

Management of mechanical ventilation in a morbidly obese patient with COVID-19-induced ARDS

S. DEMIRCAN, Z. KORKMAZ DISLI, S. KALKAN, A.B. OZER

Department of Anesthesiology and Intensive Care, Inonu University Medical School, Malatya, Turkey

Abstract. – Coronavirus disease 2019-induced acute respiratory distress syndrome (ARDS) is more severe in morbidly obese patients. Mechanical ventilation differs between obese and non-obese patients. We examined these differences in an obese (body mass index = 47 kg/m²) 32-year-old patient followed up in our clinic. The patient was admitted to the intensive care unit due to respiratory failure. Recruitment maneuvers were performed in pressure-controlled ventilation mode. The optimal positive end-expiratory pressure was 25 cm H₂O. The inspiratory pressure was adjusted to 45 cm H₂O to provide a tidal volume of 6 ml/kg and driving pressure ≤ 15. The patient was discharged with full recovery.

Key Words:

ARDS, COVID-19, Mechanical ventilation, Obesity.

Introduction

Obesity is a risk factor for severe disease in patients with COVID-19 and may cause respiratory failure^{1,2}. Obesity alone results in an increase in the respiratory workload and thus a higher likelihood of the need for ventilation. It also weakens the respiratory muscles and decreases respiratory compliance³. In coronavirus disease 2019 (COVID-19) patients who develop acute respiratory distress syndrome (ARDS), the adverse effects of obesity on breathing contribute to a worsening of their condition. Consequently, the management of mechanical ventilation in patients with COVID-19-induced ARDS may differ between the obese and non-obese. Here we describe the successful management of mechanical ventilation in a morbidly obese man with severe COVID-19-induced ARDS. We also briefly review similar cases reported in the literature.

Case Report

A 32-year-old morbidly obese (body mass index [BMI] = 47 kg/m²) male was admitted to our intensive care unit (ICU) because of respiratory failure on day 5 of hospitalization for COVID-19. His blood pressure was 115/70 mmHg, his heart rate and respiratory rate (RR) were 120/min and 40 breaths/min, respectively, and his oxygen saturation (SpO₂) was 80%. Oxygen therapy was intermittently administered *via* a high-flow nasal cannula and non-invasive bi-level positive airway pressure. Thorax computed tomography revealed bilateral diffuse ground glass densities and infiltrations, which were treated with methylprednisolone at a dose of 250 mg/day (Figure 1). His SpO₂ increased to 94% and his RR decreased to 25 breaths/min. However, the patient's respiratory condition deteriorated after approximately 2 h; the SpO₂ decreased to < 60% and the RR to 50 breath/min, so he was intubated. After the administration of sedation, analgesia, and muscle relaxants, a recruitment maneuver was performed in pressure-controlled ventilation (PCV) mode using the incremental positive end-expiratory pressure (PEEP) method. The ventilation parameters were as follows: optimal PEEP of 25 cm H₂O, tidal volume (VT) of 6 ml/kg, driving pressure (DP) of ≤ 15 [unit], total inspiratory pressure (P_{insp}) of 45 cm H₂O, and plateau pressure (P_{plat}) of 38 cm H₂O. With these pressure settings, the patient's SpO₂ increased from 40% to 92%. Recruitment was performed every 6 h, and the optimal PEEP and other parameters were adjusted (Table I). Muscle relaxant, sedation, and analgesia infusion were discontinued as the patient's respiratory mechanics improved. On day 7, the patient awoke and resumed spontaneous breathing. On day 9, pressure support ventilation was terminated, and he was successfully taken off mechanical

