

## Special Article - Ebola Virus Disease

## Ebola Patients Air Evacuation in Isolation Bubble

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## Abstract

For the past five years Medic'Air Int'l Doctors have been working to improve an internal process: Biorisk Air Transport (B.A.T.) for any request of evacuation of contagious patient needing isolation. During 2015 & 2016, Medic' Air performed with success air evacuations of five Ebola patients from West Africa to hospitals in North and Western Europe in a twinjet air ambulance using this process and isolation bubbles.

**Keywords:** Lassa; Ebola; Marburg; Hemorrhagic fevers; Air ambulance; Medevac; Air transit isolator; Biorisk air transport; Isolation bubble

## Introduction

Air evacuation for patients with highly contagious disease is a real challenge to perform with several levels of difficulties: political, logistic, financial and medical.

Medic'Air International realizes medical evacuations, mainly from Africa since more than 25 years. We progressed in this regard now with a well-defined process for evacuation of patients with hemorrhagic fevers: Ebola, Lassa (and Lujo) and Marburg.

## Objective

Aware of the endemic presence of hemorrhagic fevers in Africa, our duty Doctors in charge of each air ambulance flights are trained to be suspicious for any request coming from Africa (all areas), for a pyretic patient, with a clinical status decreasing shortly.

Our first target is to protect our medical teams and pilots from an unknown Lassa or Ebola case with a wrong diagnosis (i.e. malaria) to be repatriated from Africa. We work with epidemiologist physicians from "Doctors without Borders" year after year to establish our final B.A.T. (Biorisk Air Transport) process [1].

1) Previously, in 2010, Medic'Air evacuated a patient with suspected Lassa fever with only individual protective suits and helmet and ribavirin prophylaxis per os for flying medical attendants and pilots.

2) Since 2011, we started to use our first Air Transport Isolators (A.T.I.), with atmosphere in Positive Pressure, and our concept to isolate patient before boarding, in a soft bubble - transparent crystal walls-with filtered air through NBC cartridges. Patient is able to receive oxygen support and venous line from outside and intravenous medication by the attending crew if necessary on flight.

Without confirmation of efficiency, and with a indicated teratogen risk for pregnant woman, we stopped prophylaxis by Ribavirin tablets for our pilots, Doctor and nurse.

In the same time, the level of medical response was increasing in some places in West Africa with local infectious laboratories (i.e. Kenema hospital in Sierra Leone) able to confirm a diagnosis with Elisa test in a short delay.

In 2011, our team performed a successful long range Lassa fever

positive case evacuation by air ambulance from Freetown (Sierra Leone) to Linköping in Sweden, with an ATI for an humanitarian physician [2]. During the following months, we worked closely with WHO and "Doctors without Borders" to establish a new process: BAT (Biorisk Air Transport) for highly contagious disease air transport [3].

We have extended our concept to be able to transfer patients with aero transmissible germs and we progressed from internal Positive Pressure bubble to internal Negative Pressure bubble through another manufacturer. So, in case of an accidental tear of the crystal wall, contaminated air is maintained inside the bubble, by the vacuum pump, and with limited risk to spread the pathogens inside the aircraft cabin and time to close the gap.

From summer 2015, with the Ebola epidemic in West Africa, we activated our B.A.T. process to respond to French Health Authorities and European "ECHO" office requests for potential Ebola air evacuations to Europe [4].

During this period summer 2015 to beginning 2016, we evacuate five patients with ATI by Air Ambulance with confirmed Ebola infection or only suspicion in the first days following the exposition. All medical flights were uneventful-except the difficulties to obtain flight clearance over African countries and landing permit in Spain for refueling.

All were humanitarian European workers, Doctor or Nurse, English speaking. Only one was a confirmed case and, after treatment, fully recovered.

## Biorisk Air Transport Procedure

Opening a new Ebola case, Medic'Air duty Doctor must shortly - in touch with the local treating physicians and epidemiologists - know (and before our medical team take off from Paris):

- If blood tests (PCR) have been performed, and results?
- Estimated date of contamination?
- Are clinics signs presents, and which ones?

The target is to anticipate patient's degradation and to have conviction that patient will be eligible for the ambulance flight when our team will join him/her.

