Critical Care Explorations

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Persevering With Prone Ventilation in Coronavirus Disease 2019 Pneumonia

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Background: As well as placing unprecedented demands on resources and staff involved in the care of these patients, there has been significant uncertainty regarding the optimal management of patients with coronavirus disease 2019 pneumonia. Randomized controlled trials have shown clear benefits of both neuromuscular blockade and prone positioning in treating moderate to severe acute respiratory distress syndrome, as defined by the Berlin Criteria.

Case Summary: We present a case of a 53-year-old patient with a severe coronavirus disease 2019 pneumonia who has made a remarkable recovery following a turbulent period on intensive care. During his stay, he was prone positioned on 16 consecutive occasions and is an exemplar of the many patients we treated who benefited considerably from this intervention.

Conclusion: We believe that sustained administration of prone position ventilation was instrumental in saving his life. While there is associated morbidity, we encourage clinicians to continue with this strategy beyond their normal practice.

Key Words: acute respiratory distress syndrome; coronavirus; coronavirus disease 2019; prone ventilation; proning; severe acute respiratory syndrome

The coronavirus disease 2019 (COVID-19) pandemic has affected ICUs in the National Health Service and around the world, with an unprecedented increase in admissions and demand on resources, clinical and nonclinical staff (1). In the United Kingdom, 9,623 patients were admitted to intensive care with confirmed COVID-19 pneumonia from March 2020 to June 2020. This compares to 5,782 patients admitted with other viral pneumonias in the previous 3 years. Patients admitted to intensive care with COVID-19 pneumonia have had an average length of stay of 11 days for survivors and nine for nonsurvivors, with an average duration of advanced respiratory support (continuous positive airway pressure, high-flow oxygen, or invasive ventilation) of 12 days. Intensive care mortality in this cohort of patients is currently 42.4% (2).

The management of patients with COVID-19 pneumonia has initiated a global debate regarding ventilatory management (3–5) following appreciation that this novel disease responds poorly to current best practice mechanical ventilation as described by the Acute Respiratory Distress Syndrome Network (ARDSNet) working group (6). The physiologic benefits of prone positioning include improved oxygenation, improved respiratory mechanics, homogenization of pleural pressure gradients, reduction of atelectasis, facilitation of drainage of secretions, and reduced ventilator-associated lung injury, as demonstrated by the Prone Positioning in Severe Acute Respiratory Distress Syndrome (PROSEVA) trial (7). This randomized controlled trial of 466 patients with severe acute respiratory distress syndrome (ARDS) showed a reduction in mortality of 50% in patients who underwent prone position ventilation for 18 hours daily for an average of 4 days. Prone positioning is, however, not without risk and is associated with significant morbidity. The high frequency of nerve injury and pressure sores, as well as the risks of line disconnection and accidental extubation, mean that prone positioning must be performed with meticulous attention being paid to placement of limbs and invasive lines (8).

We present a case of a 53-year-old male who was admitted to intensive care immediately upon arrival to the hospital. He had a prolonged intensive care stay and spent around 18 hours per day in the prone position for 16 consecutive days, which is significantly longer than previously reported cases (7, 9). This example highlights both the advantages and disadvantages of prone position ventilation.

CLINICAL CASE

Early in our initial COVID-19 surge phase, a 53-year-old man, with a medical history of type 2 diabetes mellitus and hypertension,

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Written consent was gained from patient for publication.

Crit Care Expl 2020; 2:e0222

DOI: 10.1097/CCE.0000000000000222

was admitted to intensive care directly from the emergency department, having arrived as a pre-alert to the COVID-19 resuscitation area. He described a 1-week history of cough, myalgia, nausea, anorexia, and fever. Initially, paramedics found him to be profoundly hypoxic with oxygen saturations of 76% on air. This did not improve with oxygen administration, and he arrived in hospital with oxygen saturations of 79% on 15 L/min via a nonrebreather mask. He had no chest pain and was able to talk in full sentences. On arrival to the emergency department, he was met by the intensive care team, and after initial observations and investigations, he was taken to the ICU.