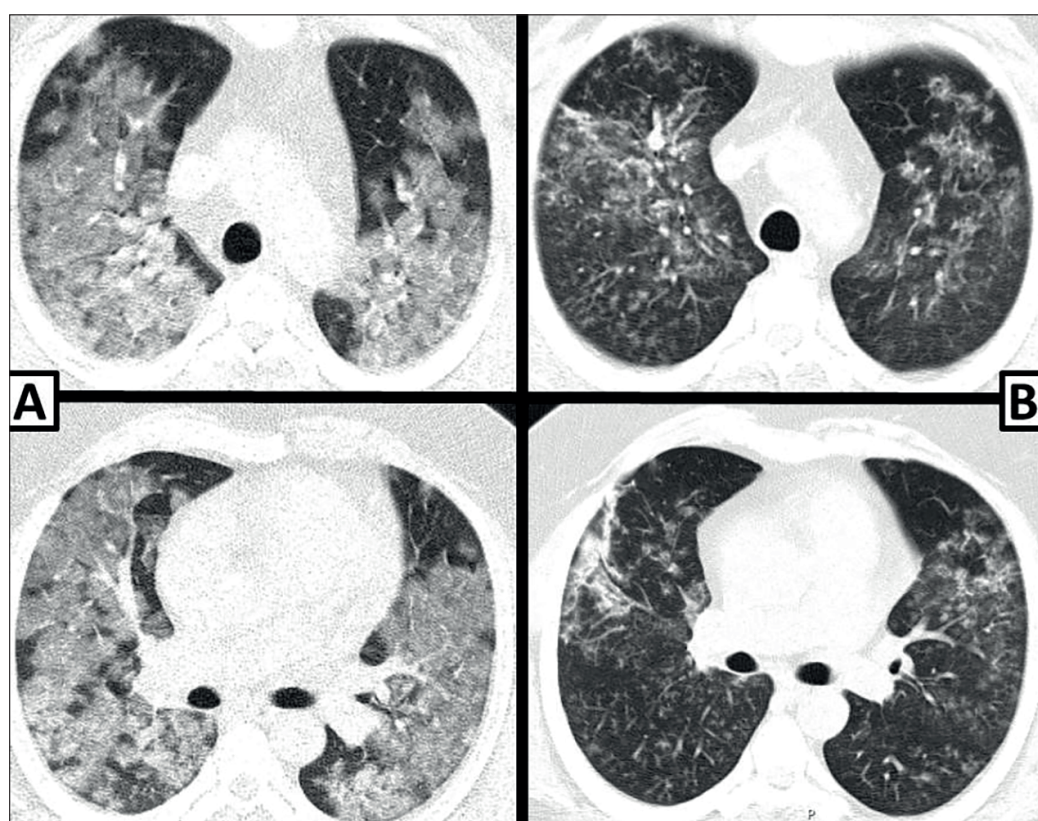


Figure 1. The patient's thorax computerized tomography images. **A**, Before ICU admission. **B**, 6 days after ICU discharge.

ventilation. His SpO₂ was 95% at a flow rate of 4 L O₂/min, provided *via* a nasal cannula. He was transferred to the ward on day 11.

Discussion

Among COVID-19 patients, ARDS accounts for a significant proportion of ICU admissions. Due to the adverse effects of obesity (BMI \geq

30 kg/m²) on respiratory function, many obese patients with COVID-19 who are hospitalized require mechanical ventilation and are admitted to the ICU⁴. These patients are at risk of ARDS, have a longer duration of mechanical ventilation and, accordingly, a longer ICU stay⁵. Moreover, ventilated patients are at risk of ventilator-induced lung injury (VILI) and will thus require lung-protective ventilation strategies, including a low VT of 4-8 ml/kg of estimated body weight

Table I. The patient's respiratory and laboratory findings.

	ICU admission	1 st day	3 rd day	5 th day	7 th day
PaO ₂ /FiO ₂	80	110	160	170	185
Pinsp (cm H ₂ O)	45	45	40	38	28
Pplat (cm H ₂ O)	38	36	33	30	26
PEEP (cm H ₂ O)	25	22	20	16	12
Compliance (ml/cm H ₂ O)	24	26	30	38	45
CRP (mg/dL)	3.5	29	6	2.3	1.2
Procalcitonin (ng/mL)	1.2	3	1.2	0.4	0.4
Lymphocyte (10 ³ /uL)	0.95	0.85	1.05	0.70	0.87
White blood cell (10 ³ /uL)	19.5	24.7	15.7	10.9	8.8
IL-6 (pg/mL)	442	20	8.3	2.5	2.8

and a Pplat of < 30 cm H₂O⁶. In addition, a higher PEEP has been shown to prevent cyclic atelectasis and re-open collapsed alveoli, thus increasing the breathing capacity and, in turn, the VT. These measures reduce the risk of alveolar overstrain and cyclic atelectasis⁷. Among patients with ARDS, those with a higher PEEP have improved oxygenation and a reduced mortality rate. Another key target in the mechanical ventilation of obese patients is a DP < 15 cm H₂O^{7,8}.

Our patient deteriorated clinically during non-invasive ventilation and was therefore intubated. During the initial phase of invasive mechanical ventilation, he had low saturation and compliance. PEEP levels were increased incrementally such that a level of 20 cm H₂O was reached, with a P_{insp} of 40 cm H₂O, compliance of 20 ml/cm H₂O, and SpO₂ of 86%. As compliance increased, the ventilation pressure also increased until an optimal PEEP of 25 cm H₂O was reached, with a compliance of 28 ml/cm H₂O. The inspiratory pressure required for a VT of 6 ml/kg was 45 cm H₂O, and the SpO₂ was 92%.

In a study comparing 21 obese and 44 non-obese patients with ARDS, increasing the PEEP from 5 to 15 cm H₂O resulted in similar changes in oxygenation and recruitability in the two groups. Fumagalli et al⁹ examined optimal PEEP titration methods in obese patients with ARDS (13 cm H₂O) and monitored the transpulmonary pressure (P_{TP}). A comparison of incremental (22 cm H₂O) and decremental (21 cm H₂O) PEEP showed that high PEEP levels provided better oxygenation and a lower DP.

Grasso et al¹⁰ reduced the use of extracorporeal mechanical oxygenation in patients with abdominal hypertension by increasing airway pressure based on a target P_{TP}, defined as the difference between the alveolar pressure and pleural pressure (PP). Karla et al¹¹ reported largely similar Pplat and DP values between obese and non-obese patients. De Jong et al² found no difference in DP between obese patients with ARDS who survived and those who died. Mezidi et al¹³ compared the PEEP in obese and non-obese patients with COVID-19 and showed that a higher PEEP (> 16 cm H₂O) in obese patients resulted in a smaller increase in Pplat than in non-obese patients (> 10 cm H₂O). They also reported that the esophageal pressure, as an indicator of PP, was higher in obese patients. Ball and Pelosi suggested the following formula for calculating Pplat in obese patients with ARDS: $27 + (\text{intraabdominal pressure} - 13)/2$ ¹⁴. In our patient, the Pplat was 38 cm

H₂O. In obese patients, reliable ventilation can be provided with higher alveolar pressure due to the increased PP.

In the maintenance of mechanical ventilation in obese patients with COVID-19-induced ARDS, good results can be achieved by determining the optimal PEEP in PCV mode based on the P_{TP} or on a DP ≤ 15 and low VT.

Informed Consent

The patient's signed informed consent was obtained.

Conflict of Interest

The Authors declare that they have no conflict of interests.

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