Air Medical Journal 38 (2019) 215–222

Contents lists available at ScienceDirect

Air Medical Journal

journal homepage: http://www.airmedicaljournal.com/

Case Report

Ebola, Airborne Medical Evacuation . . . The Danish way

René Christian Bleeg, MD *

Royal Danish Armed Forces Medical Command, Soedalsparken 20 8220 Brabrand, Denmark

The Ebola virus (EBOV) was first observed in 1976 in Sudan and the Democratic Republic of the Congo. Subsequently, there have been outbreaks in the Democratic Republic of the Congo (1995 and 2003), Gabon (1994, 1995, and 1996), Uganda (2000), Sudan (2004), and Guinea (February 2014), the latter with a mortality rate of 65.5%. The outbreak spread throughout 2014 to neighboring countries of Liberia, Sierra Leone, Guinea, Senegal, Mali, and Nigeria, making it the most extensive outbreak ever to be referred to by the American Centers for Disease Control and Prevention (March 2, 2015).

On July 20, 2014, Doctors Without Borders (MSF) stated that the outbreak was out of control and that a significant increase in effort was needed to combat the epidemic. MSF also noted problems related to the local population's reluctance to take measures against the spread of infection, including the end of traditional funeral rituals, among other things. MSF urged the world community to get involved.

The World Health Organization (WHO) issued a global appeal in September 2014 for medical staff to help with the Ebola crisis. Denmark participated with 3 medical teams, led by the Danish Emergency Management Agency and the Danish Armed Forces Medical Command over a 6-month period. A total of 75 health workers participated, including 15 doctors, 39 nurses, and logistical personnel. The Danish personnel worked in partnership with the contribution from Great Britain and Non Governmental Organisations (NGOs) from Ireland in the Ebola Treatment Center (ETC) in Port Loko, approximately a 2.5-hour drive northeast of Freetown in Sierra Leone. Accommodation for all health workers was established nearby in Base Camp Port Loko (a designated safe zone).

A total of 23,948 cases of EBOV have been reported, with 14,347 cases confirmed by laboratory tests. A total of 9,729 people died in the time period between March 25, 2014, and March 2, 2015. In addition, some cases have been reported in Spain, the United States, and England because of travel.

The Ebola epidemic ended in Spring 2015. In May 2015, the WHO declared that no new cases were reported in Liberia for 6 weeks (twice as long as the incubation period for the disease).

Danish Involvement During the Ebola epidemic

At the time when the Danish Ministry of Foreign Affairs and the National Board of Health wanted an airborne medical evacuation capacity, a total of 101 Danish workers in West Africa were registered, including 12 employed by the United Nations and the European Union, 64 civilian specialists, an unknown number of NGOs, and 25 health care professionals in Sierra Leone.

The Danish National Board of Health and the Ministry of Foreign Affairs wanted to return Danish citizens (and other Scandinavian citizens) who had either been in the risk zone in West Africa or had been exposed to Ebola infection but not showing signs of illness, as well as Danish and Scandinavian citizens infected with contagious diseases (eg, Ebola, hemorrhagic uremic fever, and so on).

In Autumn 2014, the Danish Ministry of Health and the Ministry of Defense gave the Royal Danish Air Force (RDAF) Aeromedical Evacuation Squadron 690 (MedEvac SQN 690) the task of evacuating Danish (and Scandinavian) citizens (with suspected or verified Ebola infection) from the epidemic areas in Africa. Additionally, the squadron was tasked to evacuate other types of infectious disease (Marburg fever, Dengue fever, hemorrhagic uremic fever, and so on) as well. This with only a notice of 24 to 48 hours. On a 24/7/365 basis, all Danish citizens can contact the Ministry of Foreign Affairs Globale Alarm Center (+45 33 92 11 12/bbb@um.dk) to request a Medical Evacuation.

Work Group/Faculty

In order to attain this, an entirely new system had to be developed. Experts in air transport, air evacuation, ambulance transport, infectious disease, and intensive care medicine were amassed.

