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Case Report

Transport of Critically Ill Children on Cardiopulmonary Support Assistance

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Abstract: Objective: To report two patients helicopter transport on mechanical cardiopulmonary support to a transplant center. Setting: Cardiac intensive care unit (CICU) and transport helicopter. Patients: A 9 kg and 22 kg children who suffer cardiac deterioration needing air transport on mechanical cardiopulmonary support. Interventions and Results: CPS was initiated to support these patients failing cardiac function. Transport on CPS of these two patients to a transplant institution was accomplished after determining that heart transplantation would be their more likely chance for recovery. Conclusion: A cardiac deterioration event that will lead to the need for heart transplantation can be acute and sudden sparing no time for early referral to a transplant center. It is necessary for heart centers to have a plan of action to provide inter-hospital transport on cardiopulmonary support (CPS). This protocol can involve transport by the referral institution, the receiving institution or a third institution. **Keywords:** cardiopulmonary support, pediatric, extracorporeal membrane oxygenation, Transplantation, Heart, helicopter transport. *JECT. 2010;42:80–83*

Mechanical cardiopulmonary support (CPS) is commonly used for children with severe cardiac dysfunction after cardiac surgery (1). We used a system that consists of a centrifugal pump and a hollow fiber oxygenator due to its low prime volume, ease of handling, and no requirement for gravity dependant venous drainage as in conventional extracorporeal membrane oxygenation (ECMO) systems. When the potential for return of adequate cardiac function is low and the only chance of meaningful recovery for these children is heart transplantation, the CPS system may be used because it is compact and relatively easier to transport.

Heart transplantation is offered by a limited number of specialized institutions within each state, therefore ground or air transport is necessary while on CPS. The logistics and planning needed is complex but feasible to accomplish this type of transport safely and efficiently. Extracorporeal support adverse outcome is not associated to the transport process itself according to literature reports (2). In addition, extracorporeal support as a bridge to heart transplant has been reported to be useful. One of the latest reports by Pollock et al. reported 21 out of 25 patients (13 myocarditis and 12 congenital heart disease) who underwent heart transplant survived to hospital discharge with 67% 1-year survival and 52% 5-year survival (3).

CASE REPORTS

We obtained Institutional Review Board approval to report two cases in which children were transported on CPS using a helicopter transport team.

Patient A

Patient A was a 9 kg patient with complex history of double outlet right ventricle, ventricular septal defect (VSD), severe pulmonary stenosis, and multiple aortopulmonary collateral arteries. At 1 month of age, the patient underwent placement of a 6 mm left ventricle (LV) to pulmonary artery (PA) conduit and unifocalization of several aorta-pulmonary collaterals. At age 15 months the child required replacement of LV–PA conduit with a larger size 16 mm conduit. Eight months later the child returned for

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closure of the residual VSD, atrial septal defect reduction, and placement of permanent pacing wires. Two days after the procedure, the child had progressive deterioration in her hemodynamic status. Medical management did not improve cardiac function and the child was placed urgently on CPS. Further evaluation determined that the prognosis for recovery in cardiac function was poor and the child was referred for heart transplant. Arrangements were made to transport the child on CPS to a transplant center.

Patient B

Patient B was a 27 kg patient with 1-week history of fever, headache, and fatigue. Prior to admission, the patient was treated with antibiotics and bronchodilators as an outpatient for a few days but continued to deteriorate. The patient was taken to the emergency department with a temperature of 95°F, heart rate 124/min, respiration 24/min, blood pressure 83/52, and saturation of 89% on room air. Cardiac evaluation revealed poor myocardial function with dilated myocardium and severe congestive heart failure. Diuretics were started and after cultures were obtained, intravenous antibiotics were given. Milrinone infusion was initiated and the patient was admitted to the Cardiac Intensive Care Unit (CICU). Several hours after admission, the patient deteriorated rapidly with severe hypotension and a wide complex tachycardia that required initiation of CPS. The patient's adenovirus titers returned positive and the diagnosis was confirmed to be decreased myocardial function due to adenoviral infection. After 3 days of support, there was no improvement in the patient's cardiac function and the decision was made to transfer the patient for heart transplant evaluation while on CPS.

Equipment

We used a CPS transport system from our partner institution. The CPS transport system weighs 144 lbs. Its length, width, and height are 31, 17, and 15.5 inches respectively. It includes Bio-pump console 550 (Bio-medicus® Medtronic, Minneapolis, MN), Micro-Temp pump (Gaymar Industries, Inc., Orchard Park, NY) to provide 37°C water to oxygenator heat exchanger, hematocrit/oxygen saturation unit (CDI™ 100 3M Health Care, Tustin, CA), and battery back up power unit (Smart Power, Houston, TX). They are all fixed onto an anchoring base. The anchoring base and circuit pole bracket were custom made to fit onto an AeroSled® (LifePort, Inc., Woodland, WA) helicopter transport litter.

