SPECIAL ARTICLE

Evacuation of patients with suspected or confirmed Ebola virus disease

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Abstract: The implementation of protocols for managing suspected or confirmed cases of Ebola virus disease poses organizational and logistic challenges for the whole health care system, affecting professionals, institutions, and citizens alike. Provisions must be made for essential individual and collective preparation of health care staff through education on the nature of the infective agents and training in the use of personal protective equipment. The use of isolation equipment, such as negative-pressure capsules, for evacuating patients infected with an Ebola virus will allow health care workers to reduce their level of personal protection and improve patient management.

Keywords: Ebola virus disease. Personal protective equipment. Evacuation. Isolation capsule.

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Article information:
Received: 9/29/2014
Accepted: 12/30/2014
Online: 4/17/2015

Evacuación de pacientes con sospecha o confirmación de enfermedad por el virus del Ébola

Resumen: La implantación de protocolos de gestión de casos sospechosos o confirmados de enfermedad por el virus del Ébola plantea retos organizativos y logísticos para el conjunto de la cadena sanitaria, tanto a nivel del profesional como de la organización y del ciudadano. Resulta fundamental la preparación individual y colectiva del personal sanitario mediante la formación y el entrenamiento en el uso de los equipos de protección individual y en el conocimiento de este tipo de agentes. El uso de medios de barrera para la evacuación de este tipo de pacientes como son los dispositivos de aislamiento con presión negativa permite reducir el nivel de protección individual del personal mejorando la gestión de este tipo de pacientes.

Palabras clave: Ébola. Equipo de Protección Individual. Evacuación. Cápsula de aislamiento.

Introduction

On March 23, 2014, the Minister of Health of Guinea notified the World Health Organization (WHO) of an outbreak of Ebola virus disease (EVD) in the southeast of the country[1]. Given the extent of the outbreak in Liberia, Sierra Leone, Nigeria and Senegal, and the difficulty of controlling it, the WHO adopted two decisions: first, establish the criterion of not closing borders or air routes which would prevent the arrival of international aid[2,3]. And second, declare a public health emergency of international importance for channeling aid and combat the epidemic[4,5].

The first measure, despite its positive nature, could allow a traveler, infected or not, but with symptoms consistent with EVD, to reach Ebola-free zones despite established surveillance measures[6-9]. In addition to this, due to the existence of expatriate cases, countries like the US, UK, Germany and Spain carried out missions of air evacuation of patients with suspected or confirmed EVD[10-13]. These missions have tested the coordination and capabilities of health, civil and military systems, to attend such events[14].

To manage these potential cases, protocols were established including case definition, waste management, the notification procedure, the management of diagnostic specimens and infection control measures in health centers[15].

In order to reduce the chance of infection during ground or air evacuations, transport isolation chambers were used, also called evacuation pods, with negative air pressure for the isolation of individuals, as they improve safety in the evacuation and at the same time allow patient care processes. The aim of this paper was to show the possibilities of evacuation pod use in patients affected by Group 4 biological agents, such as Ebola virus, but also for Group 3 which also require special measures to control infection.

Management of patients with suspected or confirmed Ebola virus disease

To avoid the disastrous social and economic consequences of the spread of the epidemic in West African countries[16,17], the arrival of a suspected case in neigh boring countries with strong public health systems raises important organizational and logistical challenges to control the possible source of infection. These potential imported cases challenge the health system as a whole, including primary care, hospital and outpatient care, since the symptoms of patients

who seek healthcare or that are detected in the early stages, are non-specific. Therefore, one has to activate the protocol using epidemiological or clinical judgment while waiting for laboratory test results inorder to reduce the risk to attending health workers and possible contacts[18-22]. So, in the case of Spain and in the current situation, ministries of health recommend, before heading to any health centers, notifying the emergency medical services to activate the system without putting the healthcare chain at risk[23].

This is because the Ebola virus, along with other filoviruses as well as arenaviruses, nairoviruses or poxviruses are included in group 4 biological agents (Royal Decree 664/1997). If a patient suspected to be infected with a group 4 (or group 3) virus attends a healthcare center, maximum precautions must be taken to prevent infection of the disease with serious consequences for public health[24].