MedEvac SQN 690 already has 4 modules (containers) that can be used for intensive care treatment or transport of patients. These containers are 20 feet in length, and they are isolated from the aircraft cargo bay in the C-130J Hercules aircraft. The modules were initially designed in the late 1980s, with built-in unfiltered fans but no air lock. They are soundproof, with a sound reduction of over 20 decibels. There is 230/12 V alternating current/direct current and oxygen supplement. The modules are divided into 2 components (A and B),

Acknowledgment: The author thanks C. Lie, MD, senior flight surgeon and consultant, MedEvac SQN 690, RDAF, Denmark; J.M. Ferrieux, MD, senior flight surgeon, MedEvac SQN 690, RDAF, Denmark; C. Hjoerringgaard, head of department secretariat, Aalborg University Hospital, Aalborg, Denmark; and P. Oestergaard, medical student, Aalborg University, Faculty of Medicine, Aalborg, Denmark.

* Address for correspondence: René Christian Bleeg, MD, Royal Danish Armed Forces Medical Command, Soedalsparken 20, 8220 Brabrand, Denmark

E-mail address: bleeg@dadlnet.dk

1067-991X/$36.00

https://doi.org/10.1016/j.amj.2019.01.004

which can be moved either alone or together. A standard module can accomodate 12 routine patients or 3 critical, intensive care patients. In the newly designed modules, we chose to use module B as a starting point for the (Ebola) infected patient treatment facility, which could hold 1 and possibly 2 patients simultaneously.

The purpose of using a container-based principle was to protect the medical/health care treatment team, protect the flight crew, and also protect the aircraft itself from contagious elements. An additional priority was to optimally treat the patient using the highest possible treatment standard.

The work group started inspecting and demonstrating existing air evacuation equipment. Subsequently, the entire work group brainstormed all phases of a possible infection of a person, including contact to the Danish authorities, alarm message and contact list, future contact to the infected patient, contact to on-site health care staff, modular equipment, materials, crew, medical crew, cleaning of modules and aircraft, quarantine, remuneration, freedom of application, conditions if a crewmember is infected, landing and takeoff procedures, reception of the patient, patient delivery, medical crew accommodations, toilet conditions, food, entertainment during flight, disposal of infected material, procurement and depot of protective equipment, and so on.

It soon became apparent that the existing protective equipment was inadequate because many countries required approved protective equipment. Some metal objects were also placed as fittings and hinges that could easily destroy some insulation equipment and protective equipment.

It was agreed to choose modules A and B, where module B would house the infectious patient and module A would be used as a medical crew room (living room). In addition, it was recommended to systematically use P4 insulation suits in module B.

Several different improvements were introduced to module B, which included installation of a Beth-El IsoArk N 36-6 insulation cube. Additionally, the cabin was double reinforced with interior trim and a tricolored concept with a red, yellow, and green zone. New waterproof flooring was installed in module B, and seals were made of all collections in the module. The normal filtrator was replaced with a HEPA filter in all ventilation, air conduits, and holes. An air lock and double doors were also installed.

Medical expert knowledge was obtained through collaboration of the infectious disease departments at Skejby University Hospital and Hvidovre University Hospital. MedEvac Squadron 690 provided the intensive care and anaesthetic preparedness. All air evacuation equipment and coordination were performed by MedEvac Squadron 690 in cooperation with the RDAF logistic/support unit. All technical support regarding the modules was MedEvac Squadron 690's responsibility.

Discussion

The method used to develop the Danish Ebola evacuation concept was quite unconventional; collaborators from the military, health authorities, and the civilian hospital had to work together in a short, 6-week period of time and tight deadline to develop a new concept. Cooperation was facilitated by the fact that several of the associated doctors and nurses in the MedEvac Squadron 690 were permanently employed in full-time positions in the civilian hospital system, with a reserve officer contract with the Danish Armed Forces Health Services and the RDAF already in place. This resulted in familiarity/use of the same health-related terminology, and the military staff of health care professionals in the MedEvac squadron had daily cooperation and networking with the RDAF Air Transport Squadron 721. The conclusion of melding the 2 countries' different infectious medicine departments at Aalborg Airbase added positive dynamism and synergy, and through many professional discussions, the final goal of a durable concept was achieved in a surprisingly short time.

The fact that the National Board of Health participated on a daily basis meant that there was "political" support for the method, which could affect civilian staff health care professionals. Specifically, this meant that the civilian staff health care professionals could be exempt from their civilian work upon very short notice and, if contaminated, could be absent for up to 11 weeks, to allow for isolation, because of Ebola's incubation time from infection to symptoms.

