THE EFFICIENCY OF PRONE POSITIONING IN A COPD FEMALE PATIENT WITH ACUTE RESPIRATORY FAILURE

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ABSTRACT

Introduction: Chronic obstructive pulmonary disease (COPD) is characterized by progressive impaired gas exchange in the lungs, which can lead to acute respiratory failure. Clinical trials showed that prone positioning (PP) has a positive effect on blood oxygenation and can decrease mortality. Although prone positioning in acute respiratory distress syndrome (ARDS) is generally associated with positive effects, the clinical response of the individual patient is hard to predict.

The study aimed to present a case study of a female patient with COPD hospitalized in an ICU due to acute respiratory failure, and to show the effectiveness of prone positioning during mechanical ventilation. The analysis of medical records (medical history, observation charts, tests results), observation of the patient, and monitoring of vital signs were carried out.

Case study: The patient with COPD experienced an exacerbation of symptoms with increased airway obstruction and hypoxaemia, followed by hypercapnia, which required the implementation of mechanical ventilation. Despite antibiotic therapy, mechanical ventilation, and treatment with glucocorticoids and bronchodilators, symptoms of respiratory failure with increasing obstruction persisted. During hospitalization, comprehensive treatment, nursing care, and rehabilitation were carried out. After implementing prone positioning for 4 consecutive days, 12-14 hours/day, a significant improvement in ventilation and gas exchange was achieved without complications associated with this positioning. This enabled the extubation of the patient and stabilization of her clinical condition.

Conclusions: Prone positioning was an effective element in treating the presented patient.

Key words: chronic obstructive pulmonary disease, acute respiratory failure, mechanical ventilation, prone position, nursing care.

INTRODUCTION

Chronic obstructive pulmonary disease (COPD) is an illness characterized by the progressive reduction of airflow through the respiratory tract due to pulmonary emphysema and the chronic inflammatory process in the respiratory tract. Some patients with COPD experience acute exacerbations that lead to acute respiratory distress syndrome (ARDS), which requires mechanical ventilation [1]. The prone position (PP) is now recommended for patients with severe or moderate-to-severe ARDS receiving invasive mechanical ventilation [2]. Numerous clinical trials have shown that prone positioning improves oxygenation in this group of patients [3-5]. Potential mechanisms of oxygenation benefit from patient proning are as follows: reduction of ventilation/perfusion mismatch, homogenizing the distribution of transpleural pressures, decreasing lung stress and strain by increasing lung volumes, and recruitment of nonaerated dorsal lung regions of the lung [2, 4-6]. Several multicentre prospective controlled trials (e.g. the PROSEVA study) and meta-analyses have shown that prone positioning in ARDS decreases mortality [4, 6-10].

Although the PP is generally associated with positive effects, the clinical response of an individual patient is sometimes hard to predict. According to arterial blood gas changes after proning, patients can be classified as "responders" or "non-responders" [3]. Apart from proven improvement in oxygenation, potential complications are associated with the PP [4], with different frequencies, such as the following: endotracheal tube/tracheostomy displacement, airway obstruction, cardiovascular system instability, displacement of intravenous lines, muscular-skeletal injury (brachial plex-

us), facial or peri-orbital oedema, corneal abrasions, pressure damage, and a greater need for paralysis or sedation [4, 7, 8, 11-13]. There are also contraindications for using the PP in some patients including the following: acute bleeding, multiple fractures or trauma, spinal instability, raised intracranial pressure > 30 mmHg, or cerebral perfusion pressure < 60 mmHg. Relative contraindications are as follows: shock (persistent mean arterial pressure < 65 mmHg), major abdominal surgery, recent pacemaker, severe burns, and clinical conditions limiting life expectancy [4]. Recently, some of the clinical conditions previously considered as contraindications have been revised; for example, massive obesity – an increasing ICU population worldwide, because these patients often benefit [14].

The study aimed to present the case study of a patient with acute respiratory failure and to show the effectiveness of prone positioning during mechanical ventilation.

The data were collected for 33 days during the patient's hospitalization in the ICU in one of the hospitals in Krakow. The analysis of medical records (medical history, intensive care observation charts, results of diagnostic tests and specialists' consultations), physical examination, observation of the patient, and monitoring of vital signs were used. Particular attention was paid to the patient's respiratory parameters during mechanical ventilation.

CASE STUDY

The study was carried out in a 72-year-old COPD female patient who developed acute respiratory failure requiring mechanical ventilation. The patient had been treated for COPD for 3 years. The comorbidities were as follows: arterial hypertension, obesity, chronic venous insufficiency, pre-tracheal nodules, and a tumour of the right adrenal gland. On the day preceding hospitalization, the patient experienced respiratory-expiratory dyspnoea and cough with a small amount of mucopurulent sputum. The patient was brought to the Hospital Emergency Department and then, due to severe respiratory-expiratory dyspnoea, was urgently referred to the hospital ward.

