Respiratory Medicine Case Reports 25 (2018) 225–227

Contents lists available at ScienceDirect

Respiratory Medicine Case Reports

journal homepage: www.elsevier.com/locate/rmcr

Case report

Partial neuromuscular blockage to promote weaning from mechanical ventilation in severe ARDS: A case report

Peter Somhorst*, Mart W. Groot, Diederik Gommers

Department of Intensive Care, Erasmus MC – University Medical Center, Dr. Molewaterplein 40, 3015 GD, Rotterdam, The Netherlands

ARTICLE INFO

Keywords:
Acute respiratory distress syndrome
Neuromuscular blocking agents
Patient self-inflicted lung injury
Partial neuromuscular blockage

ABSTRACT

Spontaneous breathing efforts during mechanical ventilation can lead to patient self-inflicted lung injury (P-SILI). In order to prevent P-SILI, patients are generally heavily sedated and receive muscle relaxation, resulting in a slower weaning process. We present a case in which we applied partial neuromuscular blockage in order to prevent P-SILI while allowing spontaneous breathing but with limited efforts during assist mechanical ventilation.

1. Introduction

Protective ventilation with low tidal volumes and airway plateau pressure (P_{plat}) limitation is advocated especially in patients with severe acute respiratory distress syndrome (ARDS) [1]. Guérin et al. [2] showed that prone positioning reduces mortality in severe ARDS if applied immediately after diagnosis and during the first five days of mechanical ventilation. Also, neuromuscular blocking agents (NMBAs) were given during prone positioning. Earlier, it was shown that NMBAs improve outcome in early severe ARDS if applied during the first 48 hours [3].

Recently, Yoshida et al. [4] showed that spontaneous breathing efforts during mechanical ventilation can induce tremendous pressure (P_L) due to very low pleural pressure as a result of extreme effort of the diaphragm. This so-called P-SILI indicates additional injury that is a result of high local stress.

Doorduin et al. [5] showed the use of NMBAs can be used for partial neuromuscular blockage in patients with ARDS, reducing the tidal volume during pressure control ventilation or neurally adjusted ventilatory assist, thus reducing the risk of developing P-SILI. This was a proof-of-concept study in which partial neuromuscular blockage was applied only for two times one hour.

We report a case where we applied partial neuromuscular blockage as an escape strategy during assist mechanical ventilation after three weeks of mechanical ventilation for severe ARDS, in order to prevent high tidal volumes and promote the weaning process, resulting in significant and rapid patient improvement.

2. Case report

The patient was a man of eastern European origin in his late twenties with a medical history of depression for which he received antidepressant medication, and a history of Hepatitis B during his childhood for which he received Interferon type II (INF-γ). He recently travelled to the Netherlands for work. He presented himself to a general practice center with general malaise and dyspnea. He had a dry cough and a temperature of 40.4 °C. He received antibiotic treatment (augmentin) for a suspected pneumonia and was sent home. The next day he returned and was sent to the emergency room of a general hospital due to a low Sp_{O_2} of 83%. He was immediately admitted to the Intensive Care Unit (ICU) and intubated.

X-ray imaging (Fig. 1) showed bilateral patchy consolidations. Later, a polymerase chain reaction test would confirm the diagnosis of respiratory failure due to Influenza A infection. With a lowest measured ratio between Pa_{O_2} and Fi_{O_2} the of 76 mmHg and in absence of a suspicion of cardiac failure the patient satisfied the conditions for the diagnosis of severe ARDS [6]. The patient was transferred to our hospital with a possible indication for extra-corporeal membrane oxygenation. The following days the patient was treated with antibiotics (doxycycline, ciproxin, cefotaxim), anti-viral medication (oseltamivir) and active cooling. The patient was sedated, received muscle relaxation and was mechanically ventilated in prone positioning for approximately 16 h per day with a tidal volume (V_t) of 6 mL/kg_{IBW}, 20 cmH_2O of positive end-expiratory pressure (PEEP) and a peak airway pressure (P_{peak}) of 32 cmH_2O.

