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Original Research

Interhospital Transfer of Critically Ill Patients Because of Coronavirus Disease 19–Related Respiratory Failure

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A B S T R A C T

Objective: Interfacility transfer of patients with coronavirus disease 2019–related acute respiratory failure is high risk because of the severity of respiratory failure and potential for crew exposure. This article describes a hospital-based transport team's experience with interfacility transport of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2)–positive patients.

Methods: A retrospective study of transports for respiratory failure caused by SARS-CoV-2 was performed. All transports were performed by a single critical care transport team. The team was already trained in advanced mechanical ventilation, blood gas interpretation, and management of shock. Guidance from the Centers for Disease Control and Prevention was followed regarding the use of personal protective equipment.

Results: Twenty patients were enrolled. The average patient age was 47 years (standard deviation [SD] = 12 years). The average Acute Physiology and Chronic Health Evaluation and Sequential Organ Failure Assessment scores were 10 (SD = 4) and 24 (SD = 7), respectively. The average transport distance and time were 18 miles (SD = 9 miles) and 25 minutes (SD = 11 minutes), respectively. Nineteen patients were intubated, 9 of whom required advanced ventilation. Two patients were transported prone. One patient experienced unintentional extubation upon transfer from the stretcher to the destination facility bed. The patient was reintubated without event. No crewmembers contracted SARS-CoV-2 infection.

Conclusion: Interfacility transfer of severely ill SARS-CoV-2–positive patients is safe and feasible.

Transport of a critically ill patient requires detailed coordination to ensure the safety of both the patient and the transport team. Smaller and critical access hospitals, as well as stand-alone emergency departments, oftentimes do not have the capacity or resources to manage critically ill patients, especially in large volumes. Thus, transfer to a larger tertiary care facility is frequently indicated. Also, secondary and tertiary care centers may need to redistribute patients based on the available resources that would typically be available but are not because of the medical surge and the ability to manage patients.

In the wake of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) outbreak, there has been an influx of patients requiring complex critical care such as advanced mechanical ventilation and extracorporeal membrane oxygenation (ECMO). By May 31, 2020, there were 8,857 cases of COVID-19 and 468 COVID-19–related deaths in Washington, DC.[1] Also, at this time, the hospitals in Washington, DC collectively had a total of 108 COVID-19 patients requiring intensive care unit (ICU) level of care.[1] Globally, it is estimated that 11% of patients with COVID-19 infection require admission to the ICU and that 18% of all patients with COVID-19 infection will develop acute respiratory distress syndrome.[2] Moreover, 5% of symptomatic patients are deemed "critical," with a mortality rate as high as 49%.[3] These patients may require transfer to a hospital with resources to provide a higher level of care.

Transport of the critically ill patient represents a logistical challenge for patient care and is not without inherent risk. One study reported that as many as 68% of transports experienced "unexpected events," and 9% had "serious unexpected events." These serious events included hypotension, the need for intubation, and increased intracranial pressure.[4] These data demonstrate the need for a careful planning and decision-making process to ensure appropriate care of critically ill patients during transport. They also show the importance of having dedicated and well-trained transport teams with proper equipment and medical oversight. When caring for patients with infectious diseases, the

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transport team is also exposed to the additional risk of disease transmission. Studies have shown that prehospital personnel are at especially high risk of exposure, in part because of suboptimal adherence to universal precaution recommendations.[5,6]

The purpose of this article is to describe methods used by the critical care transport team of a quaternary care hospital to safely transfer COVID-19−positive patients with severe respiratory failure to a higher level of care. The aim is to offer solutions to other agencies who may be tasked with transporting similarly ill patients, both during the current pandemic as well as possible future ones.

Methods

This study is a retrospective review of patients who were transported from outlying hospitals to a regional referral center by a hospital-based critical care transport (CCT) team. This team was established in January 2018 and consists of a CCT nurse, critical care paramedic, and emergency medical technician. All team members have received additional training as noted in Table 1 and are overseen by a dedicated medical director. The team uses the Hamilton T-1 portable ventilator (Hamilton Medical, Bonaduz, Switzerland), which has the ability to provide airway pressure release ventilation (APRV) and carries the majority of standard medications used to manage critically ill patients.

After obtaining approval from the institutional review board, the transport logs and medical records of all consecutive COVID-19−positive patients who were transported from an outlying facility by the CCT team from March 1, 2020, to May 31, 2020, were abstracted. Only patients who were confirmed to be infected by the SARS-CoV-2 virus were enrolled. The referring facility was not contacted for additional information that was not available in the receiving facility's medical record.

