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ARDS with Severe Hypoxia—Aeromedical Transportation During Prone Ventilation

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SUMMARY

Severe hypoxia, despite maximal conventional respiratory support, is one of the few remaining limitations to aeromedical transportation. A case of a 35-year-old female, who was referred 36 hours following major trauma for transfer by air to a tertiary center, is presented. At the time of referral the P_aO_2/FiO_2 ratio was 48. Usual manoeuvres to improve oxygenation had only minimal impact. The patient was turned and subsequently transported prone with resultant improvement in P_aO_2/FiO_2 ratio to 260. There were no patient- or transport-related adverse events. The implication of prone positioning during aeromedical transportation is discussed.

Key Words: VENTILATION: prone aeromedical transportation

Persistent severe hypoxia, despite maximal conventional respiratory support, is one of the few remaining limiting factors to aeromedical transportation, even in aircraft capable of cabin pressurization to sea level altitude. The permissible level of severity of illness during aeromedical transportation has steadily increased over time due to expanding aviation and medical technology and retrieval team expertise.

Prior studies have documented the use of ECMO[1] and/or alternative ground transport of patients with profound hypoxia[2,3], some with P_aO_2/FiO_2 as low as 35. A proportion of such patients were transported in the prone position by road ambulance[2].

We describe the aeromedical transport of a patient with severe ARDS (P_aO_2/FiO_2 ratio of 48) in the prone position with resultant improvement in hypoxaemia.

CASE HISTORY

A 35-year-old female, involved in a high speed motor vehicle accident, was admitted to a rural hospital. Admission observations were a Glasgow Coma Score (GCS) of 14, pulse of 120 beats/min, systolic blood pressure of 130 mmHg and respiratory rate of 24 breaths/minute. Her abdomen was tender, with a number of abrasions and macroscopic haematuria. Cervical spine and chest X-rays were normal. Pelvic X-ray showed fractures of the pubic rami. A cystourethrogram excluded a bladder injury. Initial haemoglobin was 100 g/l.

Over the next 20 hours she remained tachycardic, with persistent abdominal pain and oliguria. GCS was maintained at 15, and the patient interacted with her family. Spinal immobilization procedures were not considered necessary. Based upon a fall in the haemoglobin to 57 g/l, an abdominal CT was performed, showing a splenic injury and large amount of intra-peritoneal blood. Non-operative management was decided upon. The abdominal symptoms persisted, and were associated with an increased abdominal girth (from 82 to 88 cm), oliguria, tachycardia (including an episode of supraventricular tachycardia), hypotension, respiratory difficulty and GCS of 13-14. A laparotomy and splenectomy was performed 26 hours following admission. Prior to laparotomy, the patient had received 1000 ml of colloid, 5000 ml of crystalloid and 3 units of packed red blood cells.

The patient remained intubated for two hours post-operatively, after which she was extubated and subsequently reintubated two hours later because of a persistently low SaO_2 (documented <88%). Mechanical ventilation was initially set at a tidal volume of 600 ml, rate 12 breaths/min, PEEP 5 cmH_2O and FiO_2 of 1.0. Soon after an arterial blood gas analysis showed a pH 7.25, P_aCO_2 45 mmHg, P_aO_2 48 mmHg, and HCO_3^- 19 mmol/l. Chest X-ray showed diffuse bilateral infiltrates, basal segment air bronchograms and the endotracheal tube to be in a good position.

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Peak airway pressures were 55 to 60 cmH_2O. Transfer to a tertiary ICU was requested 32 hours after admission.

A retrieval team consisting of a senior anaesthetic registrar from the NRMA CareFlight and NSW Air Ambulance flight nurse was dispatched. Upon arrival they found the patient to be sedated, ventilated in pressure control mode, with peak airway pressure set at 35 cmH_2O, rate at 14 breaths/min, PEEP of 5 cmH_2O and FiO_2 of 1.0. Blood pressure was 130/65 mmHg, heart rate 112 beats/min and central venous pressure (CVP) 11 mmHg (measured whilst PEEP set at 10 cmH_2O). The urine output was 0.4-0.6 ml/kg/h. A 12 lead ECG demonstrated only a sinus tachycardia.

