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Case Report

Role of Implementing Proning Protocol as Rescue Treatment for severe ARDS in Trauma Patients - A Level 2 Trauma Center Experience

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Abstract

Background: Acute Lung Injury (ALI) and Acute Respiratory Distress Syndrome (ARDS) make up 7-10% of admitted patients (Koulouras, Esteban). Large randomized trials and meta-analyses have shown that prone ventilation when used in conjunction with lung protective strategies early and in sufficient duration may improve outcomes in patients with ARDS (Koulouras, Guerin, Voggenreiter, Fridrich, Gattinoni). As a new community based, Level 2 Trauma Center at a 455-bed community hospital, we found it necessary to have prone ventilation protocols in place in patients with traumatic ARDS.

Materials and Methods: In this paper, we present a case report of a young female patient who sustained multiple traumatic injuries with eventual development of ARDS. Prone ventilation was initiated with positive patient outcomes. A literature review was performed on PubMed using the following terms "ARDS", "Prone ventilation", "Traumatic Lung Injury", and "Lung Protective Ventilation".

Results and Discussion: The Berlin criteria and described pathogenesis of ARDS show inflammatory lung edema from increased permeability of pulmonary capillary endothelial cells and alveolar epithelial cells leading to reduced lung gas volume and development of nonaerated regions, resulting in respiratory failure which required invasive ventilation (Kim, Chiumello, Pelosi, Ranieri). However, despite recent advances in management of ARDS, mortality associated with the condition remain between 40-60% (Jozwiak, Papazian). The Proning Severe ARDS Patients (PROSEVA) trial demonstrated prone ventilation to decrease 28-day and 90-day mortality along with decreased time to extubation (Jozwiak, Guerin, Koulouras).

Conclusion: ARDS is a difficult condition to treat, as evidenced by persistently high mortality and morbidity. Polytrauma patients are at higher risks for development of ARDS and necessitate the most aggressive management. Using evidence from literature available, along with the case report described, we found it important to create standardized protocol for when prone ventilation should be initiated in community based centers with less ARDS volume.

Introduction

Acute Lung Injury (ALI) and Acute Respiratory Distress Syndrome (ARDS) make up for 7-10% of admitted patients [1,2]. ARDS was first described in the 1960s during the Vietnam War and it was not until 1974 that prone positioning was suggested to improve gas exchange in patients with severe ARDS [1,3,4]. ARDS has two major pathophysiological models - the "sponge lung" model and the "shape matching" model [1]. Prone positioning has proven to be in alignment with both models [1]. Large randomized trials and meta-analyses have shown that prone positioning when used in conjunction with early lung protective strategies for sufficient durations may improve survival in patients with ARDS [1,3-7].

The aim of this paper is to present a case of severe, refractory ARDS in a trauma patient that required prone positioning. As a community based, Level 2 trauma center with an average critical care admission of 10-15 per month, and injury severity score averages of 20-25, there was no standardized prone protocol in place. The following case of ARDS, which ultimately required rescue prone positioning therapy, led to development of protocols to recognize patients with ARDS who were candidates for prone ventilation.

Case Report

The patient was a 19-year-old female who was an unrestrained backseat passenger in a motor vehicle accident. The patient's injury severity score was 41-48. The patient suffered multiple traumatic injuries including multiple rib fractures, deglovement of the scalp, ruptured left globe, maxillary and mandibular fractures, right femoral and tibial fracture, ligamentous injury to the cervical spine, and acute respiratory failure. The patient required multiple trips to the operating room for treatment of her injuries; specifically, exploration of scalp wound, fixation of right femoral and tibial fracture, repair of severe eye injury, and ultimately a tracheostomy.

During the initial eight hospital days, the patient was responsive to APRV (Airway Pressure Release Ventilation). However, on hospital day 9 through 11, the patient remained persistently hypoxemic, with worsening of compliance that necessitated manual bagging to maintain adequate oxygenation. The addition of paralytic agents and adjustment to the ventilator were largely unsuccessful. Pressure controlled ventilator support was trialed unsuccessfully, with the patient unable to reach an SO2 of 85% as well as having a PaO2: FiO2 ratio that remained persistently < 150mmHg. The patient's hospital course led to the development of Acute Respiratory Distress Syndrome (ARDS) refractory to the traditionally described ARDS ventilator modalities.