The esophageal pressure (P_{es}) and the intra-tracheal pressure (P_{trach}) were simultaneously measured to calculate the P_L. The P_L was 7 cmH_2O

* Corresponding author.
E-mail address: p.somhorst@erasmusmc.nl (P. Somhorst).

https://doi.org/10.1016/j.rmcr.2018.09.008
Received 20 June 2018; Received in revised form 11 September 2018; Accepted 11 September 2018

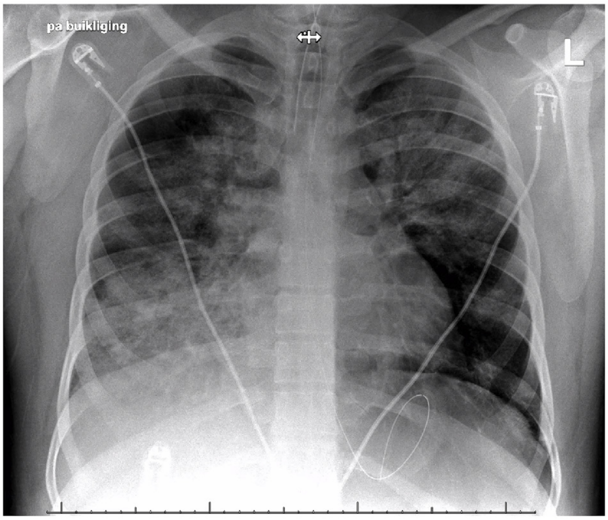

Fig. 1. X-ray imaging of the chest in supine position after transfer to our hospital on second day of admission, showing bilateral patchy opacities.

at end of expiration and 14 cmH_2O at end of inspiration. As the P_L during inspiration was well below the threshold of 25 cmH_2O [7], PEEP was increased 20 to 28 cmH_2O resulting in a P_{peak} of 40 cmH_2O and a P_L of 19 cmH_2O during inspiration. As a result, oxygenation improved significantly.

During the first week the patient was kept sedated, given muscle relaxation and the patients position was switched between prone and supine approximately every 12 hours. After six days on mechanical ventilation, rocuronium infusion was stopped and the patient was kept in supine position. The patient improved slowly but had multiple periods of discomfort with increased blood pressure, increased respiratory rate, patient-ventilator asynchrony, deterioration of Sp_{O_2}, restlessness and grimacing. Therefore, clonidine (0.85μg/kg/h) was started and remifentanyl was increased 10–17μg/kg/h to keep the patient comfortable.

On day 10 of admission the sedation levels were reduced in an attempt to switch from controlled mechanical ventilation to pressure support ventilation. However, the patient became restless again and the tidal volume increased 500–870mL (11 mL/kg_{IBW}) and respiratory rate increased 25 to 34/min. We had to increase sedation levels again and kept the patient on controlled mechanical ventilation. On day 18 we tried to stop the muscle relaxation again, again resulting in discomfort and ventilator asynchrony. Therefore, esketamine (53μg/kg/h) was started and remifentanyl was switched to sufentanil (0.66μg/kg/h), whereby the patient became more comfortable.

On day 21 we tried again to switch the patient from controlled mechanical ventilation to pressure support ventilation. Tidal volumes increased up to 1200 mL ((15 mL/kg_{IBW})). Therefore, we decided to apply partial neuromuscular blockage. A bolus of 10 mg of rocuronium was repeatedly administered intravenously until 50mg was infused in 45/min. Tidal volume decreased 850 to 550mL on average (10.6 to 6.9mL/kg_{IBW}) while the respiratory rate increased 15 to 23/min. Without NMBAs the patient created a negative pressure swing of around 38 cmH_2O in the esophagus during inspiration (ΔP_{es}), which decreased to 21 cmH_2O with partial neuromuscular blockage. Fig. 2 shows tracings of ventilator waveforms, the P_{trach}, P_{es} and P_L right before and after the first bolus of rocuronium. Thereafter, we started a continuous infusion of rocuronium (48mg/h) titrated to target a tidal volume of around 500 mL (6.3 mL/kg_{IBW}). After 18 h the rocuronium infusion was stopped while tidal volumes remained stable.

