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Case Report

Triple Threat: Postpartum, Coronavirus Disease 2019 Positive, and Requiring Extracorporeal Membrane Oxygenation

Brian M. Clough, EMT-P, FP-C *

Tampa General Hospital, Tampa, FL

A B S T R A C T

In the current coronavirus disease 2019 (COVID-19) pandemic, air medical transport has been faced with many challenges that have been taken for granted in the past. The transport of these patients has been shrouded in many controversies, from the appropriate level of personal protective equipment, what facilities are appropriate for which patients, and the appropriate means of transport for COVID-19 patients. When you add in multiple high-risk comorbidities, as well as specialized devices and treatment, the care becomes even more complicated. The case of a 34-year-old, 150-kg, pregnant female who presented to a critical access hospital with shortness of breath and rapid decompensation presented unique challenges when she tested positive for COVID-19. The patient underwent a cesarean section and rapidly decompensated to the point where extracorporeal membrane oxygenation was required. A cardiothoracic surgeon and perfusionist were flown with the flight crew to the critical access hospital to cannulate the patient before transport because of the patient's severely unstable hemodynamic status. The patient was admitted to a tertiary facility for multiple rounds of treatments and was later discharged back to the critical access hospital for rehabilitation and recovery.

An approximately 150-kg (body mass index of 50 kg/m^2 and body surface area of 2.7 m^2), 34-year-old woman presented to an outside hospital emergency department complaining of shortness of breath for 1 week. This patient was also 35 weeks' pregnant with no reported prenatal care. Shortly after the patient presented to the emergency department, she began to decompensate and was emergently taken to the operating room for a cesarean section. The patient was intubated for the procedure. After the procedure, the patient was unable to be extubated because of her worsening respiratory status. Upon transfer to the medical intensive care unit, the patient's coronavirus disease 2019 (COVID-19) nasal swab was positive. During the intensive care unit (ICU) admission, the patient went through multiple treatments to include airway pressure release ventilation and proning. The patient remained hemodynamically stable but critically ill because of her respiratory status until the day before transfer. The patient was admitted to the medical ICU for 8 days before the decision to transfer. On the day before the transfer, the patient was proned in bed. While attempting to roll the patient supine, the patient became bradycardic and hypotensive. This happened twice as the patient was rolled back to supine after proning. After the second incident, the patient could not lay flat and had to be sat up in a low Fowler's position in bed. The decision was made at the outside hospital for the patient to be transferred to a tertiary care facility with more capabilities to manage the patient and the disease. During the call to the receiving physician, it was determined that that patient would need to be cannulated for extracorporeal membrane oxygenation (ECMO) before the transfer because of the high risk of hemodynamic collapse during movement and transfer. The decision was made for the cardiothoracic surgeon and perfusionist to be flown with the flight crew to the critical access hospital to cannulate and place her on ECMO before transport.

On arrival of the flight team, which consisted of a registered nurse and a paramedic, and the cardiothoracic (CT) surgeon and perfusionist, the report was received. Because of the patient's COVID status, it was decided that the surgeon and perfusionist would enter the room with the intensivist from the critical access hospital and 1 bedside nurse to cannulate the patient. The flight crew assisted the surgeon and perfusionist in donning the appropriate personal protective equipment (PPE) to ensure the lowest exposure risk. Per the flight program's new COVID protocol, bunny suits (also known as clean room suits), N95 masks, gloves, goggles, and face shields were donned. The patient's initial vital signs noted on the critical access hospital's cardiac monitor

*Address for correspondence: Brian M. Clough, EMT-P, FP-C, Tampa General Hospital, 1 Tampa General Circle, Tampa, FL 33606.