Due to the lack of improvement with traditionally proposed ARDS management, prone ventilation was initiated. The patient was placed in prone position with Pressure Regulated Volume Control ventilation allowing Positive End-Expiratory Pressure (PEEP) to be increased to 12-14, Peak inspiratory Pressure (Pins Pressure) set to 32-34mmHg, Respiratory Rate (RR) of 28, and a Fraction of inspired Oxygen (FiO2) 80%. The patient maintained prone positioning for 16 hours with rotation of the bed every four hours (Q4hrs) which was followed with imaging to confirm positioning of the endotracheal tube. Improvement in aeration and pulmonary compliance was shown through serial ABG results. The patient's FiO2 and PEEP were titrated down on the second day of prone ventilation. Prone ventilation was discontinued on the third day of therapy, as the patient was able to tolerate APRV with a FiO2 of 50%, PEEP of 5, Pins Pressure of 33, RR of 20 and a TV of 400 (Figure 1).

Materials and Methods

A literature review was completed through PubMed. The search was conducted using the following terms- "ARDS", "Prone positioning", "Traumatic Lung Injury" and "Lung Protective Ventilation". Using the results of the literature review, we used evidence for the necessity of having a prone ventilation protocol in those being treated for ARDS in trauma patients. From this, an initial protocol was created for prone ventilation in traumatic patients who develop ARDS.

Results and Discussion

In 1994, the American and European Consesus Conference (AECC) characterized ARDS and ALI (Acute Lung Injury) based on the arterial oxygen tension to the inspired oxygen fraction (PaO2/ FiO2) - ALI is defined as havingPaO2/FiO2 ratio< 300mmHg, with

the diagnosis of ARDS occurring with a ratio <200mmHg [1,8,9]. In 2011 the European Society of Intensive Care Medicine proposed an updated version to the diagnostic criteria; termed as the Berlin Criteria. Although similar to the AECC, the newly proposed criteria considered timing, imaging, and the degree of hypoxemia and PEEP to characterize the severity of the disease [1,10]. The Berlin Criteria and the described pathogenesis of ARDS shows inflammatory pulmonary edema from increased permeability of pulmonary capillary endothelial cells and alveolar epithelial cells leading to reduced lung gas volume, with subsequent development of nonaerated regions, causing severe respiratory failure which require invasive ventilation [10-13]. Lung injury prediction score has been useful for predicting patients at risk for ARDS [3,11,14]. However, even with advances in treatment of ARDS, mortality associated with the disease remain 40-60% [15,16].

In the setting of traumatic injury, ARDS is associated with severe blunt chest trauma but occurs at an increased incidence in those suffering polytrauma [3,14]. The risk factors for developing trauma-associated ARDS include direct pulmonary injury, direct chest wall injury, aspiration, hemorrhagic shock, massive transfusion, older age, underlying diseases, malignancy, severe traumatic brain injury, and quadriplegia [3,15-20]. The patient described above, even though young and without several of the risk factors, presented with a significant injury severity score (41-48). The Proning Severe ARDS Patients (PROSEVA) trial results demonstrated prone ventilation to decrease 28-day and 90-day mortality as well as a shorter duration to extubation [1,5,15].

In 1974, Bryan et al, were the first to speculate and study the possible benefit of prone positioning in ARDS patients [1,3,4]. The current ARDS models, namely, "sponge lung" and "shape matching", categorize ARDS to be a heterogeneous syndrome, with the postulation that prone positioning may assist in recruitment of alveoli and the improvement of the associated pulmonary edema [11-20]. Additionally, the "sponge lung" model of ARDS describes the way gravity affects the pulmonary edema, which result in loss of aeration [1,7,17]. The "shape matching" model explains how prone ventilation can affect the inherent heterogeneity of alveolar stress and pulmonary edema to improve aeration, and oxygenation in patients with ARDS [1,19,20].