The Danish EBOV medevac concept ensures the safety of the flight crew and health care personnel through the use of double-insulated containers inside the aircraft. By using a container-based concept, it offers the RDAF a high operational capacity because the aircraft can fly around the world with just a few refuels and no airplane needs to be dedicated only for the purpose of air medical evacuation.

The treatment module, module B, offers high-level intensive medicine health care and safety during flight. One must keep in mind that the medevac team must be ready to handle unexpected medical events en route on the long demanding missions because not all countries allow aircraft to land. Therefore, a number of operational and diplomatic factors must be in place before the mission can be executed because it takes time from the optimal transferral of a patient to a Danish treatment facility within 48 hours of potential initial exposure to Ebola infection.

If flight and medical crew safety could be guaranteed by using the IsoArk, BETH-EL Zikhron Yaaqov Industries Ltd.,1 Avshalom Road, Zikhron Yaaqov, Israel. EpiShuttle, EpiGuard AS, Norway without installing them in the infectious modules, it would be possible to use smaller and faster, and thus cheaper, aircraft types, eventually by combining commercial and military capabilities in the future.

Conclusions

The RDAF developed, together with the 2 leading infectious medical departments in Denmark and the Danish National Board of Health, for a very short time, a durable and now tested concept for air evacuation of Ebola-infected Danish patients. The concept has been tested in 2 cases and proved to be effective. However, there is still a follow-up and further educational work to be done. Measures must be taken to develop pure infectious disease medical modules with the latest technology incorporated into the modules themselves. New storage facilities for emergency medical treatment and optimized waste treatment/sorting should be developed.

It is of crucial importance that the EBOLA faculty meet on a regular basis to obtain updates regarding the WHO's evaluation of new outbreaks, new treatment algorithms, standard operation procedures, and new equipment and to exercise in a realistic environment. Optimally, this should occur once a year and more frequently when new outbreaks occur.

Perspectives

With the experience gained from the 2 case reports/evacuations with potentially infected Ebola patients, measures have been taken to develop new modules/containers that are specifically designed to relocate/evacuate infectious patients (including Ebola, Dengue fever, and hemorrhagic fever) in which there will be improved HEPA filters as well as pressure chambers.

Moreover, there will be improved facilities for medical crewmembers, who must stay for up to 36 hours in the closed modules. In the new modules, the new Norwegian EpiShuttle system may perhaps be implemented.

Ebola Facts

Ebola virus (EBOV) is 1 of 5 known viruses (Bundibugyo virus, Sudan virus, Taï Forest virus, and Reston virus). They are all within the genus *Ebolavirus*, family Filoviridae, and order Mononegavirales.

EBOV was formerly designated Zaire ebolavirus, the country where it was first described, but was renamed to EBOV in 2010 to avoid confusion.

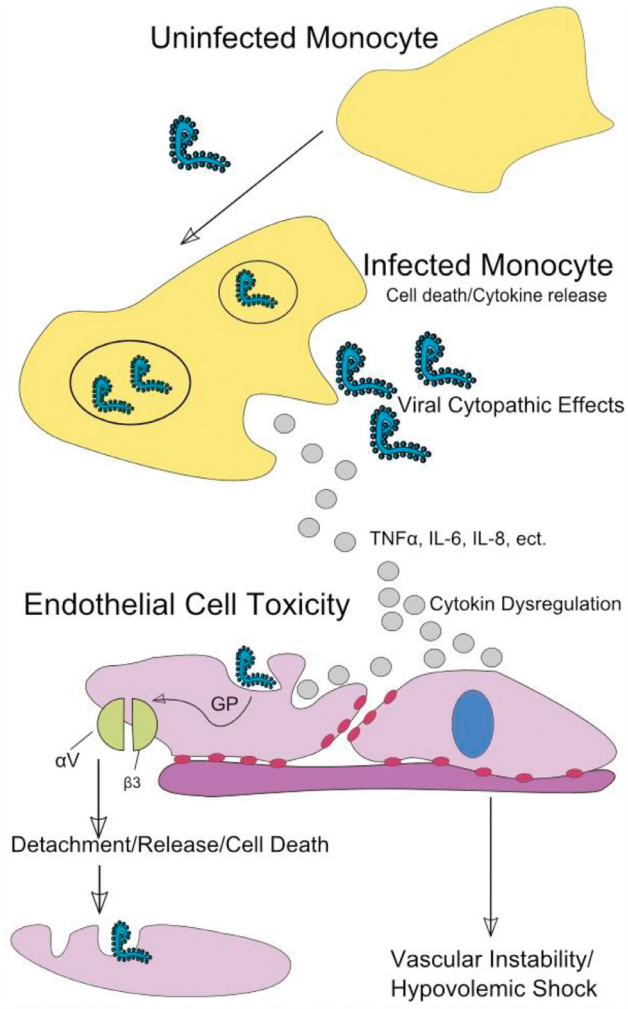
It was first suspected to be a new "strain" of the closely related Marburg virus.

