

Awake prone positioning in COVID-19

David Koeckerling,¹ Joseph Barker ,² Nadeesha L Mudalige,³ Oluwatobiloba Oyefeso,⁴ Daniel Pan,⁵ Manish Pareek,^{5,6} Jonathan P Thompson,^{2,7} G Andre Ng^{2,8}

In the absence of effective targeted therapies for COVID-19, optimisation of supportive care is essential. Lung injury with features of acute respiratory distress syndrome (ARDS) appears to be the principal characteristic of severe acute respiratory syndrome coronavirus 2 infection.¹ Recent guidance by the UK Intensive Care Society (ICS) advocates awake prone positioning to become standard of care for suspected or confirmed COVID-19, in patients requiring an $\text{FiO}_2 \geq 28\%$.² These recommendations are extrapolated from physiological principles and clinical evidence obtained in a distinct study population—patients with severe ARDS undergoing invasive mechanical ventilation (IMV).

The physiological rationale behind prone positioning in typical ARDS is to reduce ventilation/perfusion mismatching, hypoxaemia and shunting.² Prone positioning decreases the pleural pressure gradient between dependent and non-dependent lung regions as a result of gravitational effects and conformational shape matching of the lung to the chest cavity. This is believed to generate more homogeneous lung aeration and strain distribution, thus enhancing recruitment of dorsal lung units.³ Prone positioning does not appear to alter regional distribution of pulmonary blood flow, with perfusion predominating towards dorsal lung aspects due to non-gravitational factors.⁴ With improvements in ventilatory homogeneity and relatively constant perfusion patterns, a subsequent reduction in shunting is observed.⁵ The

use of positive end-expiratory pressure via non-invasive ventilation (NIV) or CPAP in the management of ARDS is beneficial by preventing alveolar de-recruitment but may also result in overdistension of previously well-ventilated alveoli.^{6,7} Similarly, spontaneously breathing patients in acute hypoxaemic respiratory failure can generate high respiratory drives and forceful inspiratory efforts that lead to lung injury reminiscent of ventilator-induced lung injury.⁸ Prone positioning in these patients and in combination with NIV/CPAP may help to mitigate this detrimental effect in part by reducing regional hyperinflation.⁹

Prone positioning is an established evidence-based practice in patients with typical ARDS undergoing IMV, but limited evidence exists in non-ventilated awake patients. In a multicentre, randomised controlled trial of patients with severe ARDS receiving IMV, prone positioning halved 28-day mortality rates (16% vs 32.8%, $p < 0.001$) with no additional complications.¹⁰ Meta-analyses suggest that early prone positioning for 12–16 hours/day combined with low tidal volume IMV reduces mortality in severe hypoxic respiratory failure.^{11–13}

Presently, no published trials investigate the effectiveness of prone positioning in awake patients with typical ARDS. Evidence in awake prone positioning is limited to case series and small observational studies with heterogeneous approaches to non-invasive respiratory support. These reports demonstrated short-term improvements in oxygen requirements (PaO_2) and demand (FiO_2) with no harm to patients.^{14–16} Valter *et al* applied prone positioning to four patients with indications for IMV and found rapid improvements in PaO_2 —all patients avoided IMV and tolerated prone positioning well.¹⁴ In an observational study of 15 patients receiving non-invasive respiratory support for acute hypoxaemic respiratory failure, repeated prone positioning led to transient but substantial improvements in oxygenation.¹⁵ In a prospective observational study of 20 patients receiving non-invasive ventilation for moderate-to-severe ARDS, $\text{PaO}_2/\text{FiO}_2$ ratio increased by 25–35 mm Hg

following awake prone positioning; but 78% of participants with severe ARDS eventually required IMV, and therefore awake prone positioning should not delay the use of IMV when indicated.¹⁶

