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Case Report

Response to the prone position in spontaneously breathing patients with hypoxemic respiratory failure

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Objectives: The prone position is used for intubated patients with adult respiratory distress syndrome (ARDS) and acute lung injury (ALI). The physiological changes associated with the prone position in nonintubated patients may be even more favorable than in intubated patients. We examined the effect of the prone position on arterial blood gases and patient compliance in four awake, nonintubated patients with hypoxemic respiratory failure.
Design: We present four consecutive cases of hypoxemic respiratory failure, in which mechanical ventilation was indicated. An attempt was made to avoid assisted ventilation by placing patients in the prone position, while breathing spontaneously. The effect on the clinical condition and the changes in blood gases were registered.
Results: We found good patient tolerance. A rapid increase in PaO_2 was found, and intubation was avoided in all patients. No significant complications were registered.
Conclusion: The prone position may prove beneficial in some cases of hypoxemic respiratory failure, even in awake patients, by avoiding mechanical ventilation and ventilator-associated complications.

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Key words: Prone position; respiratory failure; spontaneous breathing.

Application of the prone position in mechanically ventilated patients with hypoxemic respiratory failure was introduced in 1975, and has been applied for cases of adult respiratory distress syndrome (ARDS) and acute lung injury (ALI). One study observed an effect on pulmonary edema (1). However, it is not widely applied, in spite of the effect on oxygenation. The average response rate is 69%, leading to reductions in FiO_2, Positive End-Expiratory Pressure (PEEP) and peak pressure. The incidence of ventilator-induced lung injury, which contributes to ARDS and ALI, may be reduced (2).

The prone position is most often applied to mechanically ventilated patients. Three cases of its use in spontaneously breathing patients, in addition to cases of infant pneumonia, have been described (3–5).

Physiological alterations associated with the prone position would also be considered to apply to spontaneously breathing patients and may be even more advantageous in this patient category. We present four cases of hypoxemic respiratory failure in which awake prone positioning was used. All patients were managed without mechanical ventilation or sedation.

Case 1

A 75-year-old female with a history of myocardial infarction, congestive heart failure, and recent vaginal hysterectomy, was admitted with ileus and dehydration. She presented with dyspnea, productive cough, pyrexia and elevated inflammatory markers. The chest X-ray showed bilateral pneumonic infiltrates. On day 7, the patient was transferred to the ICU with respiratory and circulatory failure. She was intubated and treated on mechanical ventilation with i.v. fluids, inotropic support and antibiotics.

As her condition improved, extubation was performed on day 13, but the following day the respiratory function declined. Body temperature and inflammatory markers increased, and bi-level noninvasive positive pressure ventilation was initiated (IPAP 9 cmH_2O/EPAP 3 cmH_2O). Nevertheless, the patient remained dyspneic and increasingly fatigued [respiratory rate (RR) 40 min^{-1}, PaO_2 9.2 kPa, $PaCO_2$ 6.2 kPa, pH 7.45] at an inspiratory oxygen fraction in the delivery system (FiO_2) of 0.7. The patient was placed in the prone position without ventilatory support, and she tolerated it well. After 50 min, dyspnea had markedly improved, and oxygen delivery could be reduced (RR 20 min^{-1}, PaO_2 10.4 kPa, $PaCO_2$ 6,0 kPa, pH 7.5, at an FiO_2 of 0.4). After 2 h the patient was turned supine, and maintained a $SaO_2 > 93\%$ with an unchanged FiO_2 of 0.4 for the following 24 h. On day 18 she suffered a cerebral infarction and died.

Case 2

A previously healthy 50-year-old male was admitted to the hematological ward with suspected myelodysplastic syndrome, with trombocytopenia, anemia, pyrexia and elevated inflammatory markers. He complained of shortness of breath and productive cough (PaO_2 6.2 kPa, $PaCO_2$ 4.8 kPa, pH 7.43 kPa at an FiO_2 of 0.21). Chest X-ray showed bilateral pulmonary infiltrates. Echocardiography was normal. Increasing respiratory distress developed, and he was transferred to the ICU. continuous positive airway pressure (CPAP; 10 cmH_2O) was initiated with no effect (RR 26 min^{-1}, PaO_2 6.7 kPa, $PaCO_2$ 3.3 kPa, pH 7.4 at an FiO_2 of 0.7). He was placed in the prone position for 4 h without CPAP. Dyspnea and blood gas values improved within an hour (RR 16 min^{-1}, PaO_2 7.9 kPa, $PaCO_2$ 5.3 kPa, pH 7.48 at an FiO_2 of 0.4). He was turned supine and returned to the ward the following day, with an unchanged FiO_2, and was discharged 8 days later.

