

Improved Oxygenation After Transport in Patients With Hypoxemic Respiratory Failure

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Abstract

Objective: The purpose of this study is to measure the rate and magnitude of changes in oxygenation that occur in patients with hypoxemic respiratory failure after transport by a critical care transport team.

Methods: We performed a retrospective review of 239 transports of patients with hypoxemic respiratory failure requiring a fraction of inspired oxygen (FiO_2) > 50% transported from October 2009 to December 2012 from referring hospitals to 3 tertiary care hospitals. We analyzed the change the ratio of the partial pressure of oxygen in the blood to FiO_2 from the sending to the receiving hospital as well as the percentage saturation of oxygen (SpO_2) before, after, and en route.

Results: The mean change in the $\text{PaO}_2/\text{FiO}_2$ ratio from the sending to the receiving hospital was an increase of 27.62 (95% confidence interval [CI], 15.84-39.40; $P = .0003$). The mean change in PaO_2 was an increase of 27.85 mm Hg (CI, 17.49-38.22; $P < .0001$). The mean SpO_2 was not significantly changed at -0.12 (CI, -1.69 to 1.45 , $P = .9$). Despite improvement in the $\text{PaO}_2/\text{FiO}_2$ ratio and a stable SpO_2 on arrival, 28.1% of patients desaturated to $\text{SpO}_2 < 90\%$ in transport.

Conclusion: In patients with hypoxemic respiratory failure, $\text{PaO}_2/\text{FiO}_2$ and PaO_2 increased after transport by a critical care transport team despite 28.1% of patients desaturating with hypoxemia in transit.

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Introduction

Critical care transport (CCT) teams are highly trained professionals who are regularly called on to transport critically ill patients, either by air or ground. In the United States, CCT teams typically consist of specially trained nurses and paramedics¹⁻³ who provide airway management, advanced ventilator support, invasive monitoring, and other intensive care procedures beyond advanced life support capabilities, with a goal of providing care commensurate with that provided in an intensive care unit (ICU). Our CCT service is a consortium of 6 academic medical centers with approximately 2,700 transports a year, of which approximately 85% are interfacility.

Although CCT teams routinely transport extremely ill patients, many regional and national guidelines advise against transporting patients until they have been stabilized.⁴⁻⁶ The decision to transfer patients with respiratory failure is an issue of patient safety and requires weighing risks and benefits of transport. Critically ill patients have a high rate of deterioration in vital signs and other adverse events in transport although this rate appears to be lower when transported by dedicated CCT teams compared with traditional emergency medical service systems.^{7,8} Hypoxemic patients specifically have been considered 1 of the most hazardous patient populations to transport,^{4,9} and mechanical ventilation has been shown to be an independent risk factor for an adverse event in transit.^{7,8} However, when stabilization cannot occur until the patient receives tertiary-level care, one must decide if the benefits of transport outweigh the risks.^{4,6}

For patients with severe or time-sensitive critical illnesses such as trauma, stroke, and myocardial infarctions, regionalized centers have been shown to improve outcomes, and similar regionalization has been proposed for acute respiratory distress syndrome (ARDS) patients.¹⁰ Studies have shown that transferring ARDS patients to tertiary care centers, especially those with extracorporeal membrane oxygenation (ECMO) capabilities, improved survival over patients remaining in referring hospitals.^{11,12} Although numerous case series reported that initiating ECMO before transport improved the safety of traveling,¹³⁻¹⁵ ECMO cannulation is not universally available at all hospitals. While the benefit of transport to a tertiary care ECMO center has been shown and some authors have advocated ARDS regionalization, few studies have addressed the risks attributable to transport. We designed this retrospective study to measure the rate and magnitude changes in oxygenation that occur during and after a trans-

port by a CCT team for patients with severe hypoxemic respiratory failure.

Methods

This study was approved by the institutional review boards of the 3 receiving hospitals, with the institutional review boards waiving the need for informed consent. We performed a retrospective review of transports of patients with severe hypoxemic respiratory failure from October 2009 to December 2012 from referring hospitals to 3 tertiary care hospitals. All decisions to transfer a patient were initiated by the physicians at sending facilities. Transport records were searched for the terms “ARDS,” “hypoxia,” or “hypoxemia.” The charts of patients receiving at least a fraction of inspired oxygen (Fio_2) of 50% were selected for inclusion.