The natural reservoir of EBOV is believed to be bats, particularly fruit bats, and it is primarily transmitted between humans and from animals to humans through body fluids.

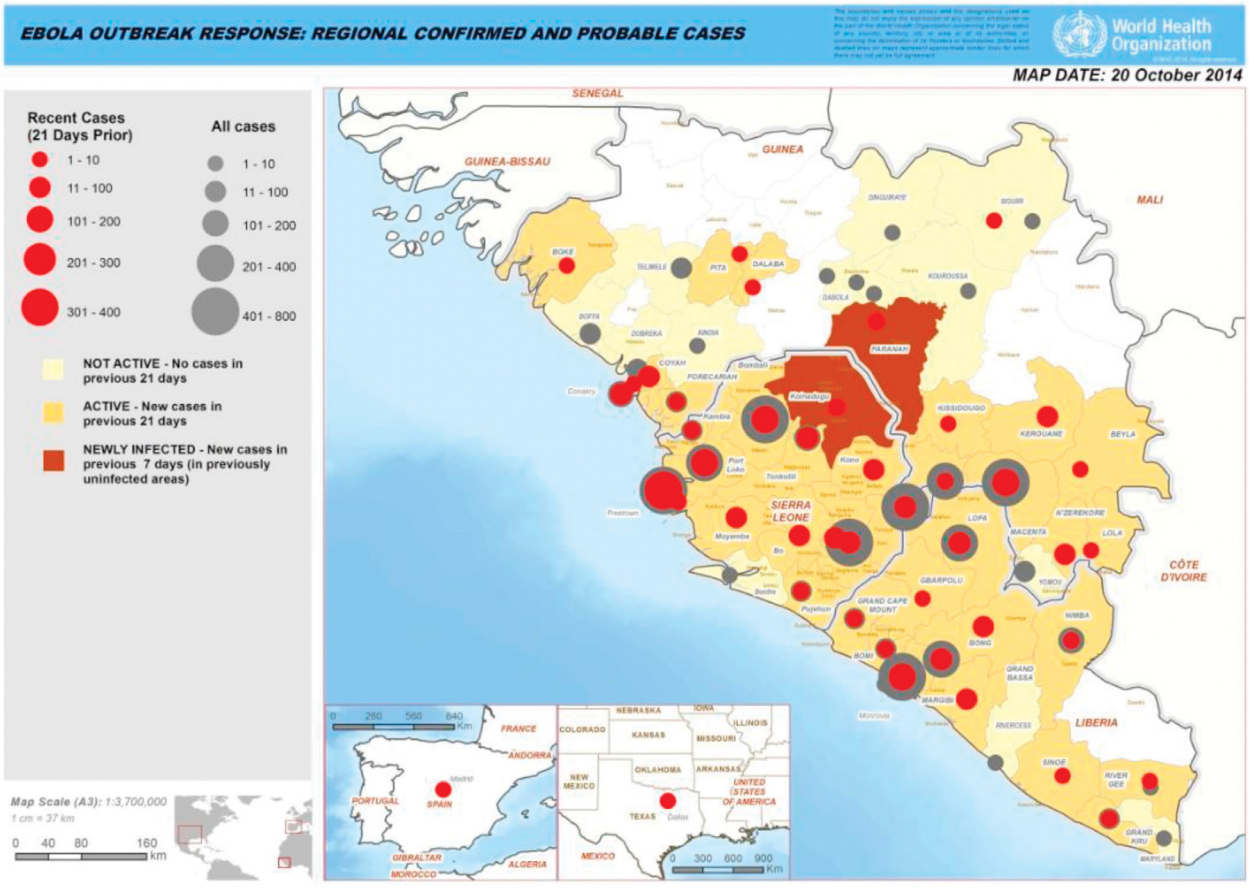
Four of the 5 known ebolaviruses, including EBOV, cause a severe and often fatal hemorrhagic fever in humans and other mammals, known as Ebola virus disease (EVD).