Initial investigations showed a lymphocyte count of 0.8 ($\times 10^9$/L), a C-reactive protein of 138 mg/L, and four-quadrant infiltration on chest radiograph. Once in intensive care, noninvasive ventilation was commenced. There was a further deterioration overnight and by the next morning, the patient had developed severe ARDS, with a Pao_2/Fio_2 (P/F) ratio of 66 mm Hg. The decision was made to intubate the patient followed by immediate prone positioning. The patient was established on volume control - synchronized intermittent mandatory ventilation with tidal volumes strictly limited to 4–6 mL/kg, driving pressure limited to 15 cm H_2O, while targeting a Pao_2 of circa 60 mm Hg. At this stage of the pandemic, positive end-expiratory pressure was titrated according to the ARDSNet protocol. There was a very good response to prone ventilation, which was undertaken for 18 hours, followed by 6 hours supine before re-proning. The P/F ratio improved initially up to 225 mm Hg at the end of 18 hours and this improvement continued over the next 15 days with an almost daily rise in the P/F ratio from less than 75 mm Hg in the supine position to greater than 150 mm Hg when proned (**Fig. 1**).

A referral for extracorporeal membrane oxygenation was made on day 7, but the patient was not deemed suitable due to the duration of mechanical ventilation. Subsequently, piperacillin/tazobactam was administered to treat a ventilator-associated pneumonia as was treatment-dose dalteparin to manage a presumed pulmonary embolism. At this stage of the disease process, prone positioning became less effective. He did not receive any targeted COVID-19 treatment, having been entered into clinical trials for data collection only.

Through days 16–30, there was a steady improvement in the patient's respiratory function. Paralytic medication was stopped, and a surgical tracheostomy was performed on day 30 of his intensive care stay. Respiratory support was gradually reduced, leading up to discharge from intensive care after 48 days and from hospital 14 days later. Once the tracheostomy had been performed and sedation was reduced, it was discovered that the patient had suffered a brachial plexus injury while in the prone position. This mainly affected the function in his left hand. When discussing this with the patient following discharge from the ICU, he disclosed a history of mental health problems and a coping strategy of playing the guitar. His main complaint was that this would be affected due to the brachial plexus injury, making the follow-up by the rehabilitation and physiotherapy teams key in his ongoing care.

DISCUSSION AND CONCLUSIONS

Randomized controlled trials, including the PROSEVA trial, have shown significant mortality benefits in prone position ventilation in patients with ARDS. In the PROSEVA trial, the mean number of episodes of prone ventilation was four, resulting in a 50% reduction in mortality at 28 days (7). Our case presents a patient who had 16 consecutive episodes, suggesting a benefit in persisting with this ventilation strategy beyond the relatively short time undertaken by patients in the PROSEVA trial. A key factor, in this case, is that the patient remained in single organ failure, facilitating consideration of continued use of prone ventilation.

Prone position ventilation is a standard procedure in our ICU and is normally considered when P/F ratios approach 100 mm Hg. Despite our familiarity with the procedure, it was extensively rehearsed as we incorporated operating room personnel onto our staff and expanded from 36 to 60 beds. Pharmacological paralysis is maintained with cisatracurium and the patient ventilated with 100% oxygen, while a five-person team pronates the patient who is firmly "sandwiched" between bedsheets (10, 11). The five-person