The patient's condition before admission to the ICU

The patient's condition was severe, and dyspnoea increased despite the treatment (nebulisations from Berodual 1 ml, Pulmicort 1000 µg, Solu-Medrol 60 mg i.v.). Due to the rapid deterioration of the patient's consciousness, hypoxaemia, CO_2 retention, and respiratory acidosis, the patient was intubated and transferred to the ICU for further treatment.

The period of mechanical ventilation in the supine position

In the ICU, mechanical ventilation and analgosedation (Fentanyl i.v. 100 mcg/h, Midazolam i.v. 10 mg/h) were implemented. Despite the treatment with glucocorticoid (Solu-Medrol 60 mg i.v.), theophylline (Teofilina 2 × 300 mg i.v.), nebulisations (Salbutamol 6 × 1 ml, Atrovent 2 × 100 mcg, Berodual 6 × 2 ml) and antibiotic therapy (Ceftriaxone 2 × 1 g i.v., Levoxa 1 × 500 mg i.v.), recurrent severe bronchial obstruction was noted. It was necessary to use deep analgosedation and neuromuscular blocking drugs (Cisatracurium i.v. infusion 14 mg/h or Rocuronium i.v. 50 mg/h) to ensure adequate ventilation. Between the 1st and 15th days of ICU stay, hypercapnia and hypoxaemia also persisted.

Table 1. Mechanical ventilation – parameters during analgosedation in the supine position (days 1-12 of hospitalization)

Day of ICU stay	Ventilation parameters							Oxygen saturation (%)
	Spontaneous breathing (rate/min)	Mode of ventilation	RR/min	FiO_2	TV (ml)	Ppeak (cm H_2O)	PEEP (cm H_2O)	
1-2	0	AC/PC	12-15	0.3-1.0	302-533	31-50	3-7	82-96
3-4	0-4	AC/PC	15-16	0.3-0.4	243-485	30-34	8	89-97
5-12	0	AC/PC	16-18	0.4-1.0	263-563	26-35	6-10	80-94

RR – respiratory rate, FiO_2 – fraction of inspired oxygen, TV – tidal volume, Ppeak – peak inspiratory pressure (PIP) – the highest level of pressure applied to the lungs during inhalation, PEEP – positive end-expiratory pressure

Table 2. Arterial blood gases during analgosedation in the supine position (days 1-12 of hospitalization)

Day of ICU stay	pH	pCO_2 (mmHg)	pO_2 (mmHg)	HCO_3^- (mmol/l)	BE (mmol/l)
1-2	7.215-7.340	48.3-57.9	70.7-105.0	17.5-27.6	–7.7 to +4.9
3-4	7.397-7.230	54.4-84.4	69.0-109.0	30.6-28.1	7.9 to 7.0
5-12	7.356-7.484	50.6-69.8	51.2-74.8	35.8-40.1	13.8 to 22.7

$PaCO_2$ – partial pressure of carbon dioxide, PaO_2 – partial pressure of oxygen, HCO_3^- – bicarbonate, BE – base excess

The parameters of mechanical ventilation and the results of blood gases tests are presented in Tables 1 and 2. Numerous infiltrative-atelectic foci were found in computed tomography (CT), mainly in the parabasal and dorsal locations.

The period of mechanical ventilation with prone positioning

Due to the atelectasis in the dorsal areas of the lungs, with severe hypoxaemia, mechanical ventilation was carried out in the prone position, after excluding contraindications, between the 13th and 16th days of hospitalisation (12-14 hours/day). Pharmacotherapy with glucocorticoid (Solu-Medrol 60 mg i.v.), theophylline (Teofilina 2 × 300 mg i.v.), and nebulisations (Salbutamol 6 × 1 ml, Atrovent 2 × 100 mcg, Berodual 6 × 2 ml, Nebbud 2 × 1000 ug) were continued as well as analgosedation and neuromuscular blocking. The gradual decrease in pCO_2 and an increase in pO_2 and saturation were observed with a reduction in ventilator support (Tables 3 and 4).

Table 3. Mechanical ventilation – parameters during analgosedation in the prone position (days 13-16 of hospitalization)

Day of ICU stay	Ventilation parameters							Oxygen saturation (%)
	Spontaneous breathing (rate/min)	Mode of ventilation	RR/min	FiO_2	TV (ml)	Ppeak (cm H_20)	PEEP (cm H_2O)	
13	0	AC/PC	18	0.65-0.7	384-540	27-35	10	87-98
14	0	AC/PC → AC/VC	14-18	0.4-0.7	478-570	26-31	10	91-98
15	0-9	AC/VC → AC/PC	12-14	0.4-0.45	400-631	25-28	10	91-97
16	1-7	AC/PC	12	0.3-0.45	476-825	25-26	10	93-99

RR – respiratory rate, FiO_2 – fraction of inspired oxygen, TV – tidal volume, Ppeak – peak inspiratory pressure (PIP) – the highest level of pressure applied to the lungs during inhalation, PEEP – positive end-expiratory pressure

Table 4. Arterial blood gases during analgosedation in the prone position (days 13-16 of hospitalization)