Case 3

A 75-year-old female with chronic obstruntive pulmonary disease (COPD) and recent myocardial infarction was admitted with pneumonia. Chest X-ray showed a large unilateral infiltrate, but no signs of congestion. She presented with severe dyspnea, pyrexia and productive cough (RR 26 min^{-1}, PaO_2 6.7 kPa, $PaCO_2$ 11.0 kPa, pH 7.24 at an FiO_2 of 0.6). Bi-level noninvasive positive pressure ventilation was started (IPAP 11 cmH_2O/EPAP 7 cmH_2O) with an improvement in $PaCO_2$–8.0 kPa, but a reduction in PaO_2–5.6 kPa at an FiO_2 of 0.6. Treatment in the prone position, without ventilatory support, was initiated. The clinical condition improved within an hour, and the FiO_2 could be reduced to 0.3 (RR 20 PaO_2 9.1 kPa, $PaCO_2$ 9.5 kPa, pH 7.32). The clinical condition and blood gas values remained stable on the following days. Transfer to the general ward took place on day 5, and she was discharged on day 15.

Case 4

An 18-year-old female was admitted to the ICU with a 6-day history of cough, thoracic pain, pyrexia, increasing confusion and respiratory distress (RR 25 min^{-1}, PaO_2 8.2 kPa, $PaCO_2$ 7.0 kPa, pH 7.26 at an FiO_2 of 0.7). Chest X-ray showed a large unilateral infiltrate. Inflammatory markers were elevated and treatment with antibiotics was started. Because of respiratory distress with a raise in the RR to 36 min^{-1}, the patient was placed in the prone position. Within an hour, blood gas values improved (PaO_2 11.0 kPa, $PaCO_2$ 6.3 kPa, pH 7.30 at an FiO_2 of 0.7). The patient remained in the prone position for 5 h. In the supine position, the condition remained stable and oxygen delivery was reduced to a FiO_2 of 0.5 (RR 22 min^{-1}, PaO_2 9.3 kPa, $PaCO_2$ 4.9 kPa, pH 7.39). On day 4 she returned to the general ward, and she was discharged on day 10.

Discussion

The improvement of arterial oxygen tension in the prone position (PP) is based on three physiological mechanisms that reduce the ventilation/perfusion (V/Q) mismatch:

1. Dominant pulmonary perfusion dorsally and near the diaphragm in the supine position does not change to a dominant ventral perfusion in the prone position (6).
2. Atelectasis formation is reduced in the prone position (7). Inflammation and positive pressure ventilation increase atelectasis formation in the dependent lung portions, because of a less negative pleural pressure, and the weight of intrathoracic structures (8). In the prone position, atelectasis formation is less pronounced in the anterior portions, because of a more negative pleural pressure, and the heart resting on the sternum.
3. The prone position switches ventilation to more well-perfused regions (8). In healthy lungs, dependent regions are better ventilated in the supine position. In diseased and/or artificially ventilated patients with atelectasis of dependent lung portions, ventilation shifts to ventral regions, partly as a result of the weight of the abdominal viscera and the relaxed diaphragm. In the prone position atelectasis formation is reduced, and ventilation is partially shifted to the dorsal, well-perfused regions.

The prone position thus provides a more uniform perfusion, and shifts ventilation to well-perfused lung segments as demonstrated in studies on ARDS patients (8), and the principles are likely applicable to spontaneously breathing patients. A persistent improvement of oxygenation after prone position treatment may be the result of recruitment and of improved clearance of lung secretions (7).

The prone position applied on awake patients depends on tolerance and compliance. The procedure must be thoroughly explained. In most studies, patients are placed on supportive cushions under the pelvis and upper thorax to relieve the pressure on the abdomen, but in 20% of the studies the patients laid flat and no difference in response has been shown (8). The duration of prone position ventilation varies from 30 min to 42 h in the literature, and there are no clear recommendations. Common complications are pressure wounds, accidental extubation, loss of i.v. cannulas and other catheters, facial edema, corneal ulceration, and pressure neuropathies. These can be minimized if placement is carefully planned and carried out by experienced staff (8). Contraindications are severe facial injuries, raised intra cranial pressure (ICP), recent abdominal surgery, raised intra-abdominal pressure, intestinal ischemic, unstable fractures and unstable circulation.

The prone position contributes to the achievement of partial goals that may prevent intubation and mechanical ventilation. Several studies on prone position ventilation have been published (9), but a convincing reduction in mortality has not been shown (10).

Whether mechanically ventilated patients are comparable to spontaneously breathing patients in regard to the prone position is unclear. The prone position while the patient is awake may be a treatment modality for some cases of hypoxemic respiratory failure, and the findings in these cases warrant further studies.

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