Aeromedical Evacuation Using Extra Corporeal Life Support After Resuscitated Cardiac Arrest

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BACKGROUND: Extra corporeal life support (ECLS) is presently first line therapy for refractory cardiogenic shock. Mobile circulatory support teams implant ECLS or extra corporeal membrane oxygenation (ECMO) in patients in the hospital without circulatory support. These patients are then transported to specialized centers. Here we report a case of sending a mobile circulatory support team abroad, followed by air ambulance evacuation, which, to our knowledge, has never been used as part of medical assistance abroad.

CASE REPORT: In June, during a holiday in Turkey, a 56-yr-old woman complained about chest pain. She had a cardiac arrest and was resuscitated with no no-flow time in the local hospital. ECG showed ST segment elevation. Medic'Air International medical assistance (Paris, France) contacted the hospital, which was not equipped with coronarography or cardiac ultrasound and the local treating doctor refused transfer of the patient to another facility. A medical team completed by a cardiothoracic surgeon and a perfusionist went from Paris to the patient's bedside by air ambulance. They implemented the ECLS and successfully repatriated the patient to her home country (Belgium). The patient's condition improved, she neurologically improved, and returned home on the 14th day.

DISCUSSION: Possible indications for ECLS repatriations firstly take into account recognized ECLS indications and case-by-case discussions on the evaluation of inadequacy of the health facilities and risk-benefit balance. In international medical assistance, this case's description is an example of repatriation for patients who previously could not be transferred due to high risk of such intervention.

KEYWORDS: medical assistance, air ambulance, cardiac surgery.

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During the last decade, the technological advances benefiting from use of extracorporeal membrane oxygenation (ECMO) allowed generalization of its use and notably placed it in first line treatment for refractory cardiogenic shock.[1,4] There are two main applications of this technique: the extra corporeal life support (ECLS) veno-arterial in refractory cardiogenic shock and postoperative cardiac surgery; and the ECMO veno-venous in acute respiratory distress syndrome.[4, 9]

The urgency of ECLS implementation in refractory cardiogenic shock usually involves the cannulation of the femoral vein up through the vena cava to the right atrium. The arterial cannula is inserted through the femoral artery and slid into the descending thoracic aorta. To avoid leg ischemia phenomena, an arterial reperfusion line is implanted. The femoral venous blood flow is aspirated by an electric centrifugal pump and oxygenated through a membrane. The oxygenated blood is transferred into the arterial circulation as a retrograde flow. ECLS allows the stabilizing of the patient's state in order to make a diagnosis and assess the prognosis.[4]

Miniaturization and portability of ECLS enabled the mobile circulatory support units to become established in France. These units are dependent on a hospital of reference, whose role is to implement ECLS on patients in hospitals without circulatory support.[7] These patients are then transported to the specialized center, usually by ground transportation. However, literature describes cases of continental or intercontinental repatriation by air transportation.[2,6,8] The means of transport can vary:

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helicopter, or military or private aircraft. Some publications report fast implementation and safe use of this technique in flight with an experienced team.[5,7] These procedures appear to be essential. They take into account the organizational requirements of different contributors and the technical constraints of the means of transport used as far as on-board oxygen and a continuous source of electricity are concerned. Note that some ECLS devices have obtained aviation accreditation.

This report describes the case of sending a mobile circulatory support team for a medical evacuation mission by air ambulance abroad. To our knowledge, this procedure has not been performed as part of a medical assistance before.

CASE REPORT

During a holiday in June 2014, in Marmaris (Turkey), a 56-yr-old woman experienced chest pain and called a doctor to come to her hotel. She then had a cardiac arrest at the hotel reception and a first aider immediately initiated cardiopulmonary resuscitation (CPR). Her only medical history was of substituted hypothyroidism. CPR was continued on the way to the hospital in the ambulance together with IV epinephrine.

On her arrival at the hospital, the initial heart rhythm was asystole and soon it changed into ventricular tachycardia. CPR was supported by orotracheal intubation, IV lidocaine, IV aspirin, and SC Enoxaparin, which resulted in return of spontaneous circulation. Low-flow time was not clearly documented. Hypokalemia initially at 3.2 mmol $\cdot$ L^{-1} was corrected. The ECG found ST elevation myocardial infarction in the lateral area and troponin elevation.

That same day we were contacted for medical assistance (Medic'Air International, Paris, France). The information we obtained from the hospital about the patient's state was incomplete and confusing. We found out we were dealing with resuscitated cardiac arrest without no-flow time and related to an acute coronary syndrome. The hospital did not own any coronarography or cardiac ultrasound equipment. The local doctor refused the transport to another health facility, claiming the patient was unstable.

In these circumstances, our medical team decided, together with the patient's family and the circulatory support team, to perform repatriation on ECLS. The next morning an air ambulance Learjet 55 (Learjet Gates) took off from the Bourget Airport (France). The medical team on board consisted of an emergency physician, a nurse, a cardiothoracic surgeon, and a perfusionist.

When the medical team joined the patient, she was on mechanical ventilation (volume controlled). S_pO_2 was 98% under 35% F_IO_2. Post-arrest hypothermia was not initiated. The patient was insufficiently sedated by Propofol and was reactive to painful stimuli. Brainstem responses were normal. Other measures were: BP of 103/73 mmHg; MAP 83 mmHg; HR 103/min without use of vasopressor; and temperature 37.2°C. The arriving team switched the analgesia and sedation to fentanyl and midazolam and atracurium was used for curarization. The circulatory support team performed right radial artery and femoral venous catheterization. The ECLS settlement was proceeded by surgical opening of the scarpa and catheterization of the right femoral vein connected to the Cardiohelp system (Maquet®, Rastatt, Germany). It took the team 3 h to get the patient into a state allowing her transportation by ambulance to the airport (2 h of setting up the ECMO and 1 h to provide the treatment).