Thereafter, sedation and ventilatory parameters could be quickly reduced. Four days after the start of partial neuromuscular the patient was extubated and put on high-flow nasal cannula oxygen therapy (HFNC). Another two days later the HFNC was replaced by a non-rebreathing mask and the patient was moved back to the referring hospital just within a month after transfer to our ICU.

3. Discussion

In this case report we described the successful application of partial neuromuscular blockage after three weeks of mechanical ventilation in a patient with severe ARDS in order to facilitate pressure support ventilation and weaning. Tidal volume decreased 15 to ± 6.5mL/kg_{IBW}, while the ΔP_{es} significantly decreased 38 to 21 cmH_2O during an inspiratory effort.

The patient showed a classic case of severe ARDS due to Influenza A infection with a possible superimposed bacterial infection. Recent guidelines on the treatment of severe ARDS [8] recommend the application of low tidal volumes, $P_{plat} \leq 30cmH_2O$, prone positioning in the early phase and higher PEEP levels. The patient in this case was successfully ventilated with low tidal volumes, prone positioning and higher PEEP levels during the initial treatment. Our protocol states the P_L should stay below the suggested physiological limit of 25 cmH_2O [7] at end of inspiration. We accepted $P_{peak} > 30$ cmH_2O based on the P_L and increased PEEP to improve oxygenation.

The usage of NMBAs is frequently used in the early phase of the disease in order to control ventilator synchrony. We have reported a previous case where full paralysis by NMBAs proved to be an important part of the treatment in a patient with a high respiratory drive [9]. In the current case, breathing effort, patient-ventilator asynchronies and coughing could not be mitigated by sedatives alone, thus requiring prolonged muscle relaxation. Since the patient had been on mechanical ventilation for three weeks already and the status did not seem to change for the last ten days, we thought to do well by trying the experimental application of partial neuromuscular blockage in order to allow the patient to wake up and allowing for spontaneous efforts and partial ventilatory support. The patient in the current case would fit the inclusion criteria of Doorduin et al. [5]: an adult patient with ARDS developing high V_t during pressure support ventilation. That study showed that V_t was significantly reduced 9.3 to 5.6 mL/kg_{IBW} during partial neuromuscular blockage. In the current case, the V_t before was much higher, but we were able to reduce V_t almost to 6 mL/kg_{IBW}.

Doorduin et al. [5] studied partial neuromuscular blockage for only two times one hour, and we are not aware of any case reports in which prolonged partial neuromuscular blockage has been tried. In this case, we tried the strategy of titrating rocuronium infusion by infusion of boluses of 10 mg and subsequently a continuous infusion, allowing us to titrate the V_t between 6 and 8 mL/kg_{IBW}. We had no expectations as to how long to apply partial neuromuscular blockage and were surprised by the rapid improvement of patient comfort and patient-ventilator synchrony. The subsequent weaning from the ventilator took only four days.

Normally, NMBAs are only applied in deeply sedated patients because of the inability to adequately assess pain and anxiety during muscle relaxation [10]. It is not surprising that physicians and nursing staff questioned the method as we were preparing the infusion of boluses of rocuronium after reducing sedation levels. This resulted in a healthy discussion on the possible merits and disadvantages of partial neuromuscular blockage in the current case.

In summary, the application of partial neuromuscular blockage allowed for spontaneous efforts and partial ventilator support in a patient with high respiratory effort after severe ARDS. Patient-tailored treatment and extensive monitoring is required in such complex cases. Partial neuromuscular blockage is experimental and should be used to the discretion of the caretaker. We do not recommend partial neuromuscular blockage as part of standard treatment of ARDS.