**Table 1:** Air Transport Isolator - Bubble (ATI).

Stages	Symptoms	Starting mission	Pick up patient	Final decision with ATI
Incubation	None	None	None	low risk
First stage	Fever	Fever	Fever	high risk
	Headache	Headache	Headache	high risk
	Throat pain	Throat pain	Throat pain	high risk
	Myalgia, arthralgia	Myalgia, arthralgia	Myalgia, arthralgia	high risk
Late stage	Asthenia, anorexia	Asthenia, anorexia	Asthenia, anorexia	high risk
	Nauseas	Nauseas	Nauseas	high risk
	Vomiting	Vomiting	Vomiting	TBA
	Diarrhea	Diarrhea	Diarrheas	No Go
	Abdominal pain	Abdominal pain	Abdominal pain	high risk
	Hiccup	Hiccup	Hiccup	high risk
	Rash	Rash	Rash	high risk
Terminal stage	Hemorrhage	Hemorrhage	Hemorrhage	No Go
	Dyspnea	Dyspnea	Dyspnea	No Go
	Confusion	Confusion	Confusion	No Go
	Shock	Shock	Shock	No Go

1. With the dark grey background: when one of these signs is present:
  - 1.1. Before starting the mission: Mission is aborted immediately.
  - 1.2. When team arrives to the patient: team turns around and mission is cancelled.
2. With light grey background: To Be Advised : Discussion is open regarding the quantity, frequency and the kinetic of vomiting and the length of the flight to perform. Final decision from Medical Management, in accordance with the escort Doctor in contact with patient, to follow or not the mission.

For any patient’s transport inside an ATI (Bubble) - at this stage of our expertise - we limit long evacuations (more than 4 hours) for non-excreting patients in the first days of the contamination or illness. If the clinical status is decreasing with major symptoms like several diarrheas, polypnea, neurologic defects or hemorrhagic signs before our flying physician takes charge of the patient and the mission has to be aborted immediately.

The B.A.T. procedure includes a nomenclature that lists every stage of the disease evolution of the patient: from asymptomatic to presence of fever, headache, myalgia, nausea, diarrheas, hemorrhage and shock.

Each decision regarding the implementation of the repatriation mission is based on this nomenclature. This procedure entirely follows WHO recommendations whose purpose is to balance between risks and benefits for the patient and the team. At an advanced stage of the disease the contamination risk to the escort team is too high with bad vital prognostics against low probability of recovery for the patient.

**Air Transport Isolator - Bubble (ATI) Table 1**

In that respect full clinical examination is forbidden to the escort team. Intrusive medical acts which would interrupt the “isolation chain” are forbidden: otolaryngology examination, cardiac or pulmonary auscultation or blood pressure control. Temperature is not monitored, only pulse and oxygen saturation. If venous access is necessary, it must be performed by a local team in the hospital, a venous line is monitored by the escort team on flight medication for hydration or sedation. Oxygen by nasal cannula can also be performed on flight.

For the second main point: the B.A.T. is a complete teaching

manual for our flying Doctors and nurses: the BAT procedure enhances the balance between risk for the teams and profit for the patient by implementing successive steps during the evacuation, consistently training staff and continuously improving equipment.

The BAT procedure has lately been improved in order to face not only hemorrhagic fevers but also the risk of airborne germs such as coronavirus, H1N1 influenza, tuberculosis, etc [5].

During the entire mission our physicians are in continuous contact with doctors treating the patient locally as well as with the receiving hospital in the final destination in Europe. If patient’s clinical status is decreasing, the mission could be immediately stopped before being entrusted by the air ambulance crew.

The whole medical team is permanently informed regarding all hemorrhagic fevers including Lassa, Ebola, Marburg and the BAT procedure and trained for the use of the isolation equipment [6,7] for contagious patients transport, i.e. the ATI (Air Transport Isolator - Bubble) and the EPI (Individual Protection Equipment) with Positive pressure Helmet.

Arriving on scene, the medical team (MD & RN ) stay on the tarmac, near the aircraft. They have to prepare the bubble, and to set up their Individual Protective Equipment (E.P.I.) and Positive Pressure Helmet.

Only the physician is on contact with the patient. The clinical examination is very light: conscience, pulse, saturation (with disposable pulse oxymeter)... auscultation is forbidden.

