Aeromedical Evacuation Using an Aircraft Transit Isolator of a Patient with Lassa Fever

Eric Lotz and Hervé Raffin

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Background: Lassa fever is a viral hemorrhagic fever only present in West Africa. The mortality rate is 1% and may reach 15% among hospitalized patients. Transmission between humans is mostly due to direct contact with infected body fluids. Aeromedical evacuation of patients with viral hemorrhagic fevers (such as Lassa fever) demands strict isolation measures. Only a few cases of such evacuations have been reported in the literature during the last 40 yr. The use of an aircraft transit isolator device could be helpful. ***Case Report:*** We report the aeromedical evacuation of a confirmed Lassa fever patient from Sierra Leone to Sweden with a dedicated air ambulance using an aircraft transit isolator. The patient was a 30-yr-old physician working for a nonprofit organization. The patient contracted the disease working with infected hospitalized patients. The duration of the mission between activation and arrival at the Swedish hospital was 36 h, which is within the World Health Organization recommendations. ***Discussion:*** Evacuation of patients with potentially lethal contagious infections is possible, but only with strict isolation measures. Specific protective equipment and isolator are mandatory. Medical and technical crews performing such evacuations should be trained in proper equipment use and the isolator should first be used with a low-risk patient to create minimal risk transport conditions.

Keywords: air transfer, viral hemorrhagic fever, high-risk infectious disease, public health, air ambulance, isolation measures.

LASSA FEVER IS A viral hemorrhagic fever only present in West Africa (1). It is caused by an arenavirus and the natural host is the multimammate rat *Mastomys natalensis* (2). This viral disease was first described in 1962 in the Nigerian village of Lassa (3) and the virus was isolated in 1970 (4). The transmission between humans appears after direct contact with bodily secretions (blood, urine, vomit, feces) of a person with Lassa fever. Aerosol transmission is also possible (5).

The duration of incubation is between 6 and 21 d. The first clinical signs usually appear 6 d after infection and are not specific (2): high fever, arthromyalgia, pharyngitis, headache, abdominal pain, nausea, and vomiting. In severe cases facial edema, diffuse hemorrhage (mouth, nose, vagina, intestinal tract), pleural and pericardic effusions, encephalitis, and seizures appear. Since Lassa fever infections are difficult to distinguish from other viral hemorrhagic fevers such as Ebola and Marburg (**Table I** shows the difference between Lassa, Ebola, and Marburg fevers), definitive diagnosis requires specific laboratory tests: detection of antigens, antibodies, and by using virus isolation techniques (6). The mortality rate is 1% and can rise to 15% among hospitalized patients (2) due to multiple organ failure. The antiviral drug ribavirin is effective treatment for Lassa fever (7). The role of ribavirin as post-exposure prophylactic treatment for Lassa fever has also been discussed (8) and not recommended by the World Health Organization (2).

The first medical evacuation of a patient with Lassa fevered occurred in 1970 when a missionary nurse was evacuated from Lagos to New York City in the first class cabin of a commercial Boeing 707 aircraft. No specific isolation measures were employed. Fortunately there was no evidence of secondary cases among other passengers and crew. The first aeromedical evacuation of a patient with Lassa fever on board a dedicated air ambulance using proper isolation techniques happened in 1974 (9). In 1977, aircraft transit isolators were used by the Canadian government to transfer patients suspected of Lassa fever (10). Finally, there are only a few cases of aeromedical evacuation of those patients reported in the literature and some did suggest use of only contact isolation techniques (11). Even if the risk of secondary transmission of Lassa fever during a flight seems low (12,13), this risk should be avoided for the crews or other passengers of a commercial flight. We report the aeromedical evacuation of a nonprofit organization member with confirmed Lassa fever using a dedicated air ambulance and aircraft transit isolator (ATI) from Sierra Leone to Sweden.

Closed-systems isolators have existed since the 1970s in the medical field and were designed based on veterinary experience in animal laboratories (14). During the last 40 yr, both static isolators meant to be used in hospital facilities and transport systems have been designed. Isolators can be used to prevent the infection of a fragile patient (e.g., aplastic patient) or to prevent the spread of contaminating microbes from an infected patient (e.g., patients infected with multi-resistant bacteria or with a high-risk infectious disease). Transit isolators can theoretically be used with all means of transportation: ambulance, commercial aircraft, and dedicated air ambulance. Considering the risk, some commercial airlines may be reluctant to have such devices on board.

From Medic'Air International, Bagnolet, France.

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Address correspondence and reprint requests to: Eric Lotz, Medic'Air International, 35 rue Jules Ferry, 93170 Bagnolet, France; lotzeric@gmail.com.

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TABLE I. DIFFERENCE BETWEEN LASSA, EBOLA, AND MARBURG FEVERS.