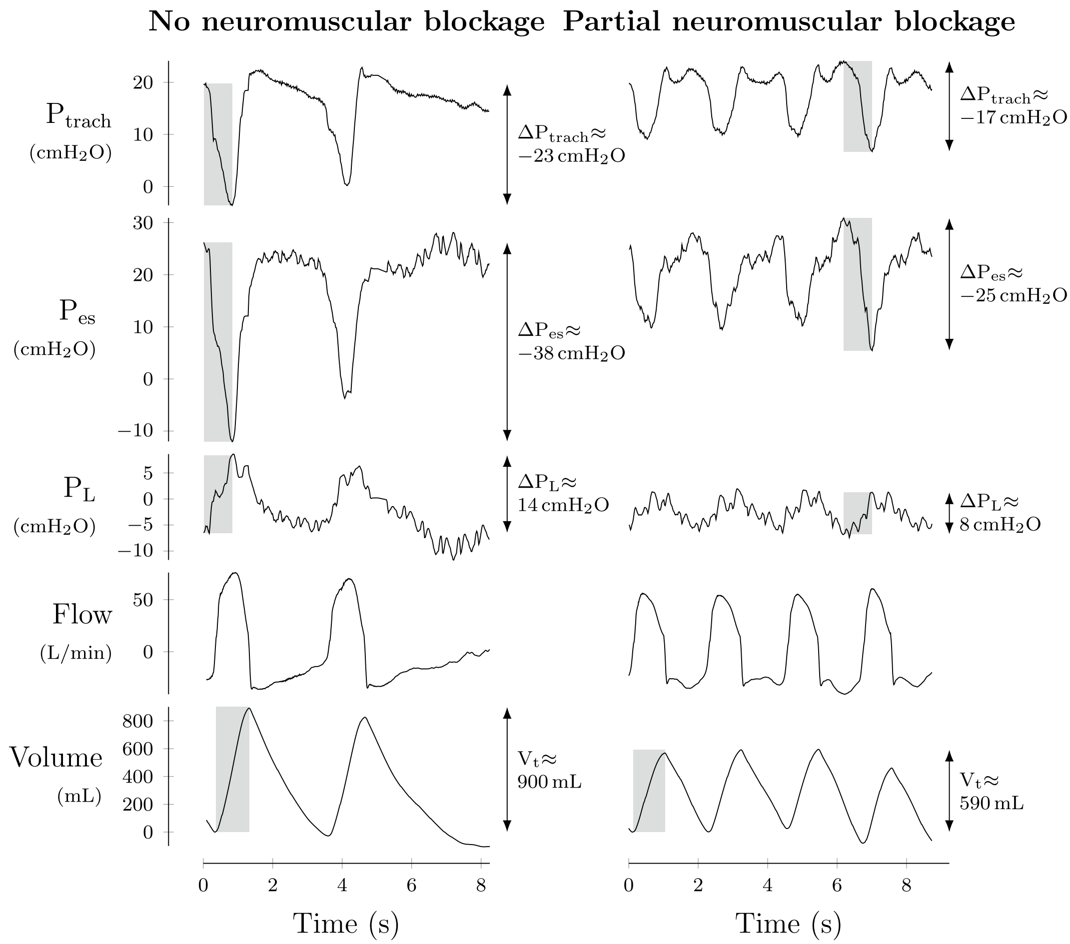

Fig. 2. Tracings of the intra-tracheal pressure (P_{trach}), esophageal pressure (P_{es}) and trans-pulmonary pressure (P_L), flow and volume without neuromuscular blockage (left) and with partial neuromuscular blockage (right). The arrows indicate the pressure swings during inspiration ((ΔP_{trach}), (ΔP_{es}) and (ΔP_L)) and the (V_t).

References

[1] The Acute Respiratory Distress Syndrome Network, R.G. Brower, M.A. Matthay, A. Morris, D. Schoenfeld, B.T. Thompson, A. Wheeler, Ventilation with lower tidal volumes as compared with traditional tidal volumes for acute lung injury and the acute respiratory distress syndrome, N. Engl. J. Med. 342 (18) (2000) 1301–1308.