In this regard, however complete these protocols may be, if medical personnel are unaware of them or do not apply them, secondary cases can occur. Hence, the main challenge for the public health system is that health workers know these agents and the protocols to be applied in the event of an epidemiological alert. The WHO has highlighted the large number of health workers affected by Ebola, considering lack of preparation to underlie failures in infection control measures. The problem is not only due to the lack of scientific knowledge, but the lack of practice in the use of personal protective equipment (PPE) due to existing shortages, coupled with the heavy workload[25].

Therefore, at the slightest suspicion that a patient is affected by an agent of group 4 (or group 3), health workers must take the appropriate precautions of physical protection, individually, both physical (waterproof coat, boots or boot / shoe covers, facial mask or goggles, double gloves) and respiratory, depending on their activity[26-28].

The level of respiratory protection is under debate in relation to the proportionality of means and resources when comparing cases in Africa and in our environment, highlighting as unnecessary the excessive measures of healthcare staff protection against a non-respiratory transmission disease, a fact that may increase the perception of risk in the population[29-31]. The determining factor in choosing a type of respiratory protection is the activity to be performed and the work environment, since it is not the same to be in indirect contact with patients as to perform aerosol-generating medical procedures[10,32]. For the management of these patients, healthcare workers should use at least FFP2 autofilter masks[10,33].

These activities in hospitals may be predictable, but not in the out-of-hospital setting, so it seems reasonable to suggest that emergency medical service (EMS) staff should increase the level of respiratory protection and use FFP3 masks, provided they are not dealing with negative pressure isolation devices, since it is not known whether aerosols are generated on the way to the health reference center.

Regarding the protective uniforms (category III of course), they should be made with tear-resistant material, preferably impermeable to liquids under pressure (type 3b) or impermeable to sprays (type 4b), leaving splash-proof suits (type 6b) or those impermeable to solid particles (type 5b) for very specific activities[34]. The use and availability of both internal and external hoods, eye protection such as goggles or masks and limb-protection will depend on the established protocol and procedure to be performed.

For the protection of the lower extremities, one can use boots, pants or waterproof boot covers, considering that they should be made from durable material, and if possible with the sole reinforced to prevent rapid deterioration due abrasion (Figure 1).

Staff will need to use double gloves (latex or nitrile) as a barrier against infection. They must be sterile for some clinical procedures (attention to those allergic to latex)[10]. Triple layer gloves may reduce the risk of contamination transfer between activities. If neoprene, butyl or other material is selected, they should be disinfected with each change of activity.

In relation to the use of duct tape to increase tightness, bear in mind that it may hamper the removal of PPE when done alone. Help may be necessary to remove the PPE without damaging the protective gear.Sometimes it may be necessary for the user of the PPE to be helped to remove it by auxiliary personnel, whether in emergencies (fainting, heat stroke, anxiety attacks, etc.) or not. These scenarios imply that the PPE should be removed from the back not the front of the user, by cuts in trouser legs, sleeves and torso protection, avoiding the generation of aerosols. Availability of PPE is clearly essential but so is training and practice in using the equipment (Figure

Figure 1. Personal wearing personal protective equipment (PPE) (Ministry of Defence).

Figura 2. Practice evacuation of a patient with suspected Ebola virus disease (EVD).

2). Proper positioning is important and very careful removal is required to avoid risk of infection[35].

Importantly, as is being demonstrated in Africa, precautionary measures not only concern the medical staff, but include all persons who have been or may be in contact with the infected person. However, there are many cultural and social differences that make an expansive outbreak unlikely in Spain, since the consumption of monkeys or bats is virtually unheard of and we do not hide our patients at home, nor do we have the same funeral rites. In fact, our health hygiene education helps us in a culture of prevention to break the infection cycle of biological agents transmitted by direct or indirect contact with secretions[36,37].

Hence the dissemination of basic information on the necessary precautions, not only to health workers but also the general public, constitutes a priority for infection control. For that purpose, we should establish appropriate communication policies to inform the general public about signs and symptoms, who to call or where to go in case of doubt in order to combat and control any outbreak. This constitutes a vital prevention measure to avoid the possibility of health centers being visited by citizens seeking help. Proper health messages prevent a distorted picture of reality that can degenerate into a state of alarm, most often unfounded, when the media and social networks emphasize the lack of preparation to attend such cases[38].

