Evaluation of the efficiency and complications of the consecutive proning in COVID-19 ICU: a retrospective study

Esra Ozayar1 · Ozlem Ozbek2 · Adem Selvi2 · Adil Ozturk2 · Ozge Gursozlu2

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Abstract
Purpose We aimed to evaluate and compare the efficacy and complications of three consecutive prone positions (PP) in COVID-19 ICU.

Materials and method Patients with ARDS and placed in PP for 3 times (PP1, PP2, PP3) consecutively were included. Arterial blood gases (ABG), partial pressure of arterial oxygen/fraction of inspired oxygen (PaO2/FiO2) ratios, partial pressure of carbondioxide (PaCO2), PEEP, and FiO2 were recorded before (bPP), during (dPP), and after (aPP) every prone positioning. Eye, skin, nerve, and tube complications related to PP were collected.

Results In all positions, PaO2 value during PP was significantly higher than PaO2 before and after prone position (p = 0.001). PaO2 values were similar in all (PP1, PP2, PP3) bPP arterial blood gases. We found difference in PaO2 values during prone position between the first (PP1) and second proning (PP2). When each prone was evaluated within itself, PaO2/FiO2 increases after proning compared to before proning. PaO2/FiO2 during PP were higher compared to before proning ones. PaO2/FiO2 during PP1 was significantly higher compared to during PP3 (p = 0.005). In PP3, PEEP values bPP, dPP, and aPP were significantly higher than PEEP values after the second prone (p = 0.02, p = 0.001, p = 0.01). In the third prone, PaCO2 levels were higher than in PP1 and PP2. There were eye complications in 13, tube-related complications in 10, skin complications in 30, and nerve damage in 1 patient.

Conclusion We believe that a more careful decision should be made after the second prone position in patients who have to be placed in sequential prone position.

Keywords Covid-19 · Intensive Care Unit · Prone position

Introduction

In the literature, many trials report the benefits of prone positioning in terms of oxygenation and survival in the management of acute respiratory distress syndrome (ARDS) [1–5]. Prone position which has shown to be beneficial in ARDS improves the ventilation-perfusion matching and the oxygenation by recruiting the dorsal atelectatic lung areas [6, 7]. During the COVID-19 pandemic, as recommended by the World Health Organization, many intensivists considered prone positioning as a part of invasive ventilation strategy in ARDS patients [8–10]. When looking at COVID-19-related prone position studies, the duration and the number of prone sessions vary. Although there are some studies searching about the optimum duration of the prone position, there is a paucity of publications regarding the number and effectiveness of prone sessions. The answers to the questions “Does every prone session has similar effect?” and “How many prone sessions are recommended to consider the benefit/risk ratio?” are unclear.

We conducted a retrospective study to reveal the complications and compare the outcomes of each prone session in terms of oxygenation, PEEP levels, and PaO2/FiO2 ratios in patients who underwent three subsequent prone positions.
Materials and method

We designed a retrospective single center study. After Ministry of Health COVID 19 Scientific Research Evaluation Commission and Local Ethic Committee approval, thirty-one patients who had a positive test result for SARS-CoV-2 RNA through nasopharyngeal swab and underwent three subsequent prone positions for 16 h were enrolled in the study. Medical data of the patients were obtained from patients’ files which are strictly filled during the pandemic. PP indication of our intensive care unit (ICU) was in case of severe ARDS with PaO2/FiO2 < 150 despite a PEEP > 10 cmH2O. Hemodynamically unstable patients were not a candidate for PP. Prone positions were performed with the use of neuromuscular blocking agents and sedatives in a controlled ventilation mode. Prone positioning was performed manually by using pillows, foam face cushions, and longitudinal foams. Due to our ICU protocol and mechanical ventilator settings, the target was 6 ml/kg (ideal body weight) tidal volume and < 30 cmH2O end inspiratory plateau pressure, and respiratory rate was arranged in order to keep PaO2 35–45 mmH2O. All the patients were left in PP for 16 h.