	Localization	Reservoir	Treatment	Mortality
Lassa	West Africa: Guinea, Liberia, Sierra Leone, Nigeria	Multimammate rat (*Mastomys natalensis)*	Ribavirin	1% overall; 15% among hospitalized patients
Ebola	Côte d'Ivoire, Democratic Republic of Congo, Gabon, Sudan, Uganda	Gorillas and chimpanzees	No specific treatment	65%
Marburg	Angola, Democratic Republic of Congo, Kenya, South Africa	Unknown	No specific treatment	80%

The transit isolator we used consisted of the following: a transparent flexible plastic envelope enclosing the isolated space with an integrated mattress; a means for manipulating within the space (two pairs of gloves integrated to the walls); a ventilation system through filters at each side of the isolator (a pump injected air filtered by cartridges at the patient's head and non-return valves let out the air through cartridges near the patient's feet); and sealed outputs for the passage of cables and pipes. The isolator opened and closed with a sealed zipper. For technical reasons, the pressure inside the chamber was higher than the atmospheric pressure and air was filtered at its output. This is a contrast to hospital isolation rooms where the atmosphere is at lower pressure than the ambient conditions, allowing a flow of air from outside to inside. The pressure variations (including at the descent) could be corrected by increasing or decreasing the pump flow. Pump and filters were provided separately from the isolator.

CASE REPORT

The patient was a Swedish 30-yr-old woman without past medical history working as a physician in charge of patients hospitalized with Lassa fever in Sierra Leone. On February 26, 2011, she presented with a fever (38°C/100.4°F), watery diarrhea (five stools a day), and headache. The fever disappeared on March 1, but reappeared on March 3. The diagnosis of Lassa fever was indicated by a positive rapid test and further confirmed by a positive ELISA assay. The patient was transferred from the reference center at the "Lassa Unit" of Kenema Hospital in Sierra Leone. Upon admission, she complained of headache, weakness, and abdominal pain. The clinical examination revealed: temperature at 38.4°C (101.1°F), blood pressure at 110/70 mmHg, heart rate at 88 bpm, and respiratory rate at 24 per minute. Her general condition was good. Her abdomen was soft. There was no sign of viral hemorrhagic fever complication: no bleeding, no shock, no pleural or pericardic effusion, no sign of encephalitis, and no seizures. The clinical state of the patient remained stable until repatriation.

The reference treatment was established with intravenous ribavirin upon admission on March 4, with a loading dose of 30 $mg \cdot kg^{-1}$, followed by a maintenance dose of 15 $mg \cdot kg^{-1}$ every 6 h, associated with ceftriaxone. The organization in charge of the patient decided to arrange as soon as possible her aeromedical evacuation to her home country, Sweden. After contacting several air ambulance companies, it appeared that only Medic'Air International had the resources and expertise to perform this evacuation quickly in optimal security conditions for the patient and the various stakeholders (including medical staff and pilots).

Medic'Air was contacted on March 5 at 11:00 (Paris time) and the mission was confirmed the same day at 15:20. The medical team on alert, composed of an emergency doctor and a registered nurse, both with previous experience in air ambulance transport and trained on use of the proper support equipment, was activated immediately. The support equipment was prepared jointly by the medical regulation team and consisted of standard resuscitation and monitoring material, as well as protective equipment for high-risk infectious pathogens: intervention hoods with positive pressure, protective clothes, and the ATI. Meanwhile, the receiving hospital in Sweden contacted the Linköping airport authorities so that the plane could land at anytime, as it was usually closed at night. French health national authorities are also aware of our procedures for transporting high-risk infected patients and each high-risk evacuation is declared to the aviation authority.

The dedicated air ambulance of Medic'Air, a trijet Falcon 50, took off from Le Bourget airport (Paris, France) at 20:00 to be on standby at Dakar, Senegal. After a pilot rest of 12 h and transport of the patient via ground ambulance during the daytime to Freetown airport (Sierra Leone), the aircraft took off to meet the patient on the tarmac of Freetown at 16:00 (Paris time). She arrived with protective outfits (contact and respiratory isolation) after 6 h transport in the ground ambulance. The medical team then donned their protective equipment to take charge of the patient. The positive pressure hoods were used during the first examination of the patient, her installation in the ATI, and then kept nearby in case of a broken ATI seal for the duration of transport.

Patient clinical state had remained stable since her admission at Kenema hospital. Her Glasgow coma scale was 15, blood pressure was 116/68 mmHg, heart rate was 76 bpm, and respiratory rate was 19 per minute. Despite fatigue and abdominal discomfort, her clinical condition was reassuring. The medical team installed the patient on the tarmac in the ATI, then loaded the stretcher on board the aircraft (**Fig. 1**). During the flight, the clinical state of the patient was continuously checked by the medical team, who provided care (including administration of intravenous ribavirin) using gloves included in the wall of the ATI, ensuring the continued integrity of the isolation condition.

Fig. 1. Loading the patient on board the aircraft.

