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Case Report

Air Medical Transport of Patients Diagnosed With Confirmed Coronavirus Disease 2019 Infection Undergoing Extracorporeal Membrane Oxygenation: A Case Review and Lessons Learned

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A B S T R A C T

The coronavirus disease 2019 pandemic disrupted health care delivery in every respect, including critical care resources and the transport of patients requiring extracorporeal membrane oxygenation. Innovative solutions allowing for safe helicopter air transport of these critical patients is needed because extracorporeal membrane oxygenation resources are only available in specialty centers. We present a case demonstrating the interfacility collaboration of care for a patient with coronavirus disease 2019 infection and the lessons learned from the air transport. Careful planning, coordination, communication, and teamwork contributed to the safe transport of this patient and several others subsequently.

The coronavirus disease 2019 (COVID-19) pandemic has significantly disrupted the planet, and the critical care transport community is not immune. The efficacy of extracorporeal membrane oxygenation (ECMO) support, both venovenous and venoarterial, has been carefully studied throughout the COVID-19 pandemic. Although early evidence shows that there is some benefit to patients infected with COVID-19 who receive early ECMO support for persistent acute respiratory distress syndrome (ARDS) or pneumonia, many unknowns still exist.[1,2] Air rotary wing critical care transport programs evolved and pivoted to ensure safety for both patients and crews while providing high-quality critical care for patients. Through "ECMO-on-the-Go," a collaboration between Hartford HealthCare's Heart and Vascular Institute and LIFE STAR, our air medical program, we are able to provide primary ECMO capabilities (ie, patients deemed too unstable for interfacility transfer can have ECMO implanted at the sending center for stabilization with subsequent transfer to a tertiary care center) to COVID-19 patients with severe respiratory failure.

Although descriptions of ground medical transport of critically ill COVID-19–positive adults exist, patients undergoing primary ECMO therapy for COVID-19 infection moved by helicopter are not described and offer unique challenges. This report describes our first rotary wing air medical transport of a COVID-19–positive patient who underwent primary ECMO at a remote site and was transferred to a tertiary care center by helicopter and lessons we learned.

Case

A 43-year-old man with diabetes mellitus type 2 presented with dyspnea and was diagnosed with COVID-19 pneumonia. Over several days, his respiratory status decompensated with worsening hypercarbic and hypoxic respiratory failure despite aggressive therapy including intubation, prone positioning, high positive end-expiratory

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pressure (PEEP) ventilation, paralytics, and inhaled pulmonary vasodilator use. The ECMO-on-the-Go team was consulted, and the patient was deemed an appropriate candidate for venovenous ECMO therapy. Unfortunately, there were no local ECMO centers available to accept this patient, and the closest accepting center was 150 miles away.

This was a scenario previously considered by the ECMO-on-the-Go team, and preparations for such an event were already in place. Before making patient contact, the team addressed all variables, logistics, and anticipated challenges associated with the transport. It was decided among the pilot, air medical crew, and ECMO team that the patient could be safely transported by air to the receiving facility.

On arrival to the patient's bedside, the insertion team (ECMO physician lead/implanter, perfusionist, and LIFE STAR air medical crew [registered nurse paramedic, respiratory therapist paramedic, or paramedic]) found him intubated and supine in bed. His oxygen saturations were in the low 90s despite a PEEP of 22 cm H_2O and a fraction of inspired oxygen (F_{IO_2}) of 100%. The patients arterial blood gas on arrival was 7.29 with P_{CO_2} of 52, P_{O_2} of 54 on Volume Control/Assist Control, a respiratory rate of 22 breaths/min, tidal volume of 480, PEEP of 22 cm H_2O, and F_{IO_2} of 100%. He was tachycardic with labile blood pressures of 80/40 mm Hg despite a norepinephrine infusion. Propofol and fentanyl were infused for sedation and analgesia, as was inhaled epoprostenol for oxygenation.

ECMO support was initiated by the ECMO-on-the-Go team via an inflow cannula from the right femoral vein (24F end hole) and an outflow cannula to the right internal jugular vein (19F arterial cannula). Initial ECMO flows were 5.5 L/min with a sweep of 6 L/min. Once on ECMO, the heart rate decreased, and the blood pressure increased, with resultant downward titration of norepinephrine. Oxygen saturation increased to 100% and remained between 96% and 100% throughout transport. Post-ECMO, ABG was 7.43 with P_{CO_2} of 37, P_{O_2} of 109 on Pressure control ventilation/Assist control, a respiratory rate of 12 breaths/min, distending pressure of 28 (tidal volume of approximately 250 mL), PEEP of 15 cm H_2O, and F_{IO_2} of 80%. The patient was transitioned to hydromorphone and lorazepam infusions for sedation and analgesia while he was prepared for transport.

The team, taking appropriate personal protective equipment (PPE) precautions, transferred the patient and associated medical equipment to the helicopter stretcher. Careful consideration was taken when moving the patient to ensure that decannulation did not occur with manual stabilization of the cannula sites during position changes. The patient and associated medical equipment was wrapped in plastic bags to minimize contamination and secured into the aircraft in preparation for flight. In addition to the air medical crew, the physician and perfusionist escorted the patient to the receiving center.