In relation to cases of infection by agents of group 4 in general and EVD in particular, the organization of health care centers for patients who arrive by their own means is an important challenge. It includes establishing a triage area (where the staff assigned to this task performs a preliminary assessment of the patient, based on epidemiological or clinical judgment, and establishes whether or not there is a suspected case), and the activation of observation and isolation areas for patient care. This, which may entail high logistical complications in hospitals, may be even more difficult in primary care centers due to fewer available resources and personnel.

Proper management of a suspected or confirmed case includes strict isolation, and notification, according to the procedure established by the public health service, who shall decide on transfer to a reference healthcenter. Strict isolation is essential to prevent nosocomial spread of diseases such as viral hemorrhagic fevers, plague and smallpox, which may be sufficient and necessary in those circumstances, but when the epidemiological situation so requires, it may be necessary to have separate places for casessuch as designated health centers, gyms, stadiums and even homes, instead of placing them in special rooms with negative pressure[39].

To reduce the risk of infection, all the material, tools and equipment in contact with suspected or confirmed cases of diseases caused by agents of groups 3 or 4, and particularly EVD, including their secretions, should be considered as contaminated and therefore be treated properly, either by disinfection or discarded as waste according to contaminated waste disposal protocols.

Bedding and clothing material as well as healthcare material that is not for single use must be disinfected in accordance with procedures that ensure inactivation of the agent, either by physical disinfection by autoclaving or chemical disinfection with disinfectant solutions of sodium or calcium hypochlorite and other authorized disinfectants[40].

The remaining single-use materials and equipment, including PPE, are considered hazardous group 1 Class III waste and must be disposed of as such[41,42]. In the hospital setting this is easy to implement using standard rigid containers, bit in out-of-hospital contexts it may present major logistical and operational complications of having to transport the waste to adesignated base or health center. Therefore, to reduce the possibility of contamination of surfaces and equipment, ambulance interiors in contact with the patient should be protected (wrapped) in plastic or similar material as a barrier to prevent contamination transfer.

Another vital aspect of proper management of these patients is that biological samples are considered to fall within Class 6.2, as infectious substances for humans according to the UN classification and identified with the number 2,814. Depending on the mode of transport, samples should be packed according to specific procedures outlined in national and international transport regulations[43].

Transportation under biocontainment conditions

Large-scale evacuation in cases of transmissible diseases, by analogy with intentional biological incidents, can complicate the epidemiological situation

Figure 3. Repatriation of a patient (Ministry of Defence).

and increase the number of secondary cases. However, small-scale evacuation when preventive measures are taken can be considered on condition that the movement of patients is the minimum necessary to provide treatment and care[39].

The organization and management of a land or air evacuation of patients with diseases caused by biological agents of group 3 and 4, as with suspected or confirmed cases of EVD, presents challenges that

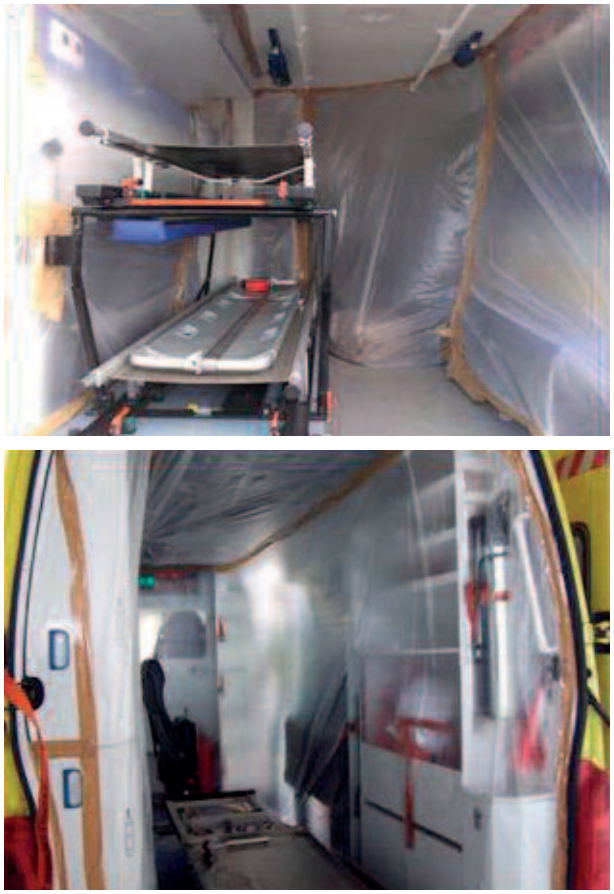

Figure 4. Military (above) and civil ambulance (bottom) with plastic covering.