The patient described in this case report responded positively to the application of prone ventilation. As demonstrated in table 1, the patient showed a steadily decrease in FiO2 requirement after initiating
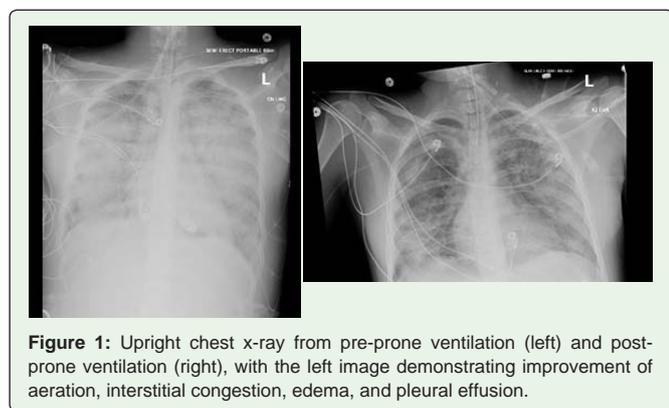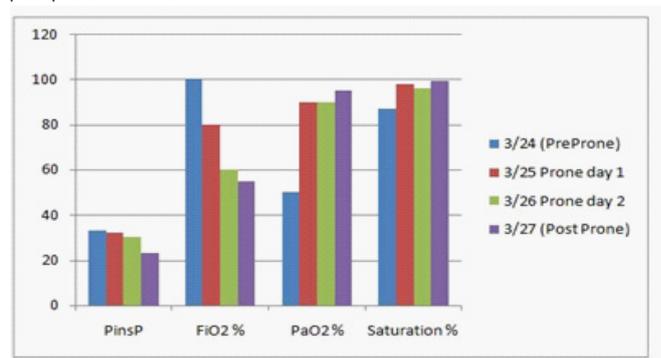
Figure 1: Upright chest x-ray from pre-prone ventilation (left) and post-prone ventilation (right), with the left image demonstrating improvement of aeration, interstitial congestion, edema, and pleural effusion.

Table 1: Clinical parameters in respiratory status from pre-prone ventilation to post-prone ventilation.

Table 2: PaO2/FiO2 measurements pre-prone ventilation and post-prone ventilation.
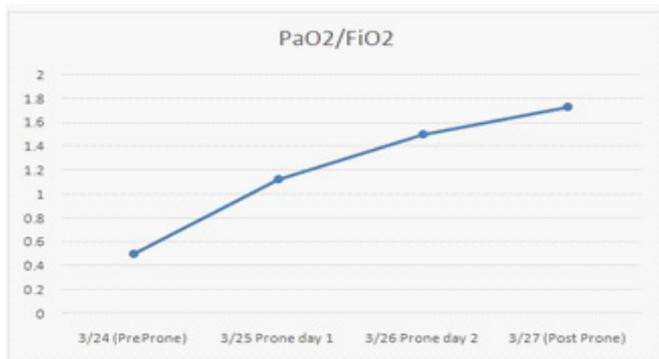
prone ventilation. Improvement in PaO2, oxygenation along with a decreased FiO2 requirement may be due to the shifting gravitational force and decreased in shunting associated with the "sponge lung" and "shape matching" models.

Prone positioning has shown to increase arterial oxygenation and pulmonary recruitment [15]. Proning patients have shown an improvement in intrapulmonary shunt with an increase in oxygenation from better ventilated, well-perfused lung areas with dorsal recruitment [1,5,7]. Increases in arterial oxygenation is evident by the increase in arterial oxygen pressure over inspired oxygen fraction (PaO2/FiO2) ratio as seen in table 2, showing increasing PaO2/FiO2 ratio after beginning prone ventilation [15].

Overall, this case demonstrated in conjunction with the literature above: prone positioning is a beneficial rescue therapy for refractory ARDS. The patient PaO2/FiO2 showed marked improvement, consistent with the literature review. In addition, patient clinical parameters showed expected recovery. It further proves the importance of creating a protocol to identify patients that are at risk and would benefit from prone positioning.

Conclusion

Acute Respiratory Distress Syndrome (ARDS) is severe lung injury leading to inflammation and edema preventing gas exchange and oxygenation. ARDS has high associated mortality rate and long-term morbidity. Overall, the results from using the treatment extrapolated from the literature review demonstrated prone positioning to be beneficial in those refractory to supine ventilation treatment in ARDS. It reiterates the importance of creating a protocol to identify patients that are at risk and would benefit from prone positioning. Patients that present with a high severity injury scores are at an increased risk for development of ARDS. As in this discussed case, the patient's dramatic improvement after initiation of prone ventilation, ultimately lead to the development protocoled procedures for prone ventilation and ARDS management of trauma patients at our institution. The protocol also allows us to train our staff and healthcare providers to implement rescue therapy in a timely manner. This protocol will provide some prospective data in the future to assist in improving patient care.

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