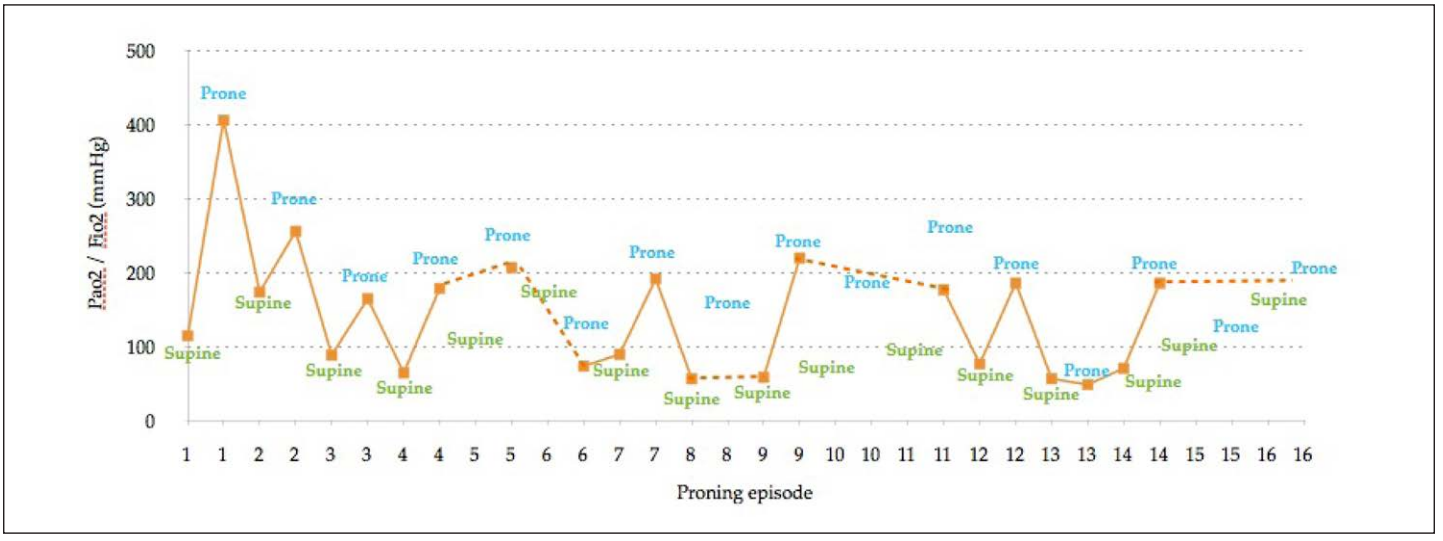

Figure 1. Pao_2/Fio_2 ratio showing peaks during prone ventilation with subsequent troughs when returned to supine.

team is led at the head end by a critical care doctor or advanced nurse practitioner with critical care nurses completing the rest of the team. Patients are left in a "swimming" prone position on pillows beneath the chest and pelvis for approximately 18 hours with head turns (undertaken by a similar team) every 2–4 hours. A proning timetable was generated which was handed over at each shift change.

During the first peak of the COVID-19 pandemic, our expanded ICU cared for 93 patients with COVID-19 pneumonia whom suffered a mortality of 35%. We prone positioned 53 of the 66 ventilated patients (80%) we cared for; however, the patient described here was a notable outlier due to the number of proning episodes he completed. It is remarkable that this patient survived following a prolonged and turbulent intensive care stay, however, there was a significant morbidity associated with this. The brachial plexus injury, as well as superficial facial pressure sores, were a result of repeated prone positioning. While both are recognized complications of treating patients in the prone position (12, 13), we emphasize the need to meticulously check pressure areas and the care with which patients are positioned. This applies equally to both turning the patient from supine to prone, prone to supine, and when head turns are performed to achieve a satisfactory swimming position.

We believe that the sustained administration of prone position ventilation in this patient was instrumental in saving his life. This case predates the evidence-based identification of effective specific therapy, and in the absence of a clear understanding of how best to mechanically ventilate patients with this disease, we undertook this effective intervention on a prolonged basis and for longer than our prior experience or otherwise know of. While this therapy did result in significant morbidity, this particular patient is accepting of this and grateful for the overall outcome. We would encourage clinicians to consider persevering with prone position ventilation beyond their normal practice, particularly in those with single organ failure.

Dr. Byrne sought consent for publication, wrote the initial draft, obtained relevant images, and made alterations after technical review by Drs. Bandla and Scott. Dr. Kler obtained and analyzed relevant data. Dr. Scott identified the educational benefits of this case and was supervising author.

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The authors have disclosed that they do not have any potential conflicts of interest.

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