The primary outcome was the change in the partial pressure of oxygen (Pao_2) to the Fio_2 ratio from the sending facility to arrival at the receiving facility. Secondary outcomes were change in Pao_2 and the change in oxygen saturation in transport and on arrival at the receiving hospital, nadir saturation, and time spent at the nadir saturation. Desaturation was defined as an absolute decrease in the percentage saturation of oxygen (Spo_2) of at least 3% points, and a critical desaturation as an absolute drop in Spo_2 of 10% points regardless of the initial Spo_2 . Hypoxemia was defined as $\text{Spo}_2 < 90\%$, with severe hypoxemia as Spo_2 79% to 70%, and profound hypoxemia as $\text{Spo}_2 < 70\%$.^{16,17} Transports were performed by nurse and paramedic crews. Patients were ventilated in transport with an LTV 1200 (CareFusion Corporation, Yorba Linda, CA) transport ventilator. For documentation, the CCT teams record initial vital signs and ventilator settings at the sending facility along with the initial patient assessment. The teams record all ventilator changes and parameters in real time during transport. During the transport, vital signs are displayed continuously. The transport monitor stores the time-stamped vital sign information, with automatic collection at least every 5 minutes, and it is reproduced in the patient medical record after the transport. However, the crew will also note abnormal or changing vital signs, such as an Spo_2 nadir, even if it is not captured on the printout because 1 crewmember is always monitoring the vital signs and ventilator during transport.

The transport records were reviewed for demographic data and pertinent comorbidities, including obesity, asthma, chronic obstructive pulmonary disease, immunosuppression, and pregnancy. Information regarding diagnosis, as known to the CCT team, was recorded. Data reviewed from transport included vital signs, initial ventilator settings, and changes in the patients' vital signs. Highest and lowest oxygen saturations both before and during transport were recorded as well as the number of minutes at the lowest values. The number of minutes spent with the nadir Spo_2 in each tercile of desaturation (89%-80%, 79%-70%, $< 70\%$) was also noted. Arterial blood gas (ABG) and other pretransport laboratory data available to the CCT team were recorded. Charts were reviewed for adverse

events in transport, including overt barotrauma, defined as a new pneumothorax or pneumomediastinum, extubation, and cardiac arrest. Data extracted from receiving hospital records included oxygen saturation on arrival, initial arterial blood gas information, Fio_2 , and adverse events on arrival.

Data were analyzed in a descriptive manner. For the primary outcome, we compared the change in $\text{Pao}_2/\text{Fio}_2$ ratio at the sending with the value at the receiving hospital. We also compared the Pao_2 and Spo_2 before and after transport. We compared initial Spo_2 measurements with the lowest Spo_2 en route. For patients who desaturated in transport, we assessed the number of minutes the nadir saturation spent in the strata of desaturation from 89% to 80%, 79% to 70%, and $< 70\%$. For patients whose initial saturations were $> 90\%$, we noted how many dropped below 90% in transport. Subgroup analysis of patients from each stratum of oxygenation (100%-90%, 89%-80%, and $< 80\%$) as well as a subgroup of patients who were on an Fio_2 of 100% before transport was performed to analyze the percentage in each group that had changes in oxygenation during and after transport.

One patient had a cardiac arrest without return of spontaneous circulation during transport. This patient's data were included in all analyses except the changes in oxygenation parameters pre- and post-transport.

Statistical analyses were performed using JMP Pro version 11.0 (SAS Institute Inc, Cary, NC). Comparisons between the subgroups (initial saturations of 100%-90%, 89%-80%, and $< 80\%$) were performed using unmatched 2-tailed Student *t*-tests with unequal variances. A 95% CI was used. Confidence intervals for differences between parameters of interest before and after transport were performed using normative distribution with an alpha of 0.05. A scatterplot of $\text{Pao}_2/\text{Fio}_2$ before and after transport was used to determine the correlation of pre- and post-transport $\text{Pao}_2/\text{Fio}_2$. Changes in oxygenation and ventilation characteristics of the 239 patients were included in final analyses.

Results

We identified 239 charts for review. Patients were transferred from 52 community hospitals to 3 tertiary care centers. The most common etiology for respiratory failure was pneumonia, and 15.9% of patients had confirmed or suspected H1N1-related respiratory failure. Patient demographics are outlined in Table 1.

Three patients did not have Spo_2 measurements available, and 1 patient arrived in cardiac arrest, leaving 235 patients for Spo_2 analysis. Of the patients analyzed, 19.2% had an oxygen saturation of $< 90\%$ when the CCT team arrived for transport. Fifteen patients were not intubated at the time of the team's arrival, and of these, 12 were intubated by the team before transport. Two patients were transported on noninvasive ventilation, and the remaining patient was intubated in transport. One patient had a pneumothorax at the time of the receiving hospital chest x-ray, with a saturation of 95% and no pressor requirement. No patients were extubated or devel-

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