EBOV is the most dangerous of the known EVD-causing viruses and is responsible for the largest number of outbreaks and caused the majority of human deaths from EVD.

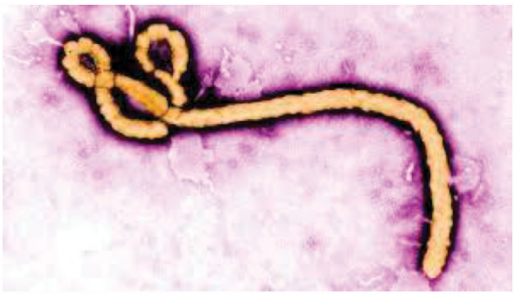
The EBOV genome is a single-stranded RNA approximately 19.000 nucleotides long. It encodes 7 structural proteins: nucleoprotein (NP), polymerase cofactor (VP35), VP40, GP, transcription activator (VP30), VP24, and RNA-dependent RNA polymerase (L).



The EBOLA RNA



WHO EBOLA MAP



EBOLA strain

The author R C Bleeg

Because of its high mortality rate (up to 83%-90%), EBOV is also listed as a select agent, World Health Organization Risk Group 4 pathogen, requiring biosafety level 4—equivalent containment.

The virus spreads by direct contact with body fluids of an infected human or other animals. This may also occur through contact with an item recently contaminated with bodily fluids. Spread of the disease through the air between primates, including humans, has not been documented in either laboratory or natural conditions.

There is a general agreement that the infection with EBOV can be divided into 3 periods: the infectious period, the incubation period, and the latent period.

The incubation period, the time interval from a possible EBOV exposure to the onset of any EVD symptoms, is 2 (48 hours) to 21 days.

It is believed that humans are not infectious until they develop symptoms.

Therefore, the noninfectious interval is arbitrarily set to 48 hours in the incubation period, and this is also the deadline medevac operators work with in regard to the isolation and protection level during transport of Ebola-infected patients.

Symptoms

Symptoms typically start between 2 days and 3 weeks after contracting the virus with a sudden influenzalike stage characterized with a fever higher than 38.3°C (101°F), feeling tired, weakness, decreased appetite, muscular pain, joint pain, sore throat, and headaches. Then, vomiting, diarrhea, and abdominal pain occur along with decreased function of the liver and kidneys. At this time, some people begin to bleed both internally and externally.

Death often occurs because of low blood pressure from fluid loss, electrolyte derangement, and multiorgan failure (sepsis) and typically follows 6 to 16 days after symptoms appear.

Diagnostics

The following diagnostic methods are used to diagnose EBOV in the early stages when the symptoms begin: antibody-capture enzyme-linked immunosorbent assay, antigen-capture detection tests, serum neutralization test, reverse transcriptase polymerase chain reaction assay, electron microscopy, and virus isolation by cell culture.

To confirm infection with EVD, there must be 2 (A + B) positive blood samples.

Treatment and Vaccines

Supportive care rehydration with oral or intravenous fluids and treatment of specific symptoms (eg, electrolyte derangements) improve survival. There is as yet no proven treatment available for EVD. However, a range of potential treatments including blood products, immune therapies, and drug therapies are currently being evaluated.

An experimental Ebola vaccine proved highly protective against the deadly virus in a major trial in Guinea. The vaccine, called rVSV-ZEBOV, was studied in a trial involving 11,841 people during 2015. Among the 5,837 people who received the vaccine, no Ebola cases were recorded 10 days or more after vaccination.

Case Report 1

During undressing from the protective suit, a Danish nurse at Ebola Treatment Center Port Loko accidentially sustained a tear in her protective gloves after her daily duties inside the Ebola Treatment Center with Ebola-infected patients. She did not report the incident despite standing orders to do so for the sake of other health workers safety and returned to the Base Camp Port Loko. A couple of hours later, the nurse became worried, and at 21:45 hours, she reported the incident to her commanding officer.