The transport team was instructed to wear eye protection, an impervious gown, 2 pairs of gloves, and a fitted N95 mask for each transport and was asked to self-monitor for signs or symptoms of COVID-19 after they completed transfers. This involved twice-daily temperature checks and self-reporting of symptoms suggestive of COVID-19 infection. The ambulance was decontaminated with an ammonium chloride and chlorine dioxide (Vital Oxide RTU) virucidal fogging agent after each transport. Personal hygiene practices were emphasized.

Results

The CCT team performed 154 transports during the study period. Of this number, a total of 20 COVID-19−positive patient transports were completed and constituted the study cohort. All transports originated from within the District of Columbia, Virginia, or Maryland and terminated in Washington, DC. The average distance traveled by the transport team was 17.95 miles (standard deviation [SD] = 8.5 miles), and the average transport time was 25 minutes (SD = 11 minutes). Only 1 transport required the medical director to accompany the team, but no intervention was required by the physician. The decision to accompany the team was made by the medical director because this was the first time that the CCT team had to transport an intubated patient in the prone position. Overall, 18 patients were transported supine, and 2 were transported prone during the study period. Six (30%) of the transports necessitated real-time guidance and/or orders from the medical director compared with 81 of 1,402 (6%) transports in the 24 months before the COVID-19 pandemic. Nearly all guidance requested was related to advanced mechanical ventilation for severe hypoxic respiratory failure. Frequently, medical control was sought because of concomitant severe hypotension and hypoxemia despite pre-existing vasopressors and high ventilator settings.

The average age of the patients was 47 years (SD = 12 years), and 14 (70%) were men. The majority were Hispanic (n = 11, 55%) and the remainder were black (n = 7, 35%) and white (n = 2, 10%). The length of stay at the outside facility before transfer averaged 5.5 days (SD = 3.5 days). The reason for transfer included ECMO evaluation (n = 14, 70%) and a lack of ICU bed availability at the referring hospital (n = 6, 30%).

Paralytics were used before transport in 8 (40%) patients, and 5 (25%) patients had continuous paralytic infusion during the transport. Vasopressors were necessary before transport in 8 (40%) patients and were initiated during the transport in 9 (45%) patients. The most commonly used vasopressor was norepinephrine, which was used in 6 patients before transport and in 7 patients during transport. The average dose noted before transport was 8 μg/min (SD = 4 μg/min), whereas the average dose during transport was increased by the crew to 13 μg/min (SD = 9 μg/min). One patient required concomitant vasopressin infusion at 0.04 U/h before transport and 0.08 U/h during transport. Epinephrine was used for 2 patients at an average dose of 8 μg/min (SD = 4 μg/min) before transport and 12 μg/min (SD = 2 μg/min) during transport. Vasopressin infusion was used alone in 6 patients (30%) before transport. This infusion was stopped by the CCT team before transport because it was deemed to not be necessary to maintain an adequate blood pressure. One patient required concomitant support with epinephrine, norepinephrine, phenylephrine, and vasopressin. Patients were sedated during the transport using a combination of propofol (n = 6, 30%), opioid (n = 8, 40%), dexmedetomidine (n = 1, 5%), and benzodiazepines (n = 5, 25%).

Before transfer, 9 patients (45%) were being ventilated using the volume control mode (a combination of pressure regulated/volume control, continuous mandatory ventilation, and synchronized intermittent mandatory ventilation), and 9 patients (45%) were being ventilated using the APRV mode. One patient was on pressure control, and 1 patient was on a high-flow nasal cannula. The average volume control mode ventilator settings before transport were as follows: a fraction of inspired oxygen of 90% (SD = 15%), positive end-expiratory pressure of 16 cm H_2O (SD = 3 cm H_2O), tidal volume of 440 mL (SD = 48 mL), and a total respiratory rate of 25 breaths/min (SD = 10

Table 1
Critical Care Transport Team Added Scope of Practice and Training[a]

Nurse	Paramedic	EMT
• Intubation • Needle and surgical cricothyroidotomy • Tube thoracostomy insertion and management • Central line insertion • Ventilator management, including volume and pressure control modes and airway pressure release ventilation • Noninvasive ventilation, including positive-pressure ventilation and a high-flow nasal cannula • Blood gas interpretation and ventilator adjustment • Electrocardiographic interpretation and both electric and pharmacotherapy as indicated • Initiation of vasopressor therapy based on protocol	• Ventilator management, including volume and pressure control modes and airway pressure release ventilation • Surgical cricothyroidotomy • Blood gas interpretation and ventilator adjustment	• Assisting with setting up mechanical ventilation • Assisting with setting up ICU-level monitoring equipment

EMT = emergency medical technician; ICU = intensive care unit.
[a] Does not include skills that are commonly associated with a particular degree (eg, intubation for the paramedic).