Figure 5. Negative pressure isolation capsule with combined filter.

necessitate activating special resources for transport, where vehicles and staff are prepared specifically either using vehicles specially designed for this function or vehicles with plastic lining of the inner surfaces or barriers between the patient, the cab and the staff to reduce the risk of infection such as isolation capsules or transport and evacuation chambers with negative pressure (Figures 1, 3, 4 and 5)[44].

Patient preparation is vital when using this type of resource, since once the capsule is closed, the possibilities of interaction with the patient are greatly restricted. Sensors for monitoring proper catheterization must be placed or, if that is not possible, a diaper should be used. At physician discretion, premedication may be prescribed (antiemetics, tranquilizers, sedatives, etc.) to keep the patient stable during the evacuation[44,45].

The use of these resources reduces the risk of secondary infection and therefore the level of individual physical protection of personnel responsible for the care and transportation of patients affected by diseases caused by biological agents of group 4, including EVD, as long as the capsule or chamber remains closed.

These capsules or chambers with negative pressure means they can be used to transport patients with transmissible diseases, where the danger is inside and not outside. For this reason the air outlet is filtered in contrast to isolation chambers at atmospheric pressure or positive pressure used in NBC incidents where incoming air is filtered, since the danger is outside and not inside[46].

Although there are many commercial solutions to meet the needs of medical transportation with biocontainment, all are made with plastic material, generally transparent to allow visualization of the patient by medical personnel and for the patient to see outside, so reducing any anxiety produced by being in a confined space. Usually they operate independently with batteries or they are connected to the power supply of the vehicle or the network; generally they have a rigid

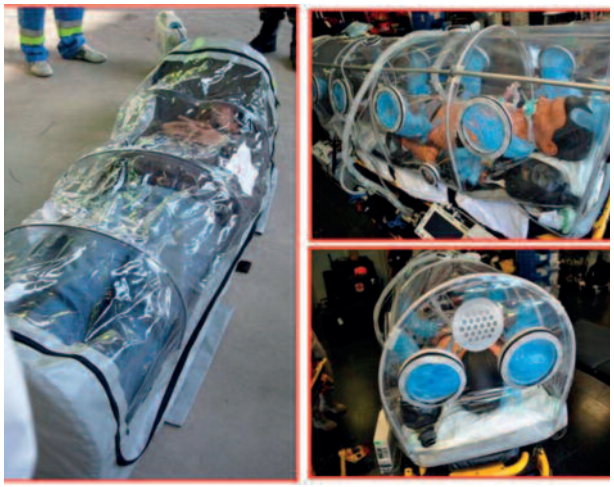

Figure 6. Negative pressure isolation capsule with HEPA filter.

structure which prevents collapse when the vacuum system is activated; the negative pressure is obtained with one or more motorized units that extract air from inside and pass it through a filter to ensure it is expelled free of contamination. One can attach different types of filters (if possible with standard thread), from combined filters (against gases and particles with a membrane filter), mechanical membrane against particles (P3 with a retention efficiency of 99.5 % against solid aerosols and highly toxic and radioactive liquids)[47-49] or HEPA filters - High Efficiency Particle Arresting (with a retention efficiency of 99.97% for particles of 0.3 microns or greater) (Figures 6 and 7)[50].

The capsules should be designed bearing in mind consider the means of evacuation since the useful space in an ambulance is not the same as the space available in an aircraft. The total length of the capsule must not exceed that of the stretcher, to which it is integrally attached.

The capsules usually have an interlock system that allows the introduction of material from the outside without changing the interior pressure. This is achieved by creating a physical space between the inside and the outside using a double seal bag (Figure 7). If this is not incorporated in the design, the introduction of material requires tearing a glove (Figure 8). Another glove, fitted into the first with the material or equipment, is fixed to the structure to prevent leakage from the interior. Thus the seal is not broken and the material can be introduced into the capsule. If this procedure is not used, one cannot open the capsule to introduce anything into it.

For the same reason the capsule must be fitted with locking system ports that allows introducing tubes, cables, or any other device necessary for the patient, and a bag where corresponding report sheets are placed. Ideally, all monitoring cables, lines, etc. have a system of engagement or attachment to the structure to prevent possible contamination risks (this is necessary in the design and length of the sensor cables, etc.) (Figures 5, 6 and 7).