En route to the receiving facility, the patient was monitored and critically stable. His heart rate remained in the 60s with systolic blood pressure in the 140s and diastolic blood pressure in the 60s despite a reduction in the norepinephrine dose, and his oxygen saturation remained 96% to 100%. He required no further interventions. Upon arrival to receiving facility, the patient was off-loaded and brought to the intensive care unit where the transition of care occurred without issue.

Once patient handoff was completed, decontamination of all equipment began in a predetermined decontamination area. All surfaces of the stretcher, monitor, ventilator, and ECMO console were thoroughly wiped down with disinfectant wipes according to our infectious disease department and the manufacturer's recommendations. Once completed, the crew went to the rooftop to decontaminate the aircraft. All doors to the aircraft were left open while the patient was being transferred to the receiving intensive care unit, allowing for approximately 45 minutes of ventilation of the aircraft. The entire interior was wiped down with disinfectant wipes and allowed to dry. Once decontamination was complete, all equipment was secured in the aircraft in the usual fashion. The return leg was then completed without incident.

After transport, a debriefing regarding the transfer and its operations with the medical crew, pilot, ECMO team, administrator on call, and communications specialist was conducted. On follow-up, the patient received a tracheostomy for short-term ventilator support and was subsequently weaned from ECMO, decannulated from his tracheostomy, and ultimately discharged home.

Discussion

To our knowledge, this is the first reported case discussing out-of-hospital transport of COVID-19−positive patients undergoing ECMO therapy by rotary wing aircraft. ECMO is successful in supporting patients during transport in cases of ARDS as well as other disease processes, both cardiac and pulmonary in nature.[3-32] The medical community infers that ECMO therapy may be beneficial in COVID-19−infected patients who are demonstrating cardiopulmonary deficiencies as a result of the infection and have reported its use.[33-57] Because the Food and Drug Administration has offered expanded use of ECMO during the COVID-19 pandemic, we can anticipate more patients being placed on ECMO support and needing transport to tertiary centers.[58]

The LIFE STAR air medical program, in collaboration with the Heart and Vascular Institute at Hartford HealthCare, continually refines its practice to optimize efficiency and safety during the transport. This service allows primary ECMO availability to patients otherwise too unstable for transport to tertiary and quaternary care.

At the time of submission, we have transported 101 patients undergoing ECMO therapy, with the majority of these transports being by ground ambulance. Recently, we started transporting appropriately selected ECMO patients by helicopter after demonstrating its feasibility using high-fidelity simulation. To date, we have flown 20 ECMO patients (8 of whom were COVID positive) successfully using procedures developed in this process.

Using air medical transport for ECMO patients is operationally challenging. Adding the factor of a highly infectious disease such as COVID-19 only increases the complexity of transport. After retrospectively reviewing our series of 8 COVID-19 ECMO helicopter transports thus far, there are several factors that we believe are essential to safely transporting these patients.

Coordination of the Transport

Central coordination is paramount in timely and safe patient evaluation and transport. Key factors include succinct and effective communication regarding team and hospital capabilities, clinical information, and coordination among service lines (air medical, physician, perfusion, and ground emergency medical services when needed). A central care logistics center is an effective means to achieve this degree of communication coordination. In our system, LIFE STAR's Emergency Communication Center works in parallel to determine which air medical crew is available and coordinate transportation based on the unique factors of the request.

Pretransport Time-out

Before every ECMO transport, a secure e-mail containing patient information is sent to the team. After the air medical team reviews the patient document, a conference call with the pilot, communications center, and ECMO physician occurs. Together, a determination is made on the best strategies for team insertion and patient retrieval (ground vs. air).

Several factors such as transport time, resource availability, duty hours, and patient condition are considered. If air transport is deemed beneficial, the pilot performs a weather check to determine air transport feasibility. If appropriate, the weights of the team, patient, and equipment are used to determine helicopter weight and balance for successful mission completion. Only then, after all factors are considered, is the final determination of air mission acceptance rendered. In light of COVID-19, other factors also need to be considered once a mission is accepted for air transport; ensuring we have enough PPE for the additional transport personnel, plastic bags to cover soft surfaces and prevent contamination, and a timeline of when pickup should occur are some of these mission-specific factors.

Infection Control and Predetermining the Necessary Equipment

It is essential to minimize the contamination of equipment and efficiently decontaminate the aircraft to ensure timely return to operational service. We used plastic bags to cover potentially needed equipment that was not in use before departure from the bedside. This also diminished the time required for posttransport decontamination. At the end of the transport, the used disposable equipment is discarded, and any reusable equipment is disinfected.

Keeping 1 Crewmember Clean

All team members at the patient's bedside are donned in full PPE when transitioning the patient over from the hospital equipment to the transport equipment and preparing them for transport. It was decided that the most efficient way to complete the transition would be to divide the air medical crew.

