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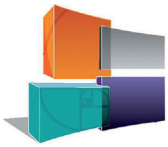

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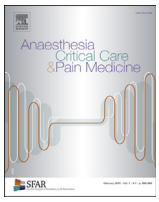

Review

Preparation of an intensive care unit in France for the reception of a confirmed case of Ebola virus infection☆

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ABSTRACT

The current Ebola Virus Disease (EVD) outbreak in West Africa is a major challenge for the worldwide medical community. On April 29th 2015, the World Health Organization (WHO) declared 26,277 infected cases; among them, 10,884 have deceased. The epidemic is still ongoing, particularly in Sierra Leone. It is now clear that northern countries will be implicated in the care of EVD patients, both in the field and back at home. Because of the severity of EVD, a fair amount of patients may require intensive care. It is highly probable that intensive care would be able to significantly reduce the mortality linked with EVD. The preparation of a modern Intensive Care Unit (ICU) to treat an EVD patient in good conditions requires time and specific equipment. The cornerstone of this preparation includes two main goals: treating the patient and protecting healthcare providers. Staff training is time consuming and must be performed far in advance of patient arrival. To be efficient, preparation should be planned at a national level with help from public authorities, as was the case in France during the summer of 2014. Due to the severity of the disease, the high risk of transmission and scarce knowledge on EVD treatment, our propositions are necessarily original and innovative. Our review includes four topics: a brief report on the actual outbreak, where to receive and hospitalize the patients, the specific organization of the ICU and finally ethical aspects.

1. Introduction

The ongoing Ebola Virus Disease (EVD) outbreak in West Africa is due to the Zaire Ebola virus, an enveloped, non-segmented, negative-stranded RNA virus from the *filoviridae* family [1]. Ebola virus, like Margburg virus, is a highly transmissible, category A biothreat pathogen [2]. In this useful classification, A represents the highest risk and highest priority agents, B the second highest priority and C the third highest priority, including emerging pathogens that could be engineered for mass spread in the future. EVD causes fever, headache, gastrointestinal symptoms, diffuse haemorrhage, multiple organ failure and has a high fatality rate.

Ideally, all the deceased patients should have been treated in an Intensive Care Unit (ICU), meaning that at least 41% of the cases would have been admitted to the ICU. Preparation of northern countries for EVD treatment is based on two transmission models. Firstly, certain healthcare workers are involved in non-governmental organizations that help treat infected people [3]. As health workers, they are exposed to contaminated blood and other body fluids. Thus, they are particularly at risk of infection and may develop the disease, either in West Africa or back at home.

☆ This work should be attributed to: The French critical care Ebola response team.

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Secondly, direct dissemination has been limited, despite the occurrence of the outbreak in cities with major commercial airports. During the current outbreak, 16 imported cases of Ebola have been reported in 6 countries (Italy, Mali, Senegal, Spain, the United Kingdom and the United States). Among the latter, 7 died. But due to the incubation period (from 2 to 21 days), it cannot be excluded that some people coming back from West Africa would declare the infection after their arrival in northern countries. Because of the severity of EVD, a fair amount of patients may require intensive care. As recently shown in two reports, renal failure and rhabdomyolysis were frequent in severe EVD cases [4,5]. Common ICU therapy, including fluid therapy and dialysis, would help decrease mortality rates [6,7].

Thus, the preparation of intensive care units in affluent countries is necessary in order to be able to receive a confirmed case of EVD with two main goals: (i) to treat the patient and (ii) to protect the healthcare providers.

The French government has required that our unit be able and ready to receive EVD cases in severe condition. We recently published a picture presenting a dedicated ICU room for EVD patients [8]. In this article, we will detail the preparation of the latter. We purposely decided to limit our presentation to confirmed cases of EVD in the setting of hospital care. Due to the severity of the disease, the high risk of transmission and scarce knowledge on EVD treatment, our propositions are necessarily original and innovative.

2. Current outbreak

The first confirmed case of the current outbreak was declared in March 2014 but it is most probable that the epidemic started in December 2013 [9]. On April 29th, 2015, the World Health Organization (WHO) declared 26,277 infected cases, 10,884 of whom have deceased (41%) [10]. The 2014 EVD epidemic is the largest in history and is affecting multiple countries in West Africa.

3. General considerations

The risk of an outbreak in northern countries seems highly improbable because of the difference in diagnostic and medical facilities and due to the absence of a reservoir. One of the main risks of contamination is contact with an infected patient, repatriated with the disease, be it already declared or not. Healthcare workers are particularly at risk of contamination [11]. To date, no aerosol transmission has been documented, nor transmission following healthy skin exposure. After contamination through human liquids (including saliva, blood, vomit, urine, etc.), the virus spreads in the organism and replicates itself at a high rate [1]. This leads to virus particles in the blood that can be as high as 10^7 plaque-forming unit/mL. The risk of transmission is very high, particularly for the medical teams. One of the goals when receiving an infected patient is to guarantee the best level of protection for healthcare providers. The risk of contamination for laboratory personnel is low thanks to laboratory procedures. To date, 4 accidents during laboratory work with Ebola virus have been reported: 1 case was fatal, 1 case was symptomatic and survived and in 2 cases there was no evidence that the accident resulted in infection and the patients survived [11]. Thus, one can assume the same level of risk for health team members. As recently seen in Spain, despite wearing personal protective equipment (PPE), a nurse was contaminated during the care of an infected patient [12]. In Texas, a delay in EVD diagnosis for a case in the emergency department led to the death of a healthcare worker and fear of several secondary cases [13]. These events underline the importance of hospital organization and the need for informing both public and healthcare workers. The PPEs in use in our centre are fluid impermeable.

According to our experience, there are only two choices available when hospitalizing a confirmed case of EVD: the infectious ward or the ICU. During the preparation of the Begin Military Teaching Hospital, a dedicated access to both the ICU and the infectious disease ward was identified, and a protected way to move a patient from the infectious ward to the ICU implemented. The procedures for corridor decontamination must be known and established. To ensure that healthcare workers are efficient in dressing with the PPE, several training sessions should be planned and supervised by experts (Fig. 1). This implies that the hospital provides wards with a sufficient number of PPEs. Even when they are considered skilled at putting on or taking off their PPE, healthcare workers must proceed in pairs, in order to verify they are not making any mistakes. Particular attention should be paid when undressing, which is the time period most as risk for contamination. Our team was taught how to undress correctly in order to avoid contact with the contaminated part of the PPE. Once the PPE is off, workers must thoroughly wash their hands with alcohol gel.

In the ICU, physical barriers must be in place to prevent visitors or unprotected staff from accessing the high-risk area. This high-risk area should be clearly marked out using coloured panels and stickers. Three kinds of area can be differentiated within the unit (Table 1). There are no clear recommendations concerning the organization of the patient's room, but the following conclusions can be drawn from knowledge from Biosafety Level-4 (BSL-4) laboratories [14]: rooms should be maintained under continuous negative pressure with an increasing pressure gradient from the airlock to the patient room. If possible, the room must include a one-way access or keep forward access. If not possible, a dressing room should be provided close to the patient's room and the

Fig. 1. Staff's training session to dress in personal protective equipment (PPE).