The notion of applying evidence generated in typical ARDS universally to patients with COVID-19 is challenged by Gattinoni *et al* based on their analysis of 150 patients.¹⁷ They hypothesise lung injury in COVID-19 to encompass a time-dependent spectrum of disease with variable patterns of lung pathology and heterogeneous responses to prone positioning.¹⁷ In early phases of COVID-19 pneumonitis, lung compliance is proposed to be high, recruitability minimal and hypoxaemia predominantly driven by impaired regulation of pulmonary perfusion patterns.¹⁷ Awake prone positioning here could temporarily improve ventilation/perfusion mismatch, but sustained benefits in highly compliant lungs are unlikely.¹⁷ With disease progression, COVID-19 pneumonitis is thought to gradually start behaving like typical ARDS, demonstrating lower compliance and higher recruitability with a more favourable long-term response to prone positioning. It is suggested that phases of COVID-19 pneumonitis may be distinguished prior to intubation using CT measurement of lung weight, gas volume and proportion of non-aerated tissue, although additional large studies are required to validate this diagnostic modality.¹⁷ During a pandemic, application of CT scanning to all patients with COVID-19 for this purpose is unlikely to be feasible and will bear future risks related to radiation exposure. Further work to confirm or refute the hypothesis put forward by Gattinoni *et al* is needed. Estimating the frequency and speed of phase transition as well as identifying pragmatic surrogate markers to predict disease phase may be useful in selecting those who could benefit the most from awake prone positioning.

Furthermore, the minimum duration requirements for maintaining the prone position in awake patients to engender clinically meaningful benefits remain undefined. Durations comparable to those necessary for patients undergoing IMV (12–16 hours/day) may be difficult to achieve. For instance, the longest duration of prone positioning achieved in observational studies of awake patients was 8 hours. Improved lung secretion drainage under gravitational forces and increased coughing following prone positioning may contribute to viral contamination of the patient environment, necessitating the

¹Medical Sciences Division, University of Oxford, Oxford, UK

²Department of Cardiovascular Sciences, University of Leicester, Leicester, UK

³Department of Epidemiology and Population Health, London School of Hygiene & Tropical Medicine, London, UK

⁴Department of Primary Care, Royal Free London NHS Foundation Trust, London, UK

⁵Department of Respiratory Sciences, University of Leicester, Leicester, UK

⁶Department of Infectious Diseases and HIV Medicine, University of Leicester, Leicester, UK

⁷University Hospitals of Leicester NHS Trust, Leicester, UK

⁸NIHR Biomedical Research Centre, Leicester, UK

Correspondence to Dr Joseph Barker, Department of Cardiovascular Sciences, University of Leicester, Leicester LE1 9HN, UK; joseph.barker@nhs.net

use of adequate personal protective equipment during patient contact.

In summary, awake prone positioning appears to be safe and may slow the respiratory deterioration in select patients with COVID-19, who require oxygen supplementation or NIV/CPAP. This in turn may reduce demand for IMV, easing the strain placed on intensive care services around the world. In resource-limited settings, this simple, low-cost intervention may serve to raise the ceiling of care for patients that might otherwise have no further option. However, a blanket policy for awake prone positioning in COVID-19, as advocated by ICS, may overstretch personnel without achieving clinically tangible benefits. This may be particularly relevant outside of critical care settings, where staff is likely to be inexperienced and untrained in the adoption of prone positioning.

Presently, uncertainties surrounding the effectiveness of awake prone positioning in ARDS and COVID-19 are substantial. High-quality studies are required to assess the degree to which awake prone positioning may be beneficial, as well as select those who may benefit from it the most. With such an easy intervention, there may be a temptation to intervene based on compassionate grounds—however, without evidence, it will be difficult to assess the true value of prone positioning for future pandemics.

Twitter Joseph Barker @jarbark

Contributors All authors contributed equally.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Competing interests None declared.

Patient consent for publication Not required.

Provenance and peer review Not commissioned; externally peer reviewed.

This article is made freely available for use in accordance with BMJ's website terms and conditions for the duration of the covid-19 pandemic or until otherwise determined by BMJ. You may use, download and print the article for any lawful, non-commercial purpose (including text and data mining) provided that all copyright notices and trade marks are retained.

