QMJ
A peer reviewed journal
QATAR MEDICAL JOURNAL

QATAR CRITICAL CARE CONFERENCE ABSTRACT

Prone positioning in ARDS: physiology, evidence and challenges

Husain Shabbir Ali, Megha Kamble

Address for Correspondence:
Husain Shabbir Ali
Department of MICU/Medicine, Hamad General Hospital, Hamad Medical Corporation, Doha, Qatar
Email: drhusainali@gmail.com

http://dx.doi.org/10.5339/qmj.2019.qccc.14
Submitted: 10 June 2019
Accepted: 1 July 2019

Cite this article as: Ali HS, Kamble M. Prone positioning in ARDS: physiology, evidence and challenges, Qatar Medical Journal, Qatar Critical Care Conference 2019:14 http://dx.doi.org/10.5339/qmj.2019.qccc.14

كيوساينس
QSCIENCE
دار جامعة حمد بن خليفة للنشر
HAMAD BIN KHALIFA UNIVERSITY PRESS

ABSTRACT

Introduction: Prone position has been used since the 1970s as a rescue therapy to treat severe hypoxemia in patients with acute respiratory distress syndrome (ARDS). Despite numerous observational and randomized controlled trials showing the effectiveness of prone position in improving oxygenation, mortality benefit was demonstrated only recently in the PROSEVA study[1]. Intensivists taking care of patients with ARDS should be aware about the physiological changes during prone ventilation, the latest evidence available and challenges that can be encountered in managing such patients.

Physiology of prone position ventilation: When a person is supine, the weight of the ventral lungs, heart, and abdominal viscera increase dorsal pleural pressure. This compression reduces transpulmonary pressure in the dorsal lung regions. The increased mass of the edematous ARDS lung further increases the ventral-dorsal pleural pressure gradient and reduces regional ventilation of dependent dorsal regions. The ventral heart is estimated to contribute approximately an additional 3 to 5 cm of water pressure to the underlying lung tissue. In addition to the weight of the heart, intraabdominal pressure is preferentially transmitted through the diaphragm, further compressing dorsal regions. Although these

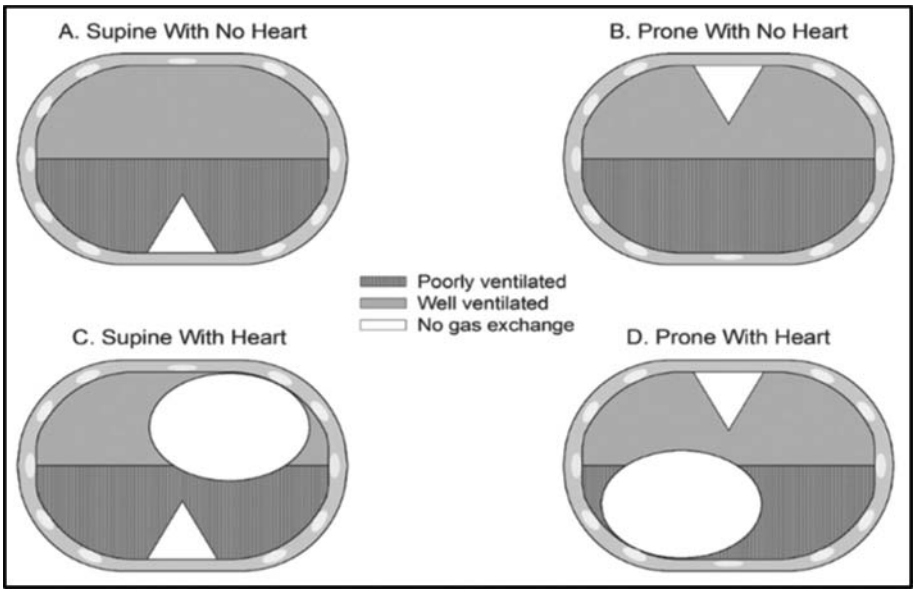

Figure 1. In a chest cavity containing symmetrical lungs, the amount of lung that is well ventilated (where the alveolar pressure exceeds the pleural pressure) roughly equals the amount of lung that is atelectatic and poorly ventilated (where pleural pressure exceeds intra-alveolar pressure) in both supine and prone positions (A and B). However, when the space occupied by the mediastinum and heart are accounted for, and the effects of the compression of lung tissue subjacent to these structures are considered, there is less ventilated tissue in the supine position (C) than in the prone position (D)[3].

factors tend to collapse dependent dorsal regions, the gravitational gradient in vascular pressures preferentially perfuses these regions, yielding a region of low ventilation and high perfusion, manifesting clinically as hypoxemia. Placing a person in the prone position reduces the pleural pressure gradient from nondependent to dependent regions, in part through gravitational effects and conformational shape matching of the lung to the chest cavity[2] [Figure 1].