The transfer of a patient on ECLS onboard the aircraft is a delicate moment. Different elements of the ECLS need to closely follow the patient's body during the boarding phase. It is pertinent to reduce declivity and jolts and to monitor the device to prevent elements from hanging or to avoid decannulation. The patient is placed on the stretcher and strapped down. Invasive measurement of blood pressure is required and must be visible and accessible. Two aircraft oxygen bottles are needed simultaneously, one for mechanical ventilation and the other for ECLS. The aircraft power supply is used for ECLS and other medical equipment. During the flight, the patient's hemodynamic and respiratory condition remained stable and no undesirable episode took place. The patient was then transported from Liège Airport (Belgium) to the Sart Tilman University Hospital in Liège, close to the patient's residence, for the rest of her care.

The first assessment in the intensive care unit found, through transthoracic echocardiogram, the following measurements: LVEF: 25–30%; VTI: 18 cm; and mitral regurgitation 2 to 3/4 without aortic insufficiency. The patient received dobutamine support within 24 h of arriving at the hospital and then the ECLS device was surgically removed. The patient's respiratory condition improved under cover of a preventive bi-antibiotherapy and she could be extubated on day 3 of her stay. The patient was transferred to the cardiology ward on day 4. On day 5, the LVEF was estimated at 40% and coronarography was performed for the second time and showed 80% stenosis in the middle third of the circumflex coronary artery that supplies all the anterior, lateral, and apical territory as the interventricular artery was underdeveloped. Angioplasty and stent implantation were performed on the circumflex coronary artery. The patient had total neurological recovery and returned home on medical treatment on day 14.

DISCUSSION

The success of an urgent medical evacuation is based on the rapid response of skilled and experienced medical assistance, trained escorts, good quality equipment, and appropriate transport.[4] Medical evacuations using ECMO or ECLS have already been mentioned in the literature,[2,6,8] but in this report we describe the first case the authors are aware of where a circulatory support team accompanied by an intensive care team was sent abroad, started the ECLS treatment, and at the same time implemented the repatriation to the home country of a patient. In the reported case, we had to send two medical teams of different areas of expertise (circulatory system and intensive care fields), which had to cooperate during the mission. The

circulatory support team owned the equipment for installation and transportation of the ECLS.

Medical evacuation decisions always take into account the risk-benefit balance. In this case, the patient was in critical condition and hospitalized in a clinic with a low level of health care. In the absence of the possibility of thrombolytic therapy or angioplasty, her prognosis was unfavorable.

The indication for use of ECLS in this case was not very obvious. Ultrasonography was not available on site; however, the patient was considered at high risk for occurrence of refractory cardiogenic shock. In the absence of reperfusion therapies, we considered there to be a significant risk of cardiogenic shock, recurrent rhythm disorder, or refractory cardiac arrest occurring. It would have been very difficult and unfortunate to manage a cardiac arrest during the air evacuation. ECLS maintained the cardiac function, prevented complications during the transfer, and enabled transportation over the long distance.

The decision was taken after consultation with the patient's family, who asked for evacuation. All the risks and benefits of intervention with ECLS were presented to them. As the locally treating doctor did not agree with moving the patient, he would not support us in organizing the ground transportation and no local Turkish facility would accept the patient's admission against the local doctor's advice. In Europe, the physician in charge of repatriation takes responsibility for the patient during medical transportation. When our team arrived at the hospital, there was no controversy over the evacuation using ECLS. In this case, the patient was repatriated to her home country, where she was provided with a higher level of care in comparison to the local structure.

Although ECLS has many benefits, it is not totally safe. Its use can result in various complications:[3] bleeding at the insertion of cannulas, limb ischemia, thromboembolic events, sepsis, and intravascular hemolysis. Also additional complications can occur during transportation: dysfunction of the electrical supply of the pump, decannulation, hemodynamic instability, and vasoplegia. Their occurrence is elevated during phases such as ground transportation, boarding the aircraft, acceleration during takeoff, and deceleration on landing. To prevent these, it is better to ask the pilot to do a "long landing" if the airport is adapted to that.

On board the aircraft we have to deal with space, electricity, and oxygen supply constraints. Each device needs to be securely fixed in a logically chosen place. Space on board should allow for easy installation of the intensive care equipment and all the ECLS devices (the oxygenator, the centrifugal pump, batteries, and extra oxygen). Considering the risks associated with takeoff and landing, as previously mentioned, these must be limited as far as possible. Therefore, aircraft size and range are two important criteria.

The cost of each air evacuation depends mainly on the flight distance and the type of aircraft. This specific repatriation cost around 44,000 euros, including 5000 euros of supplement for ECLS and the circulatory support team. It is also worth mentioning the savings made here on a quick repatriation, which decreased the risk of nosocomial infection with highly resistant bacteria in Turkey, and avoided a 2-wk stay of our patient in the Intensive Care Unit at the Turkish clinic.

When considering repatriation with use of ECLS, we need to take into account recognized ECLS indications and the risk-benefit balance for each case separately. Three factors need to be taken into account: a double medical team with its equipment available within 24 h, an appropriate air ambulance available in the same space of time, and medical management from the operation desk capable of organizing such transportation with the shortest delay, as soon as the first medical contacts have been made.

ECLS will be recommended mostly in cases where the patient is critical and unstable and located in poorly equipped, isolated facilities. This case's description is an example of repatriation for patients who previously could not be transferred due to the high risk involved in such transportation.

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