Over the next four hours, various strategies to improve the P_aO_2/FiO_2 ratio were attempted. These included use of sigh breaths, increased PEEP to 15 cmH_2O and administration of a diuretic. Following these interventions the P_aO_2/FiO_2 ratio increased only to 53. After further consultation with receiving hospital staff it was decided to turn the patient prone.

This decision was based upon the potential consequences of prolonged unresolved hypoxia (approximately nine hours at this stage), failure of more conventional therapy, and probability of missed injuries. Severity of any head injury was considered likely to be minor as the admission GCS was 14, subsequently 15. Prevailing hypoxaemia was considered to be the greater threat for a secondary brain injury[12]. The likelihood of cervical spine injury, based upon the initial normal cervical spine X-rays, absence of suggestive signs or symptoms in the presence of no spinal immobilization until this point, was also balanced with the duration, severity and persistence of the hypoxia. There was no available CT radiology service at the time of day the retrieval team was present. Under the prevailing circumstances, intrahospital transport also had a high associated risk.

After one hour of prone ventilation, the P_aO_2/FiO_2 ratio had increased to 106, and then 207 immediately prior to departure (see Figure 1). As any gain in the P_aO_2/FiO_2 ratio could potentially have been gradually reversed upon return to the supine position, and that reversal may have reached its plateau whilst the patient was in transit, it was decided to transport the patient prone for the entire transport. Monitoring consisted of ECG, invasive blood pressure, SaO_2, $ETCO_2$, and high and low pressure airway alarms.

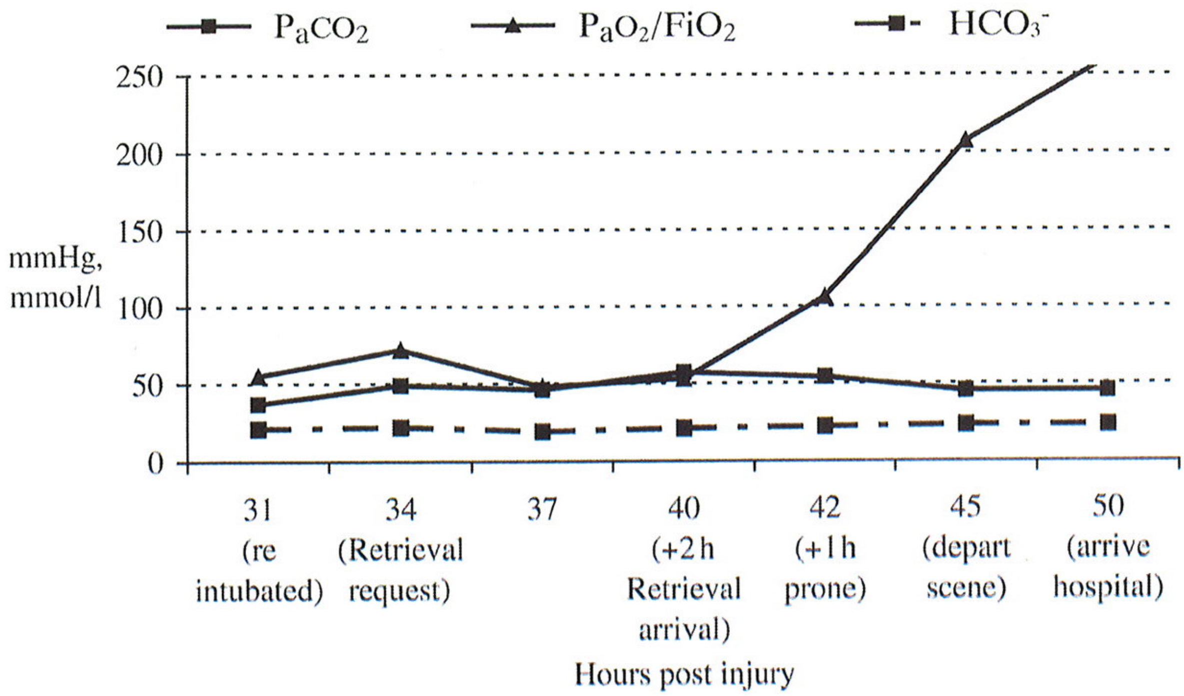

FIGURE 1: The events and associated alteration in blood gas variables associated with prone positioning.