[2] C. Guérin, J. Reignier, J.-C. Richard, P. Beuret, A. Gacouin, T. Boulain, E. Mercier, M. Badet, A. Mercat, O. Baudin, M. Clavel, D. Chatellier, S. Jaber, S. Rosselli, J. Mancebo, M. Sirodot, G. Hilbert, C. Bengler, J. Richecoeur, M. Gainnier, F. Bayle, G. Bourdin, V. Leray, R. Girard, L. Baboi, L. AyzacPROSEVA Study Group, Prone positioning in severe acute respiratory distress syndrome, N. Engl. J. Med. 368 (23) (2013) 2159–2168.

[3] L. Papazian, J.-M. Forel, A. Gacouin, C. Penot-Ragon, G. Perrin, A. Loundou, S. Jaber, J.-M. Arnal, D. Perez, J.-M. Seghboyan, J.-M. Constantin, P. Courant, J.-Y. Lefrant, C. Guérin, G. Prat, S. Morange, A. Roch, ACURASYS Study Investigators, Neuromuscular blockers in early acute respiratory distress syndrome, N. Engl. J. Med. 363 (12) (2010) 1107–1116.

[4] T. Yoshida, S. Nakahashi, M.A.M. Nakamura, Y. Koyama, R. Roldan, V. Torsani, R.R. De Santis, S. Gomes, A. Uchiyama, M.B.P. Amato, B.P. Kavanagh, Y. Fujino, Volume-controlled ventilation does not prevent injurious inflation during spontaneous effort, Am. J. Respir. Crit. Care Med. 196 (5) (2017) 590–601.

[5] J. Doorduin, J.L. Nollet, L.H. Roesthuis, H.W.H. Van Hees, L.J. Brochard, C.A. Sinderby, J.G. van der Hoeven, L.M.A. Heunks, Partial neuromuscular blockade during partial ventilatory support in sedated patients with high tidal volumes, Am. J. Respir. Crit. Care Med. 195 (8) (2017) 1033–1042.

[6] ARDS Definition Task Force, V.M. Ranieri, G.D. Rubenfeld, B.T. Thompson, N.D. Ferguson, E. Caldwell, E. Fan, L. Camporota, A.S. Slutsky, Acute respiratory distress syndrome: the berlin definition, JAMA (2012) 2526–2533 Universita degli Studi di Torino, Torino, Italy.

[7] D. Chiumello, E. Carlesso, P. Cadringher, P. Caironi, F. Valenza, F. Polli, F. Tallarini, P. Cozzi, M. Cressoni, A. Colombo, J.J. Marini, L. Gattinoni, Lung stress and strain during mechanical ventilation for acute respiratory distress syndrome, Am. J. Respir. Crit. Care Med. 178 (4) (2008) 346–355.

[8] E. Fan, L. Del Sorbo, E.C. Goligher, C.L. Hodgson, L. Munshi, A.J. Walkey, N.K.J. Adhikari, M.B.P. Amato, R. Branson, R.G. Brower, N.D. Ferguson, O. Gajic, L. Gattinoni, D. Hess, J. Mancebo, M.O. Meade, D.F. McAuley, A. Pesenti, V.M. Ranieri, G.D. Rubenfeld, E. Rubin, M. Seckel, A.S. Slutsky, D. Talmor, B.T. Thompson, H. Wunsch, E. Uleryk, J. Brozek, L.J. Brochard, An official American Thoracic Society/European Society of intensive care medicine/society of critical care medicine clinical practice guideline: mechanical ventilation in adult patients with acute respiratory distress syndrome, Am. J. Respir. Crit. Care Med. 195 (9) (2017) 1253–1263.

[9] A. Shono, P. Somhorst, D. Gommers, Electrical impedance tomography and trans-pulmonary pressure measurements in a patient with extreme respiratory drive, Respir. Med. Case Rep. 20 (2017) 141–144.

[10] M.J. Murray, H. DeBlock, B. Erstad, A. Gray, J. Jacobi, C. Jordan, W. McGee, C. McManus, M.O. Meade, S. Nix, A. Patterson, M.K. Sands, R. Pino, A. Tescher, R. Arbour, B. Rochwerg, C.F. Murray, S. Mehta, Clinical Practice Guidelines for Sustained Neuromuscular Blockade in the Adult Critically Ill Patient, Critical Care Medicine, 2016.