January 6, 2015

1230: Possible infection because of a tear in the protective gloves

2145: Report of the incident and warning notification to the Danish Health Authorities

January 7, 2015

0030: Decision made to repatriate the patient back to Denmark

1230: RDAF medevac SQN 690 was tasked to the mission

2025: Patient departure from Freetown to Brussels on board a commercial airplane

January 8, 2015

0105: Departure from Aalborg Airbase with a medevac team from SQN 690 on board a

Challenger CL604 airplane

0345: Rendezvous between the 2 airplanes at Brussels Airport

The Danish medevac team is now in charge of the patient

0400: Danish Aeroplane CL604 is grounded because of tire damage; the patient remains in the CL604

0900: A new CL604 from the RDAF lands in Brussels and the patient is shifted over

1030: Departure of the new CL604 heading Tirstrup (Aarhus) Airport in Denmark

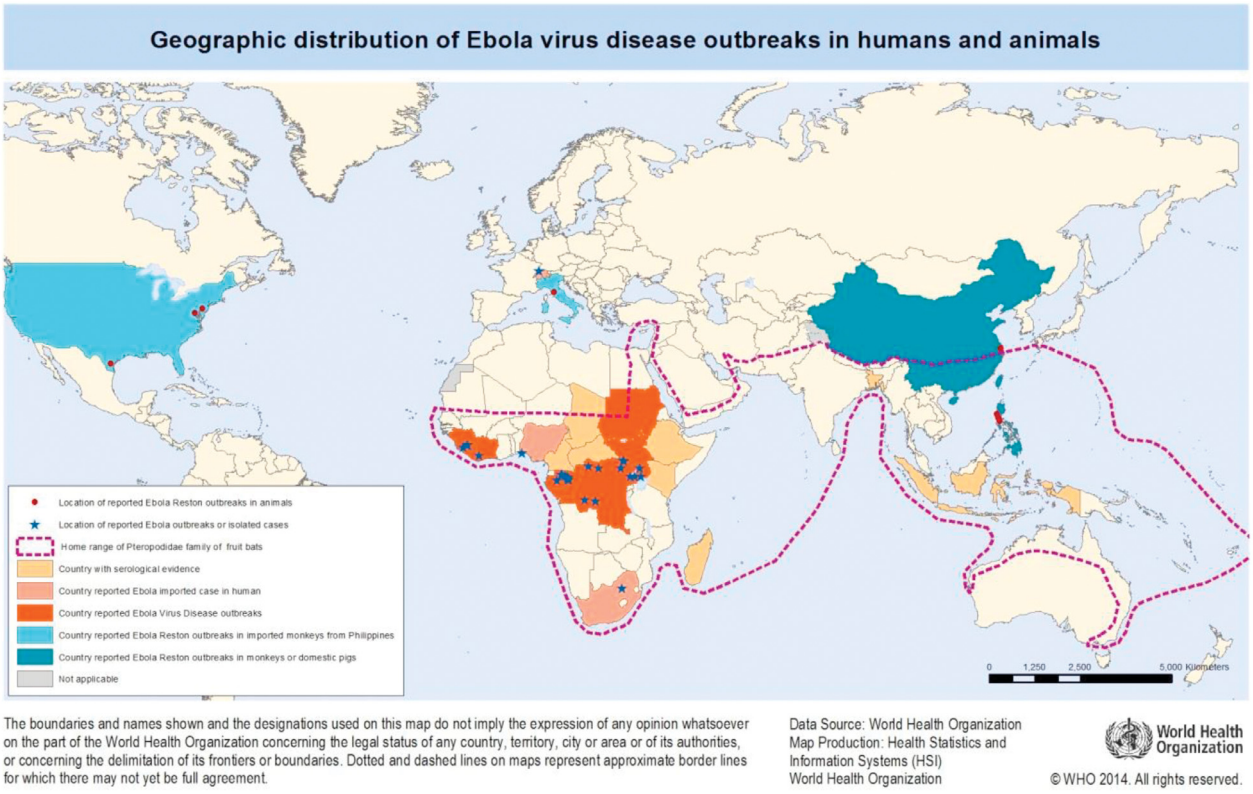
1140: Landing at Tirstrup Airport, and the patient is transferred over to the Danish Ambulance Service and transported to Skejby (Aarhus) University Hospital

1215: Patient arrives to the Department of Infectioues Diseases at Skejby University Hospital

The patient was not isolated and was under continuing monitoring of vital signs and was stable without fever enroute.