The plane took off from Freetown shortly after 18:00 (Paris time), 2 h after it had arrived, and landed at Le Bourget at midnight for a technical stop (refueling). During this stop, the patient stayed in the isolator. The plane reached its final destination at 03:00 at Linköping airport, Sweden. A team from the University Hospital was waiting for the patient to transfer her to a negative pressure room of the infectious disease ward. The University Hospital of Linköping is part of the European public health plan EUNID (European Network of Infectious Diseases). The patient, after treatment at Linköping hospital, returned home completely cured of infectious disease.

DISCUSSION

The aeromedical evacuation of patients with high-risk infectious disease requires a perfect coordination between various private and public institutions. The availability of equipment, procedures, and specific expertise is essential to achieving safe transport of these patients (15). We had on two previous occasions used an ATI for transporting patients with multi-resistant bacteria (16).

A dedicated long-distance air ambulance with a power supply (necessary as a backup for the isolator pump batteries) can respond immediately to any such request without having to deal with the understandable reluctance of private airline companies who are not familiar with the medical requirements for isolation transportation. The rapid provision of protective materials (pressured hood, ATI) can minimize the potential spread of pathogens. Full coordination and cooperation with national and international health authorities will ensure quality and professionalism when transporting patients under isolation conditions. Each transport case may comprise a specific pathogen/pathology. In such cases, the ATI is one beneficial tool to ensure patient and operator safety.

The decision to evacuate this patient, since she recovered uneventfully, warrants further discussion. The decision process is always a consideration of the benefit and risks for the patient and the crews in charge of the evacuation. In this specific case, the patient was diagnosed with a potentially lethal disease (Lassa fever) with an existing specific treatment (ribavirin) that was started in time and her prognosis was therefore good. Due to the requirement for an ATI, which results in a low ability to perform complicated patient care procedures during the flight, it was important that she remained stable. That is why repatriation was organized as soon as possible, before complications appeared and she would no longer be able to fly. It was important to be in Sweden at the time such complications might appear, since the level of care needed to treat them efficiently was not available in Sierra Leone.

This decision meets the latest WHO recommendations for medical evacuation of patients with high infectious risk (36 to 48 h) (workshop on exposure management and evacuation of WHO/GOARN staff during field investigations of highly infectious diseases, February 2011, Istituto Nazionale per le Malattie Infettive, Roma, Italy). The total duration of the mission, between activation and the arrival at the Swedish hospital, was exactly 36 h. After this high-risk evacuation, it was necessary to complete our procedures for the transportation of contagious patients infected with high risk pathogens such as viral hemmorhagic fevers. What we learned is detailed below.

Before beginning a mission, it is important to consider the specific material to put inside the ATI, since it will be impossible to open it once it is sealed and in use. These materials include consumable medical supplies, feces and urine containers (we used a system for solidifying human fluids, thereby reducing the risk of accidental contact), and food and drink appropriate for the duration of the flight. We are working with the manufacturer of the isolator to add an airlock to be able to transfer some medical items inside the ATI during the flight.

Since there are pass-through areas available for infusions in the wall of the ATI, drugs can be administered from outside, but all the other procedures have to be performed with gloves. Due to the difficult work conditions and the limited space associated with these conditions, it would not be possible to take in charge an unstable patient and complicated procedures are not possible. To ensure that the outside of the ATI was not contaminated during the installation of the patient, the crew could augment the described protocol with surface disinfectant spray (not used during this evacuation). In case of a hole or leak in the ATI, the crew must put on their protective clothes and positive pressure hoods and apply a specific adhesive patch (prepared with the transit isolator) on the leak.

Once the patient arrives safely in the negative pressure chamber, the contagious nature of the materials that have been in contact with the patient remains. Even if secondary transmission of Lassa fever is mostly due to contact with body fluids, it is necessary to have a specific disposal plan in place for any material that could facilitate the spread of the virus. For this purpose, the procedure we followed was:

- The ATI was considered a single-use item, which has subsequently been incinerated by the Swedish team after the transfer of the patient;
- Incineration of the protective outfits, hoods, and medical consumables present in the ATI;
- Disinfection of the cabin of the aircraft and medical equipment with Nocolyse spray (hydrogen peroxide, catalyst, biosurfactant) after conclusion of the mission; and
- Use of ribavirin prophylaxis was not considered for crewmembers (7), but close monitoring of the crew after the mission (fever, gastrointestinal symptoms) was performed.

Since the procedures to perform this kind of mission are complicated, appropriate training of the crew is mandatory. We think that a company who wants to use an ATI should begin by transporting low-risk patients in order to establish proper procedures regarding its specific constraints and materials.

The aircraft transit isolator is an interesting tool to organize the transfer of infected patients, but is not the solution to all the problems that will be encountered transporting patients infected with high-risk infectious pathogens. It is a good solution for stable patients, but not appropriate for unstable patients requiring complicated procedures during flight. Larger isolators could be considered, but the technical challenges would be much more difficult to deal with, requiring larger aircraft like the Hercules C130. Such capability is far from what most assistance companies have available.

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Authors and affiliation: Eric Lotz, M.D., and Hervé Raffin, M.D., Medic'Air International, Bagnolet, France.

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