It is desirable that the capsule design allows natural movements of staff for which gloves are provided in strategic locations for better interaction with the patient. These should have a removable attachment system to the structure using rubber bands, tape or clamps to allow easy removal and change of

Figure 7. System of locks for introducing or extracting material.

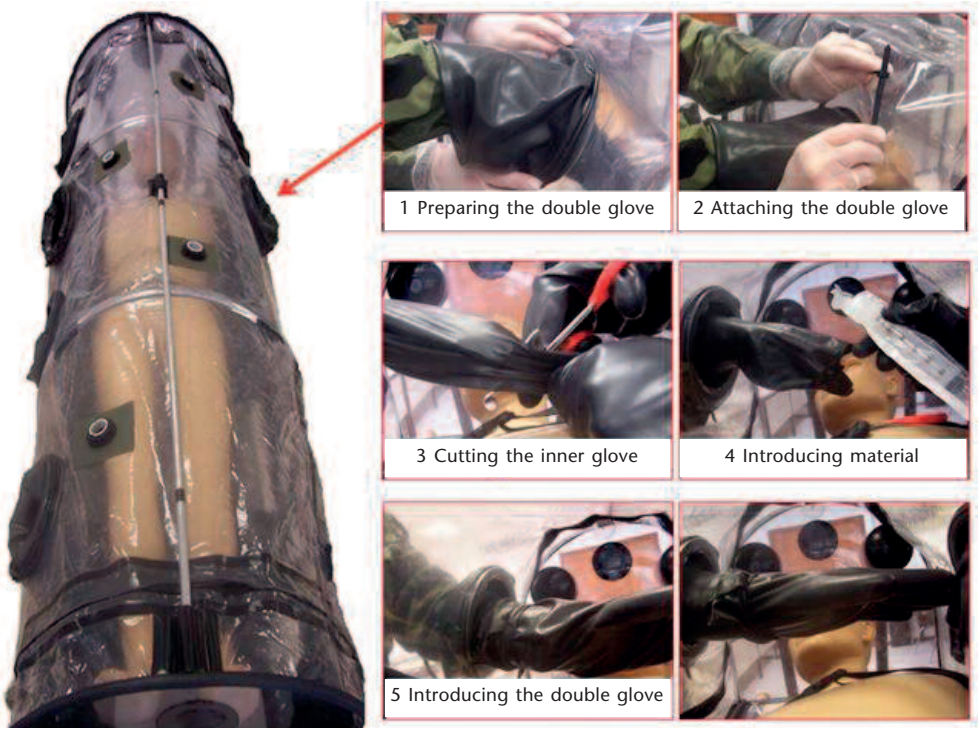

Figure 8. Introducing material in the capsule.

gloves when so required. Similarly, the design must take into account patient introduction maneuvers, but also patient extraction from the capsule, having a zip-closure system that ensures the seal (Figures 5, 6 and 7).

A primary requirement is that they are designed and manufactured so that the capsule and its motorized system can be decontaminated in accordance with standard procedures and then reused (as opposed to filters which should be managed as hazardous waste).

Conclusion

Management protocols for confirmed or suspected cases of infection by agents of group 3 and especially group 4, such as Ebola virus, can improve the management of suspected or confirmed cases. Knowledge and compliance with established protocols reduces the risk of infection throughout the healthcare chain, avoiding errors that can generate the appearance of secondary cases.

Proper training and practice in the use of PPE, both physical and respiratory, can reduce the risk of infection for health workers. The use of isolation capsules with negative pressure reduces risk and thus the level of individual protection of personnel involved in air or land evacuation of suspected or confirmed cases of highly transmissible group 3 diseases, but mainly group 4, including Ebola virus. The ergonomic design, the possibility of autonomous operation by batteries, the existence of locks for the introduction of materials or equipment, along with the placement of protected ports and rigid physical structure are aspects of design that must be taken into account when choosing this type of device.

The management of patients with suspected or confirmed Ebola virus disease involves an organizational challenge for the health sector as a whole, from the prehospital to hospital phase, as well as primary care, and this requires coordination between the different actors. Patient preparation is a critical task to consider when barrier methods are used, such as evacuation capsules, in transporting patients with suspected or confirmed EVD.

Conflict of interest

The author declares no conflict of interest in relation to the present article.

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