Clinical evidence: A few large randomized clinical trials, conducted over a period of 15 years, investigated the possible benefit of prone position on ARDS outcome [Table 1]. The improvements in oxygenation apparent in most trials were not associated with improvements in mortality, suggesting that oxygenation is not itself the source of improved survival with prone positioning. Most recently, the PROSEVA study group[1] enrolled 466 subjects with moderate-to-severe ARDS. Mortality at 28 and 90 days was significantly lower with prone position versus supine position (16% vs 33%, respectively, $p < 0.001$, and 24% vs 41%, respectively, $p < 0.001$).

Challenges: There are only a few absolute contraindications to prone positioning, such as unstable vertebral fractures and unmonitored or significantly increased intracranial pressure. Hemodynamic instability and cardiac rhythm disturbances are some of the relative contraindications. The common complications of prone positioning are pressure ulcers, ventilator-associated pneumonia and endotracheal tube

Table 1. Major trials of prone ventilation in ARDS[2].

Variable	Gattinoni et al. (2001)	Guerin et al. (2004)	Mancebo et al. (2006)	Taccone et al. (2009)	Guerin et al. (2013) (PROSEVA)
Prone mortality (%)	50.7 (ICU mortality)	32.4 (28 d)	43 (ICU mortality)	31 (28 d)	16 (28 d)
Control mortality (%)	48 (ICU mortality)	31.5 (28 d)	58 (ICU mortality)	32.8 (28 d)	32.8 (28 d)
RR of mortality (prone/control)	1.05 (P = 0.65)	1.02 (P = 0.77)	0.74 (P = 0.12)	0.97 (P = 0.72)	0.48 (P < 0.001)
Patient No.	304	802	142	342	466
Targeted disease	ALI/ARDS[a]	Resp. Failure with P/F < 300 mm Hg	ARDS[a]	ARDS[a]	ARDS[a] with P/F < 150 mm Hg
P/F ratio (mm Hg) at enrollment	128	153	139	113	100
SAPS II	40	46	43	41	46
V_T delivered (mL/kg)	10.3	7.9	8.5	8	6.1
Avg. time prone (hrs./d)	7	8	17	18	17
Avg. days prone	10	4	10	8.4	4
Significant reduction in ventilator days?	No	No	No	No	Yes

ALI: acute lung injury; ARDS: acute respiratory distress syndrome; RR: relative risk; SAPS II: simplified acute physiology score II; P/F ratio: partial pressure of oxygen in arterial blood (PaO_2)/fraction of inspired oxygen (FiO_2); V_T = tidal volume.
[a]ALI and ARDS were defined according to the American-European Consensus Conference definition of ARDS.

obstruction. More serious fatal events such as accidental extubation is rare (zero to 2.4% prevalence). A recent meta-analysis of the safety and efficacy of the maneuver showed that it is safe and inexpensive but requires teamwork and skill. Reports in the literature suggest that the incidence of adverse events is significantly reduced in the presence of trained and experienced staff. Thus, centers with less experience may have difficulty managing complications, but nursing care protocols and guidelines can mitigate this risk[4].

Conclusion: Prone position ventilation in patients with moderate-to-severe ARDS improves hypoxemia, provides mortality benefit and is relatively safe.

Keywords: prone positioning, acute respiratory distress syndrome, acute lung injury, hypoxic respiratory failure

REFERENCES

1. Guerin C, Reignier J, Richard JC, Beuret P, Gacouin A, Boulain T, et al. Prone positioning in severe acute respiratory distress syndrome. *N Engl J Med*. 2013;368(23):2159–2168.
2. Scholten EL, Beitler JR, Prisk GK, Malhotra A. Treatment of ARDS With Prone Positioning. *Chest*. 2017;151(1):215–224.

3. Henderson WR, Griesdale DE, Dominelli P, Ronco JJ. Does prone positioning improve oxygenation and reduce mortality in patients with acute respiratory distress syndrome? *Can Respir J.* 2014;21(4): 213 – 215.

4. Lee JM, Bae W, Lee YJ, Cho YJ. The efficacy and safety of prone positional ventilation in acute respiratory distress syndrome: updated study-level meta-analysis of 11 randomized controlled trials. *Crit Care Med.* 2014;42(5): 1252 – 1262.