E-mail address: BcloughPMD@gmail.com

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were arterial line blood pressure of 121/58 mm Hg, end-tidal carbon dioxide of 71 mm Hg, and oxygen saturation (SpO_2) of 95% on 100% fraction of inspired oxygen (FIO_2). The most recent arterial blood gas values obtained were pH of 7.23, $PaCO_2$ of 101, PaO_2 of 54.7, bicarbonate of 42.2, base excess (BE) of 12.4, and Arterial oxygen saturation (SaO_2)of 78.7. At this point, the CT surgeon and perfusionist entered the room and began cannulation. Because of the patient's body habitus, venous access was difficult to obtain, and initial cannulation of the inflow cannula took 25 minutes with an additional 25 minutes to obtain access for the outflow cannula. The patient was cannulated for venovenous ECMO in bilateral femoral veins. The arterial blood gas values after the initiation of ECMO were as follows: pH of 7.43, $PaCO_2$ of 57.6, PaO_2 of 113, bicarbonate of 38.7, BE of 13.1, and SaO_2 of 98.8. The initial ECMO settings were a flow of 4.16, O_2 sweep of 4 L/min, revolutions per minute (RPM) of 2,935, and venous oxygen saturation (SvO_2) of 60. Once cannulation and ECMO initiation were completed, the CT surgeon exited the room and doffed his PPE to remain "clean" for the remainder of the transfer. (The CT surgeon kept on the N95 mask and goggles as a precaution.)

At this point, the flight team entered the patient's room. Upon initiation of patient contact, the patient was on the following medications: 17.0 U/kg/h intravenous heparin, 35 μg/kg/min propofol, 7 μg/kg/min rocuronium, 75 μg/h fentanyl, and 50 ng/kg/min epoprostenol. The heparin drip was transferred to the transport pump, and epoprostenol was transported on the hospital pump using an in-line aerosolization device attached to the endotracheal tube proximal to the HEPA filter. Push doses of sedation (midazolam), analgesia (fentanyl), and paralytics (vecuronium) were administered. The patient was first transitioned to the transport ventilator (Revel; CareFusion, San Diego, CA). All efforts were used to prevent aerosolization and keep alveolar recruitment, including clamping the tube, applying the HEPA filter, and transitioning during an inspiratory hold. The initial ventilator settings were assist control volume, a respiratory rate of 30 breaths/min, FIO_2 of 100%, and a tidal volume of 250 (4 mL/kg ideal body weight of 62 kg). After the transition to the ventilator, the patient was noted to have a decrease in SpO_2 to 90% and SvO_2 to 50%. The patient took approximately 15 minutes to recover from ventilator transition and achieve SpO_2 of 98%. The patient was then transitioned over to the transport stretcher without incident. The patient was noted to have an increase in arterial blood pressure after the transition to the stretcher. The patient was then moved to the aircraft via a slide sheet, covered with an additional blanket to minimize possible contact contamination, and wrapped in a foil transport cocoon. The crew left on all PPE and began transport out to the aircraft. The patient was then loaded into the BK-117 airframe. Sedation was switched from midazolam to propofol to help better control the patient's blood pressure with good results. The transfer was completed without incident, and upon arrival to the receiving hospital, the patient was transferred to the designated COVID unit where staff had been reassigned from the cardiac ICU to manage the patient secondary to ECMO and the severity of the condition.

The admission course was complex, with multiple episodes in which the patient required vasopressor agents, blood products, and other treatments. The patient was trialed on hydroxychloroquine but was discontinued because of prolonged QT syndrome. The patient received convalescent plasma and tocilizumab as well. The patient was cannulated on ECMO for 17 days (approximately 404 hours) with no complications as it related to ECMO. On day 2 of the admission, the patient continued to test positive for COVD-19, and on day 5 of the admission the patient tested negative. She was also tested on the 2 subsequent days and tested negative as well. The patient underwent the placement of a tracheostomy and percutaneous endoscopic gastrostomy tube on day 3 of admission. During the admission, the patient also developed ventilator-acquired pneumonia and was treated with cefepime.

Discussion

By Land or by Air?