REFERENCES

1. Linden V, Palmer K, Reinhard J et al. Inter-hospital transportation of patients with severe acute respiratory failure on extracorporeal membrane oxygenation national and international experience. Intensive Care Med 2001; 27:1643-1648.
2. Uusaro A, Parviainen I, Takala J, Ruokonen E. Safe long distance interhospital ground transfer of critically ill patients with acute severe unstable respiratory and circulatory failure. Intensive Care Med 2002; 28:1122-1125.
3. Gebremichael M, Borg U, Habashi NM et al. Interhospital transport of the extremely ill patient: the mobile intensive care unit. Crit Care Med 2000; 28:79-85.
4. Piehl MA, Brown RS. Use of extreme position changes in acute respiratory failure. Crit Care Med 1976; 4:13-14.
5. Douglas WW, Rehder K, Beynen FM, Sessler AD, Marsh HM. Improved oxygenation in patients with acute respiratory failure: the prone position. Am Rev Respir Dis 1977; 115:559-566.
6. Chatte G, Sab J-M, Dubois J-M, Sirodot M, Gaussorgues P, Robert D. Prone position in mechanically ventilated patients with severe acute respiratory failure. Am J Respir Crit Care Med 1997; 155:473-478.
7. Pelosi P, Tubiolo D, Mascheroni D et al. Effects of prone position on respiratory mechanics and gas exchange during acute lung injury. Am J Respir Crit Care Med 1998; 157:387-393.
8. Gattinoni L, Gianni T, Pesenti A et al. Effect of prone positioning on the survival of patients with acute respiratory failure. N Engl J Med 2001; 345:568-573.
9. Vollman KM, Bander JJ. Improved oxygenation utilizing a prone positioner in patients in patients with acute respiratory distress syndrome. Intensive Care Med 1996; 22:1105-1111.
10. Blanch L, Mancebo J, Perez M et al. Short term effects of prone position in critically ill patients with acute respiratory distress syndrome. Intensive Care Med 1997; 23:1033-1039.
11. Mure M, Glenny R, Domino K, Hlastala M. Pulmonary gas exchange improves in the prone position with abdominal distention. Am J Respir Crit Care Med 1988; 157:1785-1790.
12. Chestnut RM, Marshall LF, Klauber MR et al. The role of secondary brain injury in determining outcome from severe head injury. J Trauma 1993; 34:216-222.
13. Wishaw KJ, Munford BJ, Roby HP. The CareFlight stretcher bridge—a compact mobile intensive care module. Anaesth Intensive Care 1990; 18:234-238.
14. Mure M, Matling C-R, Lindahl SGE. Dramatic effect on oxygenation inpatients with severe acute lung insufficiency treated in the prone position. Crit Care Med 1997; 25:1539-1544.
15. Waydhas C, Schneck G, Duswald KH. Deterioration of respiratory function after intra-hospital transport of critically ill surgical patients. Intensive Care Med 1995; 21:784-789.
16. Marx G, Vangerow B, Hecker H et al. Predictors of respiratory function deterioration after transfer of critically ill patients. Intensive Care Med. 1998; 24:1157-1162.
17. Barker M, Beale R. Optimal positioning for the adult intensive care patient while prone. In 2000 Yearbook of intensive care and emergency medicine. J-L Vincent, ed. Springer 2000; 256-262.
18. Servillo G, Roupie R, De Robertis E et al. Effects of ventilation in ventral decubitis position on respiratory mechanics in adult respiratory distress syndrome. Intensive Care Med 1997; 23:1219-1224.

Ventilation was in IMV mode with 15 cmH_2O of PEEP. The patient was sedated and not given muscle relaxants.

