individuals come in contact with the bodily fluids of individuals with EVD [10]. To prevent the spread of disease, EVD patients are treated by health care providers wearing personal protective equipment [12].

Ultrasound Use in the Isolation Unit

To date, the clinical applications of ultrasound have been limited in our institution's isolation unit. This limited use is due in part to the known pathophysiology of EVD and positive patient outcomes with current supportive care measures. For example, acute renal failure is a known complication of EVD and results from fluid losses due to vomiting and diarrhea.

Because renal failure is a known complication of EVD, it does not prompt an ultrasound examination to rule out hydronephrosis.

Additionally, the relatively limited treatment options available to EVD patients compared with patients not confined to isolation wards may curtail the imaging workup of individuals with EVD. Our infectious disease colleagues only acquire ultrasound images if the information obtained will alter management. For example, to our knowledge, no operating rooms currently exist in the United States that are designed or designated to treat individuals with EVD. Therefore, an imaging workup to establish a surgical indication would be futile if no operating room exists that is capable of caring for a patient with EVD.

To limit the potential spread of EVD, ultrasound images have been acquired by physicians who are highly trained in the appropriate use of personal protective equipment. The images are acquired using a dedicated ultrasound machine that is permanently housed in the isolation unit. To date, the anesthesiology physicians have imaged two patients to guide placement of intravascular catheters. Obtaining a chest radiograph was a multistep, time-consuming process that was performed when necessary and safe [7]. Clinicians comfortable with the use of point-of-care ultrasound were able to evaluate for pneumothorax or hemothorax after central line placement or if there was acute hemodynamic or respiratory decompensation. Evaluating for popliteal and femoral vein thrombosis was also performed when evaluating for causes of shock and hypoxemia.

The floor plan of the Emory isolation unit has been described previously [7]. The unit consists of the patient room that was designed to be capable of functioning as an ICU room, an anteroom where sanitization procedures can take place, and the area outside of the anteroom. The protocol used for cleaning medical equipment that enters the patient room in the isolation unit is as follows [13]:

1. In the patient's room, the nurse should cleanse the contaminated equipment with disinfectant designated by the hospital.
2. Both the patient room nurse and the anteroom nurse are to create disinfectant mats with disposable pads and the disinfectant (200 mL of the solution to 400 mL of water) from the patient's doorway to the storage destination.
3. The room nurse will then roll or hand off the unofficial cleaned equipment to the anteroom nurse, where the nurse will clean the equipment again with disinfectant while wearing full personal protective equipment, similar to that used by waste management.
4. The nurse will cover the equipment with plastic bags and label it as dirty so that it will be further decontaminated with vaporized hydrogen peroxide after the patient is discharged.
5. The nurse will roll or hand off the equipment to the resource nurse outside the anteroom and store it in the designated dirty storage area. The resource nurse outside the room should wear a gown, gloves, booties, and mask with a face shield.

6. The resource nurse outside the room removes the personal protective equipment in accordance with standard operating procedures. The anteroom nurse removes the powered air purifying respirator hood and sets it aside.

Issues for Consideration

When preparing for the possible ultrasound evaluation of an individual with EVD, issues to consider include what ultrasound studies will be performed, who will acquire the images, and which ultrasound machine will be used.

What Ultrasound Imaging Studies Will Be Performed?

As noted, ultrasound images are only acquired if the information gained will alter medical management. Both the natural history of EVD (rapid course typically managed with supportive care) and the relatively limited invasive treatment options available to individuals confined to an isolation ward will result in the performance of a relatively small number of ultrasound examinations in the isolation unit.

Which Personnel Will Acquire Ultrasound Images?

At our institution, to minimize the risk of disease transmission, ultrasound images are acquired by physicians with training and experience using personal protective equipment. Health care professionals also perform other jobs in the isolation unit that are more typically performed by technologists in other settings. For example, the physicians centrifuge urine specimens and analyze them under a microscope as well as perform ECGs and venipunctures.

Informally, at least two infectious disease specialists at our institution have volunteered to obtain just-in-time focused ultrasound training as needed by the patients being treated. They would then use this focused training for imaging patients with real-time feedback from radiologists or ultrasound technologists from the anteroom or the room outside the anteroom. Such limited just-in-time training seems appropriate for relatively simple applications, such as evaluating for pleural effusions or ascites, and perhaps for slightly more complex applications, such as evaluating the gallbladder for cholecystitis or the kidneys for hydronephrosis. Just-in-time training seems appropriate rather than acquiring skills in advance because the latter may atrophy with lack of practice and any imaging tests performed are expected to be rare.

If it is necessary for ultrasonographers or radiologists to acquire ultrasound images in the isolation unit, it is suggested that volunteers be sought. Some individuals in the radiology department may decide to participate in working in a high-containment isolation unit. For example, the isolation unit at Emory is staffed by nurses who volunteer to work in the unit. Informally, at least one radiologist has volunteered to perform ultrasound-guided procedures if the need arises. Such individuals will require just-in-time training in isolation procedures and work under the supervision of infectious disease specialists to ensure that appropriate procedures are followed. Thus, close collaboration between radiology and infectious disease divisions is envisioned.

What Ultrasound Machine Will Be Used?

In our institution, a designated ultrasound machine is permanently housed in the isolation unit. Space may be limited in the isolation unit, so machines with a small footprint may be preferable. Additionally, the cleaning regimens recommended to eradicate the Ebola virus may be detrimental to the longevity of an ultrasound machine. To date, an older ultrasound machine has been adequate for vascular access applications in the isolation unit. Increasingly, more clinicians are being trained to use of point-of-care focused ultrasound. The addition of a lower frequency cardiac probe (typically 2–4 MHz) with a small footprint for intercostal views would offer the benefit of being able to evaluate for volume status, right ventricular function, left ventricular function, pericardial effusion, or cardiac tamponade in a critically ill patient with EVD.

Future Directions

We are in the early stages of Ebola treatment in the United States. Most of the patients being treated are otherwise healthy volunteers who have returned from areas such as Guinea, Liberia, and Sierra Leone. In the future, if individuals are supported longer and if invasive treatment options expand, it may be necessary to perform additional imaging evaluations that would require either scanning by experienced sonographers or radiologists or focused training of the bedside physicians. In addition, if other individuals who are not otherwise healthy volunteers traveling to the more affected countries become infected, it is possible that additional imaging may be required for their other potential comorbidities.

Investment in wireless transmission technology for ultrasound and radiography equipment may be useful so that images can be viewed and interpreted in near real time by individuals distant from the isolation unit. Already, a number of palm-top ultrasound machines have become available and are being used in various clinical settings [14–16]. With dropping prices, it is conceivable that each patient's room in the isolation unit may have a dedicated scanner that never leaves the room, thus minimizing the need for repeated cleaning. Work is under way evaluating protective bubbles that may enable isolation patients to be imaged in CT and MRI machines without contaminating the machines.

In summary, ultrasound use has been limited to date in the isolation unit at Emory University Hospital. Images are acquired by physicians with training and experience with personal protective equipment and using a machine permanently housed in the isolation unit. Because the pathophysiology of the disease is well understood and most patients respond to supportive treatment, the indications for ultrasound in the isolation unit have so far been limited. However, this may change in the future, and it is incumbent on radiologists to collaborate with infectious disease specialists to be prepared to provide advanced ultrasound and other advanced types of imaging to patients with EVD.

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