The total time of repatriation from incident to arrival to a higher level of health care: 47 hours 45 minutes

The patient turned out not to be infected with Ebola virus



Distribution of EBOLA

The treatment module B

The treatment module B

The treatment module B

Case Report 2

During undressing from the protective suit on March 7, 2015, a doctor from the US Non Governmental Organisation Partner in Health Organisation at Ebola Treatment Center (ETC) Port Loko accidentially came in contact with the external shell of the protective suit after his daily duties inside the camp with Ebola-infected patients. Reportedly, the doctor was made aware of the possible contimination from other health workers, but he overruled the warning, proceeded undressing, and left the ETC by transport to Camp Port Loko. The doctor was in close contact with several health workers the following 2 days. In the morning of the second day, March 9th, the doctor was working at the local hospital GOAL in Port Loko; he started to become confused and collapsed. He was transported to Camp Port Loko and was put in the isolation room with air conditioning. He recovered quickly and was examined in the afternoon by a Danish duty doctor and a medic and

was declared fit. In the early morning of March 10th, the US doctor developed fever, fatigue, decreased appetite, and muscular pain, and he was initially mistakenly diagnosed with malaria. He was admitted to the emergency room and was examined by another Danish doctor. None of the examining doctors or medics used sufficient protective gear, only gloves.

Afterwards, he was transported to the United Kingdom Army ETC in Kerrytown. Further examination and information were obtained, and the incident at the ETC was recognized and the first (A) external ventricular drain blood sample, March 11th, turned out positive. The 48 hours of incubation time had passed for all health workers who had been in contact with the US doctor. All possible infected health workers were assembled in a isolation area. On March 11th, it was decided to repatriate the 3 Danish health workers who were declared at higher risk according to World Health Organization classifications.

March 9, 2015

Possible infection of a Danish doctor and nurse

March 10, 2015

Possible infection of a second Danish doctor

March 11, 2015

1501: Warning notice to medevac SQN 690 regarding possible Ebola evacuation

1735: Warning abolished

All patients were assembled in a isolation area waiting for further plans

March 13, 2015

1419: Decision made to repatriate all 3 Danish health workers

1445: Warning notice to medevac SQN 690

1505: Commence order to medevac SQN 690

March 14, 2015

All day: Flight and logistic planning, including overflight requests, through the Danish Ministry of Foreign Affairs and Diplomatic Missions, for The Netherlands, Belgium, France, Spain, Portugal, and Sierra Leone

1000: Departure of a RDAF C130J aircraft loaded with the infectious module A + B from

Aalborg Airbase to Moron Airbase in Spain.

1410: Landing in Moron, refueling

1540: Departure Moron to Gran Canaria, Spain

1800: Landing at Gran Canaria, flight crew exchange, last medevac preparations

2300: Departure Gran Canaria to Freetown, Sierra Leone

March 15, 2015

0400: Landing in Freetown

0430: Rendezvous and taking over charge of treatment between the Sierra Leone medical treatment team and medevac SQN 690; loading of the 3 patients in modules A + B

0530: Departure Freetown to Gran Canaria

1105: Landing in Gran Canaria, refueling

1235: Departure Gran Canaria to Tirstrup (Aarhus) Airport, Denmark

1927: C130 landed at Tirstrup Airport, and all 3 patients are transferred over to the Danish Ambulance Service and transported to Skejby (Aarhus)

University Hospital

2021: Patients arrived to the Department of Infectioues Diseases at Skejby University Hospital

2253: C130 landed at Aalborg Airbase, medevac mission accomplished

The patients were isolated in the infectious module B; they were under continuing monitoring of vital signs, and they were stable without fever en route

The total time of repatriation from incident to arrival to a higher level of health care was 6.5 days.

The patients turned out not to be infected with Ebola virus.

The 3 patients were isolated in isolation module B, remained under continuous monitoring of vital signs, and were stable without fever en route.

None of the patients turned out to be infected with Ebola virus.