The patient's estimated weight was 65 kg and height of 160 cm. Pillows were used to support the head, chest, pelvis and ankles. The eyes were taped closed. A stretcher bridge device, similar to that previously described[13], secured the monitors, syringe pumps and ventilator (Dräger Oxylog 2000) to the stretcher. The patient was secured to the stretcher by five seatbelts. Two belts were across each shoulder and buckled onto another, a horizontally aligned belt positioned at mid-stretcher level as well as a belt at the level of the patient's chest and knees.

There were no in-transit adverse patient or operational events. Soon after arrival at the receiving hospital, the P_aO_2/FiO_2 ratio was recorded to be 260. The patient was weaned from positive pressure ventilatory support and extubated over the next two days.

Total duty time for the retrieval doctor was almost 20 hours (beginning at 1800 hours) of which 16 hours was mission time. The retrieval team was first tasked at 2330 hours.

DISCUSSION

This case illustrates the clinical utility of prone ventilation during patient preparation and subsequent aeromedical transportation. Prone positioning allowed for an improvement in the P_aO_2/FiO_2 ratio and a greater degree of safety during transport.

Therapeutic prone positioning of patients with severe ARDS was suggested in 1976[4] and 1977[5]. Turning a patient prone during the early stages of ARDS results in improvement in oxygenation[4-7] and respiratory compliance[7] for 60-70% of patients[6-8]. Patients are more likely to show benefit if they have an indirect lung injury, are in the early stages of lung injury[9,10], have severe hypoxia[10] or intra-abdominal hypertension[11].

As much as 70% of improvement in P_aO_2/FiO_2 ratio occurs within the first hour following prone positioning[14]. Patients with P_aO_2/FiO_2 of less than 89 demonstrate the greatest benefit[8]. Despite patients who are ventilated prone not having been shown to have a survival benefit[8], the improvement in the P_aO_2/FiO_2 ratio reduces the risk of in transit hypoxia during transport[15,16].

Complications such as displacement of the endotracheal tube, thoracostomy tube or vascular access are no more frequent during prone positioning[8]. Consideration should be given to the increased incidence of new, or exacerbation of, existing pressure sores in at-risk areas, e.g. thorax, cheekbone, iliac crest, breast and knees[8] as well as joint position and neural tension (e.g. brachial plexus)[17]. Adverse events whilst prone have included the need for further sedation, increased/new onset patient/ventilator dyssynchrony, transient desaturation, airway obstruction, facial oedema, vomiting and dysrythmias[8]. Chest/pelvic supports do not appear to influence the impact on oxygenation as the latter improves with[18] and without[10] them.

Other actual or potential patient injuries should also be considered. Limb fractures and associated splints/traction, external pelvic fixation, spinal and facial fractures and presence and severity of traumatic brain injury are all considerations that may be relative or absolute contraindications to the prone position. These considerations may need to be evaluated, as in this case, in small rural hospitals, with limited resources, utilizing remote consultation and bàlancing what are often imprecise risk/benefit analyses.

Positioning a patient prone can require four to six people for a mean duration of 10 to 22 minutes[6,8]. When loaded into transport vehicles, supine patients are positioned so as to allow staff access to the patient. Prone positioned patients do not have the same orientation. This results in a deviation from the retrieval team's usual patient access and procedural practices. Transport stretcher length, width, restraint system and use of stretcher bridges can all impose restrictions on the allowable size of patients that can be positioned prone.

Transfer of patients in the prone position is an infrequent occurrence and exposure of individual retrieval team members is therefore likely to be small. Retrieval organizations that are involved in the care of such patients need to develop and rehearse appropriate policy and procedures and educate staff within their own transport environment. Special considerations include security of patient and medical equipment, team size, composition and duty hours. The alternative of awaiting possible improvement with conventional ventilation and delayed transportation must be balanced with the ability to supply and maintain a higher level of expertise at distant locations for an extended duration.

In summary, appropriately selected patients with profound hypoxia may benefit from and be safely transported in the prone position. Such patients provide significant clinical and logistical challenges to retrieval organizations. Considerations should include available resources at the referral location, patient actual and potential injuries, patient size, staff numbers and expertise, fatigue, patient monitoring, equipment and vehicle logistics.