Arterial cannulation was present in all patients and arterial blood gas (ABG) results (before, during, and after proning) were recorded from the patient files. The ABG before proning, after proning, and during proning were withdrawn within 10 min before, within 10 min after, and at the 8th hour of proning respectively. The ventilator settings simultaneous to ABG and calculated PaO2/FiO2 ratios were obtained from strictly filled ICU forms. Eye, nerve, and tube-related complications were harvested from nursing care part of patients’ ICU records.

In the study, version 21 of SPSS (IBM SPSS Statistics for Windows, IBM Corp., Armonk, NY, USA) was used. The distribution characteristics of the variables were examined with the Kolmogorov-Smirnow and Shapiro–Wilk tests. Descriptive statistics for continuous variables were shown as mean ± standard deviation for those with normal distribution characteristics, and as median and interquartile range for those who did not. The change clinical parameters were analyzed with the 3 × 3 design and Generalized Estimating Equation Model method, taking into account the position (before, during, and after the prone) and session (first, second, and third session) variables. Bonferroni correction was used for pairwise comparisons. The threshold value for statistical significance in all analyses was accepted as \( p < 0.05 \).

Results

Ninety-three prone sessions and 279 ABG were evaluated.

Evaluation of PaO2 results

In all positions, PaO2 value during prone position was significantly higher than PaO2 before and after prone position \((p=0.001)\). In PP1, PaO2 during prone position was higher than PaO2 before and after the session \((p<0.001)\). PaO2 after the session was significantly higher than before the session \((p=0.02)\). In PP2, PaO2 during session was significantly higher than before and after session \((p<0.001)\). PaO2 after positioning was significantly higher than before positioning \((p=0.03)\). In PP3, PaO2 during the session was higher than before and after the session \((p<0.001)\). There was no significant difference between PaO2 after and before positioning \((p=0.3)\).

PaO2 values were similar in all (PP1, PP2, PP3) bPP arterial blood gases. While PaO2 during PP2 was significantly higher than PaO2 during PP1, there was no statistical difference between PP2 and PP3 (Fig. 1).

Evaluation of FiO2 results

In PP1 and PP2, FiO2 levels were similar between bPP and dPP while FiO2 after proning was significantly lower than bPP and dPP \((p=0.001, p=0.004\) respectively). In PP3, FiO2 levels were similar between bPP, dPP, and aPP. In PP3, FiO2 level after proning was significantly higher than FiO2 level after PP2 (Fig. 2).

Evaluation of PaO2/FiO2 results

When each prone was evaluated within itself, PaO2/FiO2 ratio significantly increases after proning compared to before proning (Fig. 3). PaO2/FiO2 ratios during prone position were significantly higher compared to before proning ones.

Fig. 1 Partial oxygen pressure levels before prone position (bPP), during prone position (dPP), and after prone position (aPP) in the first prone position (PP1), second prone position (PP2), and third prone position (PP3)
PaO2/FiO2 during PP1 was significantly higher compared to PP3 ($p = 0.005$).

**Evaluation of PEEP results**

The PEEP values during PP1 and PP2, PP2, and PP3 were similar ($p = 0.1$, $p = 0.3$). In PP3, PEEP values bPP, dPP, and aPP were significantly higher than PEEP values after PP2 ($p = 0.02$, $p = 0.001$, $p = 0.01$ respectively). In the third proning, the PEEP value after proning was significantly higher than the PEEP value before PP1 ($p < 0.05$) (Fig. 4).

**Evaluation of PaCO2 according to prone sessions**

In PP3, PaCO2 level during positioning was significantly higher than PaCO2 before the session ($p = 0.05$). In the third prone, PaCO2 level during proning was significantly higher than the PaCO2 level during PP1 and PP2 ($p = 0.01$, $p = 0.01$) (Fig. 5).

There were eye complications in 13, tube-related complications in 10, skin complications in 30, and nerve damage in 1 patient.