breaths/min). The average APRV ventilator settings were high time of 4.5 seconds (SD = 1 second), low time of 0.6 second (SD = 0.1 second), high pressure of 30 cm H_2O (SD = 2.7 cm H_2O), and low pressure of 1.3 cm H_2O (SD = 3.3 cm H_2O). Adjunct treatments attempted before transfer included paralysis and/or prone positioning in 10 (50%) patients, paralysis in 10 (50%) patients, and inhaled prostacyclin or nitric oxide therapy in 3 (15%) patients. The average arterial blood gas before transport was pH of 7.3 (SD = 0.09), pco_2 of 51 mm Hg (SD = 13 mm Hg), po_2 of 97 mm Hg (SD = 61 mmHg), and oxygen saturation of 91% (SD = 10%). The average PaO2/FiO2 ratio was 108.

The mode of mechanical ventilation was not changed during transport. The average volume control mode ventilator settings were a fraction of inspired oxygen of 94% (SD = 12%), positive end-expiratory pressure of 15 cm H_2O (SD = 3 cm H_2O), tidal volume of 410 mL (SD = 111 mL), and a total respiratory rate of 22 breaths/min (SD = 7 breaths/min). The ventilator was adjusted to optimize oxygen saturation and end-tidal CO_2 while trying to avoid breath stacking. The average APRV ventilator settings were high time of 4.4 seconds (SD = 1.2 seconds), low time of 0.6 second (SD = 0.1 second), high pressure of 30 cm H_2O (SD = 4 cm H_2O), and low pressure of 0.1 cm H_2O (SD = 0.4 cm H_2O). The patient who was on a high-flow nasal cannula before transport was transitioned to 15 L/min via a mask and 6 L/min via a nasal cannula. This patient's transport time and distance were 20 minutes and 17 miles, respectively. The average oxygen saturation and end-tidal CO_2 levels during transport were 94% (SD = 8%) and 38 mm Hg (SD = 16 mm Hg), respectively. The average first blood gas results upon arrival to the receiving ICU were as follows: pH = 7.31 (SD = 0.1), pco_2 = 50 (SD = 16 mm Hg), po_2 = 109 mm Hg (SD = 68 mm Hg), and oxygen saturation of 92% (SD = 9%). However, the median po_2 was only 68 mm Hg because 3 patients had a po_2 greater than 150 mm Hg, which skewed the average significantly. Using the average po_2, the average PaO2/FiO2 ratio was 116, but this average was 72 if the 3 patients with outlying po_2 results were excluded.

The average initial Sequential Organ Failure Assessment and Acute Physiology and Chronic Health Evaluation scores on arrival to the receiving hospital were 10 (SD = 4) and 24 (SD = 7), respectively. ECMO was initiated in 5 (25%) patients. Of the 20 patients transported, 4 patients (20%) have been discharged, 11 patients (55%) died from progressive respiratory failure because of COVID-19, and 5 (25%) remain in the ICU. The hospital length of stay averaged 17 days (SD = 14 days).

There was 1 adverse event involving inadvertent extubation while transferring a patient from the ambulance to the destination ICU bed. This was immediately recognized, and the patient was reintubated without event by the receiving ICU team. Two patients died within 24 hours of transport because of their disease. No team members contracted COVID-19, and there were no other adverse events noted.

Discussion

The COVID-19 pandemic has forced health care providers to confront new problems, and the transportation of critically ill patients between facilities is no exception. This is the first study to report on interhospital transfer of COVID-19−positive patients with severe, acute, hypoxic respiratory failure. All but 1 patient required mechanical ventilation, and nearly half required vasopressor support. We found no evidence of transmission of SARS-CoV-2 from the patient to the transport team, and there was only 1 patient-associated adverse event noted with no long-term sequelae. There were also no instances of patient deterioration caused by transport.

Before the COVID-19 pandemic, the CCT team had been trained on the principles of advanced mechanical ventilation, including APRV, and blood gas interpretation/acid-base physiology. Before the COVID-19 pandemic, approximately 18% of their transports involved a patient who was intubated. As such, the CCT team was familiar with ventilator adjustment and movement of patients who are mechanically ventilated. This training was pivotal in their ability to transport patients with COVID-19−related acute respiratory failure.

In regard to prone positioning, the entire CCT team underwent "just-in-time" training by the ICU nursing staff, who have used prone positioning for many years for hypoxic respiratory failure. Specific points of education included how to position tubes and lines to ensure safety during the actual turn, how to pad pressure points to prevent pressure ulcers during transport, and how to assess for unintentional extubation upon completion of the turn. In addition to the CCT team, the medical director also underwent this training.