COVID-19 has changed the way that most, if not all, transports and patients are approached.[1] Many programs worldwide are transporting patients by ground if they are a COVID-19 rule-out or a COVID-19−positive patient. Most programs are using rotor wing as a last resort because of the crew's close proximity to the patient and the limited ability for appropriate ventilation systems.[2] There is also a common belief during this time that there is no emergency in a pandemic. However, there are instances when time may be limited because of the patient's condition, making rotor wing a better option than ground transport. In the case of this patient, air transport was used to facilitate the rapid delivery of the team. Because of the lack of critical care ground resources in the area, as well as the inability to use local EMS in this situation, it was determined that the most appropriate mode of transport to return this patient to the tertiary facility was also by air. The total patient care time for this case from patient contact (including cannulation) to transfer of care was approximately 4 hours. For this particular case, the air transport time was 16 minutes (33 miles) versus an approximately 60-minute ground transport time (47 miles). Increasing the amount of time in transport would add additional time in getting to the patient and add extra time in being exposed to a COVID-19−positive patient while in transport. Other considerations for choosing air versus ground transport relate to weight. In the case of this patient, there were 5 team members with a total weight of approximately 435 kg. With the addition of the patient weight (approximately 150 kg) and the ECMO machine and supplies (15 kg), there was 130 kg of available weight before reaching the aircraft's maximum gross weight. The fuel load was considered in the calculation of takeoff weight, and no additional fuel stops were needed during this transport. In cases in which there may be exceedance of the maximum gross weight, ground transport may be the only option. The Extracorporeal Life Support Organization (ELSO) has also developed guidelines for the transport of patients on ECMO or requiring ECMO cannulation[3] as well as updated guidelines on COVID-19−positive ECMO patients.[4]

To Cannulate or Not to Cannulate

In the current COVID-19 pandemic, ECMO seems to be becoming a more popular treatment option for patients in severe acute respiratory distress syndrome secondary to the disease. The initiation of ECMO appears to be occurring more and more at critical access facilities with subsequent transfer to tertiary care centers with ECMO managing/CT and pulmonary critical care capabilities. The physician faces a tough decision of when the appropriate time to initiate ECMO is.[5] In the case of this patient, the decision was made to cannulate the patient before transport secondary to the patient's inability to be moved without adverse events. The patient had also undergone traditional therapies for acute respiratory distress syndrome including proning and airway pressure release ventilation in an attempt to maximize oxygenation. The ELSO conventional venovenous ECMO indications of initiation of inhaled pulmonary vasodilators as well as PaO_2/FIO_2 ratio < 60 mm Hg for > 6 hours (PaO_2/FIO_2 ratio of 54.7 mm Hg for > 12 hours) were met.[4]

While initiating ECMO at an outside facility, there are many factors to consider. Can the patient be managed at the outside facility before transfer? Does the capacity exist to manage the patient within the system? In the current COVID-19 pandemic, ELSO has developed recommendations that address some of these issues including system capacity and patient triage to help guide decision making when patients are failing traditional treatment modalities.[4] It is the experience of the author that many times when a patient is cannulated at an outside facility, the perfusionist from the receiving facility is left with the patient until he or she is transferred. This allows the perfusionist to manage the ECMO device and circuit due to the outside facility staff being unfamiliar with the devices. In this patient's case, in which the surgeon was transported with the flight crew, there was no delay when the critical access hospital's staff had to manage the patient. In other cases, the staff needs to be comfortable treating and managing these patients for extended periods.

The decision to cannulate may need to be based on the local ability to transport the patient as well. In this patient's case, there is minimal access to critical care transport that is capable of transporting a patient who is receiving ECMO support. There is only 1 rotor wing program capable of transporting ECMO patients in the immediate area and minimal critical care ground transport that is proficient in the care and management of ECMO patients. Access to both critical care ground transport and utilization of local EMS for transport was unavailable for this patient. If a patient requires transport by ground, he or she will need to be accompanied by a nurse from the sending facility as well as a perfusionist. Not only can this cause delays in transport due to extended transport times but also increased exposure to the COVID-19 patient as stated previously.