Doctor installs patient inside the bubble, with water bottles, medication tablets (loperamide, painkillers...), urinal bags, sanitary

kit ... he secures if necessary oxygen pipe and venous line, then he closes with the sealing zip carefully the bubble.

The nurse has no contact with the patient, he watches to ensure aseptic handling of the A.T.I., clean twice with antiseptic solution (Sulfanios<sup>®</sup> or chlorinated solution) the bubble (zip and walls) then the Doctor by spray before to help his to remove his EPI. He has to remove after his own EPI following strict B.A.T. directions.

Patient inside the closed and cleaned bubble is ready for boarding, without specific protection now for pilots and medical crew. Patient stays inside the sealed A.T.I. under negative pressure still arrival at final destination, in isolated room in infectious ward/European hospital.

After the mission the escort team is medically followed to control any sign of contamination for 21 days (temperature checked twice a day). No sign so far.

### First Case of Ebola Evasan [8]

The patient is a Norwegian physician aged 30 years and working in a treatment center in Sierra Leone.

On the first evening she feels tired with diffuse pains. The following evening she starts feeling low grade fever, thrills and diffuse pains. Malaria suspicion is removed. However the patient begins headache and myalgia, and fever rises to 39°C. The Ebola PCR test confirms the infection.

The mission to evacuate the patient is then confirmed by the end of the afternoon to Medic<sup>’</sup>Air Operation Desk in Paris.

As she still doesn't have any bleeding signs nor gravity signs, the repatriation is set off 48 hours after the Ebola first symptoms.

Our alert team of doctor and nurse takes off at 11pm from Paris the same day in an air ambulance, Jet Citation S2 with all the isolation equipment, i.e. Bubble and EPI.

The BAT process is applied.

First stop is made in Morocco for one hour fueling, then in Dakar for the mandatory pilot rest for 10 hours. Then the following flight is direct to Freetown where the patient will be taken in charge.

#### In the meantime

Our Paris Operation desk and supervising doctors in Paris keep informed with local treating doctors in Sierra Leone and send information to the flying team and to doctors in Norway where they are waiting for the patient.

The patient is maintained at 37.9°C with paracetamol and pains have decreased. She also gets an intravenous, prepared in advance before the flight.

In spite of four small diarrheas the day before, the mission holds on after several medical contacts (with epidemiologists and local medical physicians) and agreement of the escort Doctor, before leaving Dakar stop.

The escort team arrives at Freetown airport, where the isolated patient is waiting, conscious, perfused but not suffering. Then the escort team puts on their EPI protection before putting the patient on oxygen into the bubble which they carry into the aircraft.

The team disinfects the bubble exterior and gets undressed before getting back in the aircraft and taking off.

The flight night lasts 10 hours during which no sign of worsening had to be noticed and two fuel stops under high police protection.

The worst was narrowly avoided. The aircraft had to make a stop in Las Palmas in Spain for refueling. However the Spanish national security firmly prohibited access for landing for fear of contamination.

*The discovery of the Ebola infection of a Spanish nurse was the exact source of fear for local authorities.*

The NGOs diplomatic intervention solely could weigh in negotiations leading eventually to the opening of the national Spanish air space for the landing.

The final stop was fulfilled in Oslo airport where the Norwegians physicians were waiting and finally took in charge the patient on tarmac to carry her - inside the bubble - to the receiving hospital with isolation room [9].

### Conclusion

Medic<sup>’</sup>Air BAT process can be a solution for Ebola patient evacuations if these two main conditions are considered:

- 1) An early medical decision to start evac in the first days after contamination.
- 2) To keep on alert a professional intensive care team, expert for medevac and volunteer. They must have previously specific courses regarding all hemorrhagic fevers pathologies and risks, and a regular training for protection dressing and bubble use.

If our BAT system is a light solution to evacuate patient in the best delay, it is also a full safety solution for receiving medical teams at arrival in Europe. The bubble is not fixed to the cabin aircraft structure and the patient is disembarked at destination airport still inside his isolation bubble. The patient has to stay in the A.T.I. until admission into a high isolation room at the receiving hospital without any risk on the tarmac and during ground transportation by ambulance for airport workers and medical staff.

Nevertheless, for the future, we believe that the optimal solution is to start and give specific medication or vaccine to the patient locally and stop to move in a rush these patients by air ambulance to European hospitals for antiviral treatment [10].

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