The back of an ambulance can be a disruptive environment, with frequent turns and uneven surfaces. Transporting intubated patients requires persistent vigilance to ensure the endotracheal tube does not become dislodged. This problem is well recognized and can have disastrous consequences if not recognized immediately.[7] Although the vast majority of patients were transported in the supine position, 2 required prone transport because of hypoxic respiratory failure that was refractory to conventional therapy. Both patients had already been placed prone at the referring facility for this reason. Transporting patients prone has been previously demonstrated as a safe technique in small patient studies.[8] Although air transport may allow for faster transport speed, ground transport offers the advantage of greater access to the patient for interventions. It is also possible to stop the ambulance as needed to carry out procedures, which is especially relevant in transporting patients in the prone position. If an event had occurred in which providers needed to supinate the patient and/or perform procedures (eg, reintubation), they would have been able to stop the ambulance and attend to the patient. This allowed a greater degree of confidence in quickly altering the CCT team's protocols to allow for prone transports.

The lack of a proper disinfection technique of the ambulance can lead to exposure of both the crew and subsequent patients to pathogens. This becomes particularly important when the patients being transported have a highly communicable disease and even more so when that disease has no currently proven efficacious treatment. Available evidence shows that SARS-CoV-2 can survive on various surfaces with the viability of the virus noted up to 72 hours.[9] The virus survives longest on steel and plastic surfaces, both of which are commonly found in ambulances. Therefore, we opted to decontaminate the ambulance after each COVID-19−positive transport with a fogging solution. Although this resulted in the unit being removed from service for at least 1 hour after each transport, CCT leadership felt that this was needed to assure crew safety and the continuity of operations. No transports were delayed or canceled as a result of the unit being out of service. Of note, the ambulance could be used for back-to-back COVID-19−related transports without being terminally cleaned, but such an event did not occur during the study period. We were also fortunate to have an ample supply of personal protective equipment and used accepted practices and protocols for personal protective equipment preservation.

Limitations

This study has several limitations that we acknowledge. It is a retrospective study that limited our ability to obtain clinical information on patient status before their transport. Although there was only 1 adverse event noted, the small sample size precludes us from being able to confidently comment on the safety of these high-risk transports. Future larger studies are needed to assess safety. Although we assessed final patient disposition, we did not assess daily changes in clinical status given that the study design was focused on the transport itself rather than outcomes associated with COVID-19 respiratory failure.

Conclusion

A properly equipped, well-trained transport team can provide safe interhospital transfer of critically ill patients without compromising either patient or team safety. This investigation into our experience transporting severely ill patients who tested positive for COVID-19 serves to demonstrate the importance of maintaining this resource. Health system–based transport teams provide an important logistical connection between where patients present and where they may need to be in order to receive the most appropriate care. As such, quaternary hospitals should invest in such systems as part of their mission to support community hospitals within their region and ultimately optimize health outcomes for their patients.

References

1. DC Government Coronavirus Data | coronavirus. dc.gov. Available at:https://coronavirus.dc.gov/page/coronavirus-data. Published 2020. Accessed June 19, 2020.
2. Zhang JJY, Lee KS, Ang LW, Leo YS, Young BE. Risk factors of severe disease and efficacy of treatment in patients infected with COVID-19: a systematic review, meta-analysis and meta-regression analysis. Clin Infect Dis. doi:10.1093/cid/ciaa576, accessed June 19, 2020.
3. Guan W, Ni Z, Hu Y, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med*. 2020;382:1708–1720.
4. Papson JPN, Russell KL, Taylor DMD. Unexpected events during the intrahospital transport of critically ill patients. *Acad Emerg Med*. 2007;14:574–577.
5. Bledsoe BE, Sweeney RJ, Berkeley RP, Cole KT, Forred WJ, Johnson LD. EMS provider compliance with infection control recommendations is suboptimal. *Prehosp Emerg Care*. 2014;18:290–294.
6. Teter J, Millin MG, Bissell R. Hand hygiene in emergency medical services. *Prehosp Emerg Care*. 2015;19:313–319.
7. Wang HE, Kupas DF, Paris PM, Bates RR, Yealy DM. Preliminary experience with a prospective, multi-centered evaluation of out-of-hospital endotracheal intubation. *Resuscitation*. 2003;58:49–58.
8. DellaVolpe JD, Lovett J, Martin–Gill C, Guyette FX. Transport of mechanically ventilated patients in the prone position. *Prehosp Emerg Care*. 2016;20:643–647.
9. Van Doremalen N, Bushmaker T, Morris DH, et al. Aerosol and surface stability of SARS-CoV-2 as compared with SARS-CoV-1. *N Engl J Med*. 2020;382:1564–1567.