With ECMO cannulation, there comes changes to mechanical ventilation. In this patient, a lung-protective tidal volume of 4 mL/kg of ideal body weight was used. The patient was also paralyzed with vecuronium to prevent ventilator desynchrony. The remainder of the ventilator settings in this patient were at the surgeon's request to limit the risk of patient decompensation. Minor adjustments were made after the ventilator changeover, and the patient did not tolerate them well. The ELSO guidelines do provide guidance for ventilator management strategies in the patient on ECMO support. There are also many other studies that show improved patient outcomes in those patients who undergo lung-protective ventilation strategies while on ECMO support.[5] Once this patient was admitted to the tertiary care facility, the ventilator settings were optimized to a lung-protective strategy with settings of assist control volume, a respiratory rate of 10 breaths/min, FIO_2 of 30%, and tidal volume of 250.[6] The patient showed no decline in condition on these settings.

PPE

Most EMS agencies and helicopter emergency medical service programs choose the highest level of PPE, including gloves, bunny suits or gowns, goggles, face shields, N95 masks, and hair coverings. Current Centers for Disease Control and Prevention recommendations are N95 or a higher-level respirator, face mask, gown, gloves, and eye protection.[7] The use of bunny suits is not part of current recommendations.

These use of high levels of PPE in the helicopter emergency medical services environment also pose unique challenges. When you factor in the use of helmets, you increase the amount of time that a crewmember must approach his or her face with potential contamination. Some programs, such as the one referenced in this case report, wear life vests on all flights due to flights over water. It was determined by the transporting program that at no time should safety during flight be compromised and that PPE should not interfere with pre-established safety guidelines.

Decontamination of the aircraft also has its challenges. In the aircraft used in this case report, there is a physical barrier separating the cockpit from the patient care compartment. This helped to mitigate the risk of exposure to the pilot as well as the avionics. Decontamination of the cockpit is performed to mitigate any potential of exposure after the transport of any COVID-19–positive patient. Decontamination of the patient care area consists of removing all equipment and supplies and thoroughly cleaning each item individually.

Before this transport, the transporting flight program developed a comprehensive procedure to ensure the highest level of protection for the providers. The process that was developed outlined every step, from the appropriate donning of the crewmember's PPE, to the appropriate way to transfer the patient, to the final transfer of care to mitigate exposure risk. A checklist was developed along with the procedure to ensure consistency. One of the checklist's most significant highlights was that at each step, the crew would stop and evaluate the situation to make sure all actions were being followed appropriately and forced the crew to slow down.

It should be noted that during this transport, the surgeon was allowed to lower his level of PPE to an N95 mask and goggles. With the physical separation between the cockpit and the patient care area, it was determined that the surgeon would be minimally exposed in the event of any aerosolization.

However, this procedure did not come without potential complications. With the program being based in Florida and the checklist being implemented in the late spring and summer months, outside temperatures reached heat indexes above 100°F with a humidity greater than 95% daily. Crews had to pay extra attention to hydration and their well-being because of the addition of the PPE. There was concern about contamination of the aircraft air conditioning system as well with patients who were not intubated, which led to further environmental considerations. While implementing the procedure, it was also discovered that the donning of helmets caused the N95 masks not to have a proper fit, so crew had to be fit tested again with different types of masks. There are also significant data showing that the highest risk of exposure when using bunny suits is during the doffing procedure.[8] After implementing the procedure and using it for many transports, the procedure was then re-evaluated. In coordination with recommendations from the Centers of Disease Control and Prevention along with the program's infectious disease department, it was determined that donning gowns, instead of bunny suits, would be sufficient protection. However, it should be noted that the decision to wear a gown versus a bunny suit was left up to the crewmembers based on their level of comfort. This change also allowed for better heat mitigation.

Outcome

The patient did well once ECMO support was discontinued. The patient was taken off ventilator support on day 28 of treatment, but her tracheostomy tube remained. On day 30 of admission, the patient was transferred to an outside facility for further rehabilitation and recovery. It should also be noted that the patient's baby tested negative for COVID-19 and was sent home 3 days after delivery with family with no complications related to the patient's condition.

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