Our CPS circuit was described before (4). It allows easy mounting to an intravenous pole so that all tubing components attach to the patient's stretcher, reducing the chances of inadvertent disruption of the tubing system. Electrical cords, medical gas tubing, and water hoses connect to the equipment consoles located on the litter next to the patient during air time or on the triple trolley utility cart during ground transport (Figures 1 and 2). The circuit consisted of 1/4″ tubing and Minimax-Plus (Medtronic, Inc., Minneapolis, MN) oxygenator for Patient A, and 3/8″ tubing with Affinity Oxygenator (Medtronic, Inc., Minneapolis, MN) for Patient B. Both patients had cannulation of the right carotid artery and right internal jugular vein. The arterial and venous cannulae (Bio-medicus® Medtronic, Inc., Minneapolis, MN) used were 10 and 14 FR in Patient A, and 15 and 17 Fr for Patient B, respectively.

The tubes were secured with custom made Edna clamps next to the patient (Pilling, Research Triangle Park, NC) (Figure 3). Then, the tubes were wrapped with a blanket, which was clamped to the transport stretcher using tubing clamps. Once the patient and circuit were secured, the patient, circuit, and stretcher were moved as a single unit thus minimizing the risk of accidental decannulation.

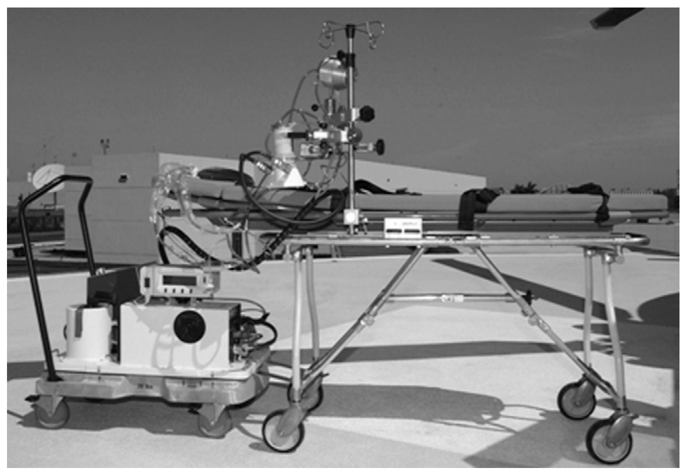

Figure 1. Transport CPS system on the ground.

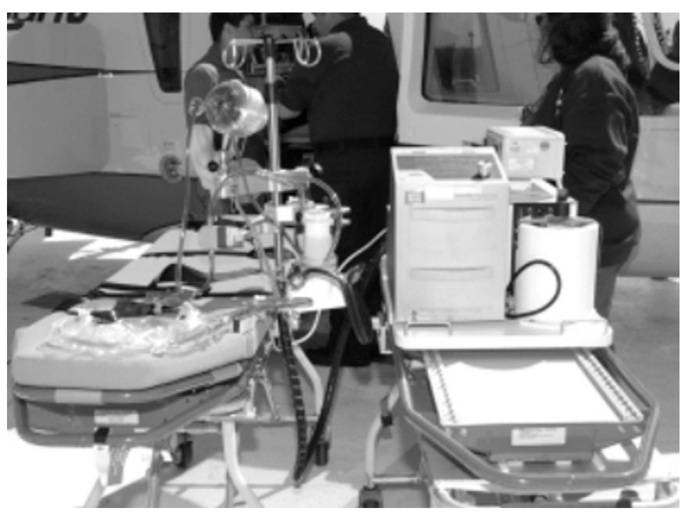

Figure 2. Transport CPS system ready for loading onto helicopter.

Figure 3. Costume made Edna tubing clamp.

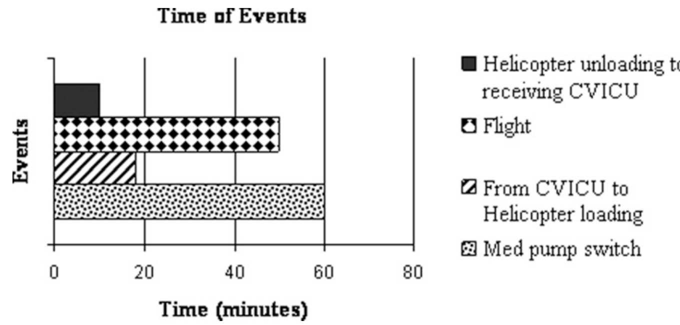

Figure 4. Transport time of events.