**Discussion**

In the COVID-19 ICU settings, PP takes an important role as a part of the mechanical ventilation strategy against ARDS. In this study, we report the results of our study assessing and comparing the ventilator settings and arterial blood gases of each prone session of three subsequent PP. The main findings of our study are as follows: (1) in all prone sessions, PaO2 and PaO2/FiO2 ratios during PP were significantly higher than PaO2 before and after PP; (2) in the second PP session, FiO2 level during prone was significantly lower than the first and third PP; (3) PaCO2 level was significantly higher in the third proning. According to these results, we can say that the least beneficial
prone session was the third one. The reason for this result may be the progression of the underlying lung pathology until the third session. The PROSEVA trial revealed the beneficial effects of prone positioning during mechanical ventilator management on outcomes in terms of 28-day and 90-day mortality [1]. In the PROSEVA trial, the PP was performed everyday up to day 28, the average number sessions were 4 ± 4 per patient, and the mean duration was 17 ± 3 h per session. A systematic review and meta-analysis found that prone positioning at least 12 h daily reduces mortality in patients with moderate to severe ARDS (PaO2/FiO2 < 200) [6]. In our retrospective study, the patients were severe ARDS with PaO2/FiO2 ratio < 150 and the duration of prone positions was 16 h with 24–48-h intervals. In their study, Jochmans et al. searched the optimal duration of PP to obtain the maximum beneficial effect and they concluded that it should be at least 24 h or longer depending on the PaO2/FiO2 ratio [11]. The number of prone sessions per patient was 2.2 ± 1.8 and the duration of proning was 21.5 ± 5 h. They also reported the lung mechanic data in addition to ABG and ventilator settings. In the study, the increment of PaO2 and decrement of PaCO2 and FiO2 were significant before and after the first PP. In our study, PaO2 in bPP was significantly higher than aPP in the first (p = 0.02) and second session (p = 0.03), but in the third session there was no statistically significant difference (p = 0.3). Our study does not include lung mechanics data, as in our ICU these data are not routinely recorded to patient files.

In the third prone session, PEEP values bPP, dPP, and aPP were significantly higher than PEEP values after the second prone (p = 0.02, p = 0.001, p = 0.01). When we looked at the PEEP levels during prone positions, we found that there was no statistical significance between them.

Corneal abrasions, pressure ulcers, tube-related complications such as unplanned extubation, and nerve injuries are important complications of PP which are not rare [12–16]. A study reported that 77% of the patients presented pressure sore after PP therapy in the COVID-19 pandemic. An interesting result came from a meta-analysis, which showed no significant difference in ocular injury between a prone and supine group in ICU [17]. Although many studies report the PP complications in terms of ocular, skin, and tube, the number of PP sessions is unclear; we recorded our PP complications after three subsequent sessions. We had 30 skin, 13 ocular, 1 nerve, and 10 tube-related complications totally at the end of all sessions.

This study has some limitations. First the severity of COVID-19 infection may differ between patients and there is not any standard method to homogenize the patient group in terms of infectious parameters, radiological findings, and respiratory parameters. The number of our patients was limited as our inclusion criteria required 3 consecutive prone positions of 16 h.

In conclusion, although the positive effects of the prone position have been proven in ARDS, we may not get the same response every time in consecutive positions. In our study, we observed that the positive effects decreased and the PaCO2 levels increased in third proning. Considering the difficulties of prone positioning and nerve, skin, ocular, and other complications, we believe that a more careful decision should be made after the second prone position in patients who need to be placed in sequential prone position.