During the implant process, 1 team member tends to the patient and readies them for transport, whereas the other remains outside of the room to access and hand off additional needed equipment. We designated this outside crew member as the "clean crewmember," meaning that this person would not enter the isolation room, thereby decreasing exposure. Additionally, this eliminated unnecessary compromise of clean supplies and minimized donning and doffing of scarce PPE. Moreover, it reduced the risk of an accidental self-contamination/exposure because donning and doffing PPE properly can be challenging at times and creates an opportunity for self-contamination.

We chose the crewmember who rides in the front of the aircraft, apart from the patient and ECMO team, to remain clean, so the person caring for the patient may configure the aircraft in the most efficient manner possible (Fig. 1). The clean crewmember kept potentially needed items with him or her to be handed back to his or her partner if necessary such as push-dose medications and controlled substances.

Positioning in the Aircraft and Aircraft Setup

We developed a visual guide to standardize where things can be safely secured (Fig. 1). Aside from effectively securing all items for

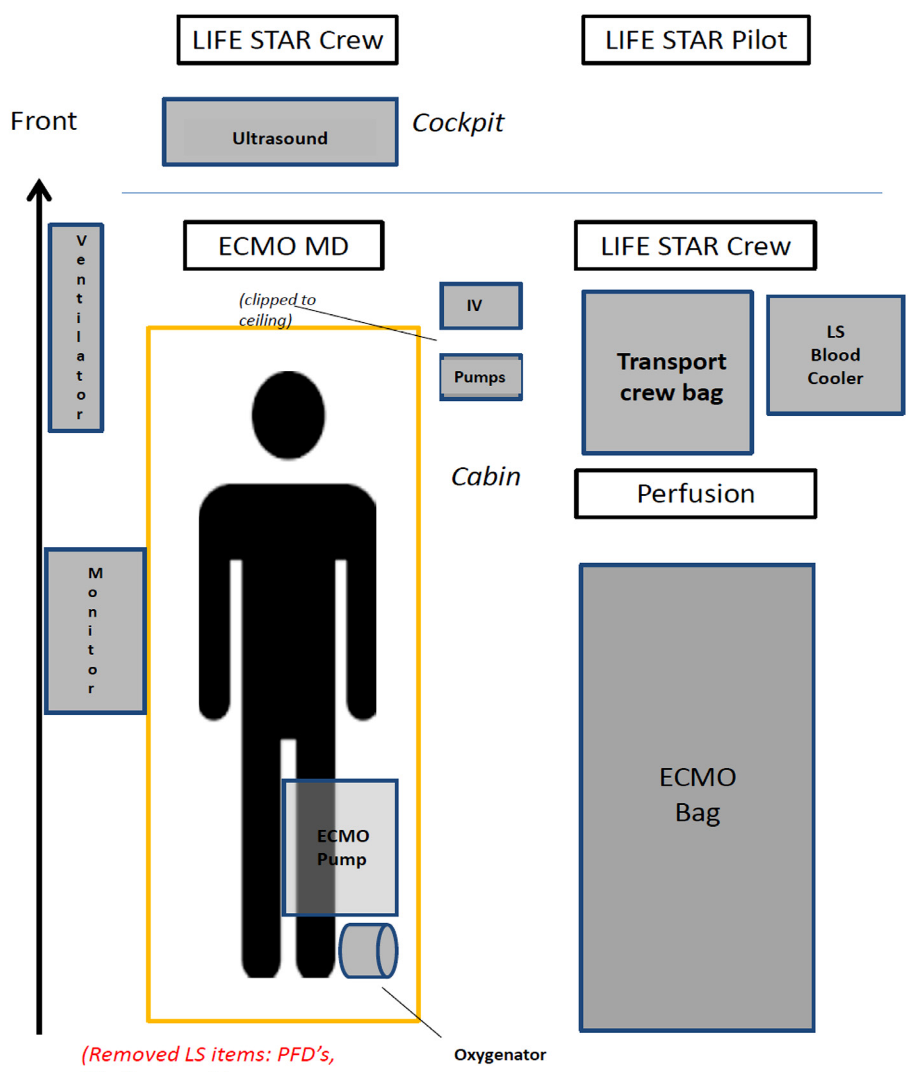

Figure 1.

transport, a major goal was minimizing contamination of equipment and personnel.

Before the mission, we remove unnecessary equipment from the back of the aircraft (this includes our ultrasound, trauma pack, and personal flotation device bag), reducing equipment vulnerable to contamination. All equipment bags were wrapped in plastic bags and secured to the floor. Anticipated equipment and medications are with the clean crewmember in front, reducing the likelihood of opening a plastic bag and decreasing contamination risk. All carrying cases for equipment were removed, allowing for easier cleaning and decreasing the need for laundering posttransport.

Posttransport Debrief

The COVID-19 ECMO transport by air is a dynamic process that is continually improving. The posttransport debrief is essential to process improvement. Lessons learned and meaningful solutions were quickly identified and assimilated by the team for the next mission.

Our administrator on call is also debriefed so operational issues on an administrative level are quickly addressed.

Summary

The COVID-19 pandemic presents unique challenges to the transportation of critically ill patients, particularly those requiring primary ECMO. With careful planning, coordination, communication, and teamwork, COVID-19 patients can be safely transported by helicopter.

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