Clinical Issues during Transport

Circuit and patient surface heat loss prevention was provided with warm heavy blankets. Patient A pump blood flow rate was kept at 990 mL/min while Patient B pump blood flow rate was kept at 3 L/min. Pump flow was monitored with TX 50 P pediatric flow probe transducer and TX 50 adult flow probe transducer (Medtronic, Inc., Minneapolis, MN) Blood gases, lactate, and activated coagulation time were measured before and after helicopter loading using I Stat blood gas analyzer (Abbott Laboratories, Inc., East Windsor, NJ) and Hemochron Jr, (ITC, Edison, NJ).

Pump flows did not change with the helicopter taking off or landing, but fluctuations were noticed in blood pressure. These blood pressure changes responded to small volume infusion in both cases (50 mL packed red blood cells (PRBCs) for Patient A and 30 mL for Patient B). PRBC infusion was used to maintain hematocrit at or greater than 35% while on CPS. During transport to and from the aircraft, E-cylinder oxygen tank was used to provide gas supply. Once inside the aircraft, we connected to medical gases inside the helicopter. Hand crank and two E-cylinder oxygen tanks were available at all time during flights (the hand crank was mounted on the circuit pole next to the bio-console external unit). Other precautionary/preparatory measures included perfusion supplies bag (connectors, stopcocks, tubing, etc.) and blood products placed in front of the perfusionist. One unit of PRBC was preloaded in 60 mL syringes for possible rapid volume expansion.

Vehicle

Transport vehicle consisted of a helicopter (1997 Sikorsky S76 C+), which was customized to carry two patients and a medical crew of four. The medical cabin allows installation and removal of a transport stretcher so that patients and CPS transport systems are not tilted during loading or unloading.

Transport Logistics

The transplant center was contacted and the children met heart transplantation criteria. The transport vehicle had to be arranged along with the transport cardiopulmonary support system from our partner institution 235 miles away. Once the estimated time of arrival for the helicopter was known, our cardiovascular team (cardiac surgeon, operating room nurse, and scrub technician) was placed on alert. The team stayed at the bedside once the helicopter arrived.

The transport team consisted of two pilots, a cardiac surgeon, a perfusionist, a registered nurse, and an emergency medical technician. Once the patient was loaded on the stretcher, 20 minutes were needed to transfer the equipment and move the child to the helicopter. Actual flight time was 50 minutes (ground distance 115 miles). Time sequence of events is shown in Figure 4. Medical management and protocol during transport continued as patients were being treated in the CICU. Four units of PRBC, two units of platelets, and one unit of fresh frozen plasma were present in transport.

DISCUSSION

The transport CPS system described is lighter and more compact than other transport extracorporeal systems described in the literature (5). No pharmacological or technical interventions were necessary throughout the entire transport process. Both patients were successfully delivered to the receiving institution CICU without complications. Upon arrival to the receiving CICU both patients were transferred to the transplant center ECMO circuit. Patient A remained on extracorporeal support for 3 days and improved to extubation. Four weeks after transport the patient had a cardiac arrest and expired while awaiting transplantation. Patient B was transferred from extracorporeal support and transitioned to a Berlin Heart EXCOR® (Berlin, Germany) on Day 3 after transport and later was successfully transplanted and discharged home.

Transporting children on mechanical cardiopulmonary support can be done technically and safely (5,6). Detailed preparation of the patient and assembling the needed equipment and staff is important in securing an efficient and safe process. The most time-consuming phase of the process was the double witness verification of medications and the exchange to flight team medication pumps. The most risky time as far as the integrity of the cannulation site and the CPS circuit is during patient transfer from/to hospital bed and transport stretcher. Another challenging point during the process is the time of loading the patient into the helicopter. At this time more effort and coordination was needed than during unloading to the ground.

The main technical difficulties encountered inside the helicopter are related to the limited space and to noise levels. It is necessary to position equipment, patient, and crew such that critical items are within reach. Helicopter engine noise will not allow for any medical crew member to hear monitor alarm sounds. As a result, monitor screens from CPS console and patient hemodynamics must be positioned to allow direct visualization during flight. Accurate utilization of headphone and microphone to communicate among medical crew members is essential. From the practical point of view, extensive intervention on the patient is not feasible in route and the approach is one of prevention and avoidance.

Ideally, any institution performing complex cardiac care should be capable of either performing cardiac transplantation or of providing adequate support and a means of access to a transplant center.

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