References

1. Guérin C et al (2013) Prone positioning in severe acute respiratory distress syndrome. N Engl J Med 368(23):2159–2168. https://doi.org/10.1056/NEJMoa1214103
2. Sud S et al (2010) Prone ventilation reduces mortality in patients with acute respiratory failure and severe hypoxemia: systematic review and meta-analysis. Intensive Care Med 36(4):585–599. https://doi.org/10.1007/s00134-009-1748-1
3. Abroug F, Ouanes-Besbes L, Elatrous S, Brochard L (2008) The effect of prone positioning in acute respiratory distress syndrome or acute lung injury: a meta-analysis Areas of uncertainty and recommendations for research. Intensive Care Med 34(6):1002. https://doi.org/10.1007/s00134-008-0166-3
4. Shelhamer MC et al (2021) Prone positioning in moderate to severe acute respiratory distress syndrome due to COVID-19: a cohort study and analysis of physiology. J Intensive Care Med 36(2):241–252. https://doi.org/10.1177/0885066620980399
5. Parhar KKS, Zuege DJ, Shariff K et al (2021) Prone positioning for ARDS patients-tips for preparation and use during the COVID-19 pandemic TT - Positionnement ventral des patients atteints d’un SDRA — conseils pour la préparation et l’utilisation de cette modalité pendant la pandémie de COVID-19. Can J Anaesth 68(4):541–545. https://doi.org/10.1007/s12630-020-01885-0
6. Munshi L et al (2017) Prone position for acute respiratory distress syndrome. A systematic review and meta-analysis. Ann Am Thorac Soc 14(Supplement_4):S280–S288. https://doi.org/10.1513/AnnalsATS.201704-140OP
7. Sud S et al (2021) Comparative effectiveness of protective ventilation strategies for moderate and severe acute respiratory distress syndrome. A network meta-analysis. Am J Respir Crit Care Med 203(11):1366–1377. https://doi.org/10.1164/rccm.202008-3039OC
8. Zaretzky J et al (2022) Increasing rates of prone positioning in acute care patients with COVID-19. Jt Comm J Qual Patient Saf 48(1):53–60. https://doi.org/10.1010/jjcc.2021.09.005
9. Berrill M (2021) Evaluation of oxygenation in 129 proning sessions in 34 mechanically ventilated COVID-19 patients. J Intensive Care Med 36(2):229–232. https://doi.org/10.1177/0885066620955137
10. World Health Organization (2020) Clinical management of severe acute respiratory infection when novel coronavirus (2019-nCoV) infection is suspected: interim guidance. World Health Organization Geneva. https://apps.who.int/iris/handle/10665/330893
11. Jochmans S et al (2020) Duration of prone position sessions: a prospective cohort study. Ann Intensive Care 10(1):66. https://doi.org/10.1186/s13613-020-00683-7
12. Ibarra G, Rivera A, Fernandez-Ibarburu B et al (2021) Prone position pressure sores in the COVID-19 pandemic: the Madrid
experience. J Plast Reconstr Aesthetic Surg 74(9):2141–2148. 
https://doi.org/10.1016/j.bjps.2020.12.057
13. Gattinoni L et al (2001) Effect of prone positioning on the sur-
vival of patients with acute respiratory failure. N Engl J Med 345(8):568–573. https://doi.org/10.1056/NEJMoa010043
14. Sud S et al (2014) Effect of prone positioning during mechanical
ventilation on mortality among patients with acute respiratory
distress syndrome: a systematic review and meta-analysis. CMAJ 186(10):E381–E390. https://doi.org/10.1503/cmaj.140081
15. Girard R, Baboi L, Ayzac L et al (2014) The impact of patient
positioning on pressure ulcers in patients with severe ARDS:
results from a multicentre randomised controlled trial on prone
positioning. Intensive Care Med 40(3):397–403. https://doi.org/
10.1007/s00134-013-3188-1
16. Lucchini A et al (2020) Prone position in acute respiratory dis-
tress syndrome patients: a retrospective analysis of complications.
Dimens Crit Care Nurs 39:1
17. Patterson TJ, Currie P, Williams M, Shevlin C (2021) Ocular
injury associated with prone positioning in adult critical care: a
systematic review and meta-analysis. Am J Ophthalmol 227:66–
73. https://doi.org/10.1016/j.ajo.2021.02.019

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