Day of ICU stay	pH	pCO_2 (mmHg)	pO_2 (mmHg)	HCO_3^- (mmol/l)	BE (mmol/l)
13	7.533	43.0	85.8	35.8	12.3
14	7.510	41.8	72.9	33.0	9.5
15	7.371	53.7	88.8	32.4	10.5
16	7.472	52.7	87.7	36.3	13.4

$PaCO_2$ – partial pressure of carbon dioxide, PaO_2 – partial pressure of oxygen, HCO_3^- – bicarbonate, BE – base excess

Table 5. Mechanical ventilation – parameters after discontinuation of sedative drugs during non-invasive ventilation (days 17-31 of hospitalization)

Day of ICU stay	Ventilation parameters							Oxygen saturation (%)
	Spontaneous breathing (rate/min)	Mode of ventilation	RR/min	FiO_2	TV (ml)	Ppeak (cm H_20)	PEEP (cm H_2O)	
17-20	6-12	AC/PC → AC/VC	12-14	0.3	370-621	20-26	9-10	91-98
21-23	2-19	AC/VC	10-14	0.26-0.3	363-503	18-26	10	96-99
24-31	10-18	BL/PC → BIPAP	1	0.21-0.3	380-678	19-21	6-10	96-100

RR – respiratory rate, FiO_2 – fraction of inspired oxygen, TV – tidal volume, Ppeak – peak inspiratory pressure (PIP) – the highest level of pressure applied to the lungs during inhalation, PEEP – positive end-expiratory pressure

Table 6. Arterial blood gases after discontinuation of sedative drugs during non-invasive ventilation (days 17-31 of hospitalization)

Day of ICU stay	pH	pCO_2 (mmHg)	pO_2 (mmHg)	HCO_3^- (mmol/l)	BE (mmol/l)
17-20	7.471-7.515	37.1-41.0	74.2-81.2	29.2-32.9	5.1-9.3
21-23	7.451-7.457	41.1-42.9	83.3-108.0	28.3-29.1	4.3-5.5
24-31	7.425-7.495	36.8-45.7	83.6-93.4	28.9-30.7	4.9-6.7

$PaCO_2$ – partial pressure of carbon dioxide, PaO_2 – partial pressure of oxygen, HCO_3^- – bicarbonate, BE – base excess

Mechanical ventilation after discontinuation of sedative drugs. Non-invasive ventilation and passive oxygen therapy

From the 17th day of hospitalization, the supply of analgosedative drugs was discontinued. The patient, however, did not regain consciousness. Pharmacotherapy was continued. The breathing parameters improved compared to the period before the PP was applied. Hypercapnia did not occur. A physical examination revealed an alveolar murmur above the pulmonary fields and no signs of obstruction. On the 19th day of hospitalization, the patient regained consciousness, initiated more breathings, and required less oxygen. Oxygen saturation values and respiratory parameters improved. On the 31st day of hospitalization, the patient was breathing through a T-tube and was extubated the same day. Non-invasive mask ventilation (NIV) was applied and then low-flow (2 l/min) oxygen therapy. In the following days, the patient breathed independently using oxygen therapy; pO_2 and pCO_2 in the blood were normal. Oxygen saturation was in the range 94-100%. The supply of Metypred (12 mg p.o.) and nebulisations with Berodual (4 × 2 ml) were continued (Tables 5 and 6).

After 33 days of ICU stay, the fully conscious patient was transferred to the pulmonology ward.

DISCUSSION

In the presented case study, the patient with COPD experienced an exacerbation of symptoms, with increased airway obstruction and hypoxaemia, followed by hypercapnia, which required the implementation of mechanical ventilation. Despite the antibiotic therapy, mechanical ventilation, treatment with glucocorticoids and bronchodilators, the symptoms of respiratory failure with increasing obstruction persisted. Because there were no contraindications for proning the patient, it was decided to implement such a postural treatment method. After using the PP for 4 consecutive days, 12-14 hours/day, a significant improvement in ventilation and gas exchange was achieved. The PP probably enabled reperfusion into ischaemic alveoli, leading to better blood oxygenation and gas exchange improvement [2, 4-6]. This enabled the patient to be weaned gradually from the ventilator and finally be extubated. It is noteworthy that combining the PP with PEEP and inhaled vasodilators could have had an additive effect in improving oxygenation and helped stabilize the gas exchange, as was shown in other studies [15].

Even though the PP has been used since the 1970s to treat severe hypoxaemia in patients with ARDS, it is still underutilized, mainly due to perceived cumbersomeness, the burdensome need for additional human resources, and a higher rate of adverse events [16].

In the presented case study, no complications of the PP were observed in the patient. The use of the prone position required an appropriate number of staff members, using their skills to position the patient and protect tissues particularly exposed to pressure ulcers. Comprehensive treatment, nursing care, monitoring, and rehabilitation were also carried out. These interventions resulted in a substantial improvement of the patient's condition.

CONCLUSIONS

In the presented case study, using prone positioning was very effective and led to improvement in the patient's blood oxygenation and normalization of her clinical condition.

Disclosure

The authors declare no conflict of interest.

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