© Author(s) (or their employer(s)) 2020. No commercial re-use. See rights and permissions. Published by BMJ.

DK and JB are joint first authors.



To cite Koeckerling D, Barker J, Mudalige NL, *et al.* *Thorax* 2020;**75**:833–834.

Published Online First 16 June 2020

Thorax 2020;**75**:833–834.
doi:10.1136/thoraxjnl-2020-215133

ORCID iD

Joseph Barker <http://orcid.org/0000-0002-5483-9608>

REFERENCES

- 1 Xu Z, Shi L, Wang Y, *et al.* Pathological findings of COVID-19 associated with acute respiratory distress syndrome. *Lancet Respir Med* 2020;8:420–2.
- 2 Bamford P, Bentley A, Dean J, *et al.* *Ics guidance for prone positioning of the conscious COVID patient*, 2020.
- 3 Scholten EL, Beitler JR, Prisk GK, *et al.* Treatment of ARDS with prone positioning. *Chest* 2017;151:215–24.
- 4 Glenn RW, Lamm WJ, Albert RK, *et al.* Gravity is a minor determinant of pulmonary blood flow distribution. *J Appl Physiol* 1991;71:620–9.
- 5 Pappert D, Rossaint R, Slama K, *et al.* Influence of positioning on ventilation-perfusion relationships in severe adult respiratory distress syndrome. *Chest* 1994;106:1511–6.

- 6 Gattinoni L, Mascheroni D, Torresin A, *et al.* Morphological response to positive end expiratory pressure in acute respiratory failure. computerized tomography study. *Intensive Care Med* 1986;12:137–42.
- 7 Mercat A, Richard J-CM, Vielle B, *et al.* Positive end-expiratory pressure setting in adults with acute lung injury and acute respiratory distress syndrome: a randomized controlled trial. *JAMA* 2008;299:646–55.
- 8 Brochard L, Slutsky A, Pesenti A. Mechanical ventilation to minimize progression of lung injury in acute respiratory failure. *Am J Respir Crit Care Med* 2017;195:438–42.
- 9 Beitler JR, Guérin C, Ayzac L, *et al.* Peep titration during prone positioning for acute respiratory distress syndrome. *Crit Care* 2015;19:436.
- 10 Guérin C, Reigner J, Richard J-C, *et al.* Prone positioning in severe acute respiratory distress syndrome. *N Engl J Med* 2013;368:2159–68.
- 11 Munshi L, Del Sorbo L, Adhikari NKJ, *et al.* Prone position for acute respiratory distress syndrome. A systematic review and meta-analysis. *Ann Am Thorac Soc* 2017;14:S280–8.
- 12 Bloomfield R, Noble DW, Sudlow A, *et al.* Prone position for acute respiratory failure in adults. *Cochrane Database Syst Rev* 2015;106:CD008095.
- 13 Aoyama H, Uchida K, Aoyama K, *et al.* Assessment of therapeutic interventions and lung protective ventilation in patients with moderate to severe acute respiratory distress syndrome: a systematic review and network meta-analysis. *JAMA Netw Open* 2019;2:e198116.
- 14 Valter C, Christensen AM, Tollund C, *et al.* Response to the prone position in spontaneously breathing patients with hypoxemic respiratory failure. *Acta Anaesthesiol Scand* 2003;47:416–8.
- 15 Scaravilli V, Grasselli G, Castagna L, *et al.* Prone positioning improves oxygenation in spontaneously breathing nonintubated patients with hypoxemic acute respiratory failure: a retrospective study. *J Crit Care* 2015;30:1390–4.
- 16 Ding L, Wang L, Ma W, *et al.* Efficacy and safety of early prone positioning combined with HFNC or NIV in moderate to severe ARDS: a multi-center prospective cohort study. *Crit Care* 2020;24:28.
- 17 Gattinoni L, Chiumello D, Caironi P, *et al.* COVID-19 pneumonia: different respiratory treatments for different phenotypes? *Intensive Care Med* 2020;382:1–6.