

In brief

Respiratory therapies and COVID-19

4 November 2021

Summary

- Clinical management of COVID-19 includes monoclonal antibodies, antiviral drugs and supportive therapies. Respiratory therapies may be used to manage acute respiratory failure, providing ventilatory support and reducing the need for intubation and admission to intensive care.¹ They include oxygen delivery devices, non-invasive ventilation, high flow nasal oxygen therapy and prone positioning.
- Respiratory supports may be used to provide oxygen for adults with COVID-19. Alternatives to invasive mechanical ventilation include standard oxygen delivery devices; non-invasive ventilation, including continuous positive airway pressure (CPAP); and high flow nasal oxygen therapy.
 - Standard oxygen delivery devices, including nasal cannulas, simple (Hudson) masks, Venturi masks and non-rebreather masks deliver varying levels of oxygen to COVID-19 patients with hypoxaemia.
 - The Australian National COVID-19 Clinical Evidence Taskforce recommends non-invasive ventilation for patients with hypoxaemia.³ Non-invasive ventilation may reduce mortality and the need for invasive mechanical ventilation.^{2, 3}
 - The Taskforce recommends CPAP in COVID-19 patients with severe hypoxaemia who are not suitable for mechanical ventilation.^{4, 5} CPAP has been found to have a positive effect on oxygenation and respiratory rate⁶ and early use may reduce mortality.⁷
 - The Taskforce recommends high flow nasal oxygen therapy when a patient is unable to maintain oxygen saturation above 92%.³ The National Institute of Health COVID-19 treatment guideline recommends high flow nasal cannula over non-invasive positive pressure ventilation.⁸
- Prone positioning has been shown to significantly decrease 28-day and 90-day mortality in critically-ill patients with non-COVID-19 acute respiratory distress syndrome (ARDS).⁹ The Australian National COVID-19 Clinical Evidence Taskforce and the World Health Organization (WHO) recommend prone positioning.^{2, 10}
- Many respiratory therapies are considered to be aerosol-generating procedures (AGPs). The WHO considers intubation, extubation, non-invasive ventilation, CPAP, BiPAP, and high-flow oxygen therapy to be AGPs.¹¹

Respiratory supports in adults with COVID-19

Standard oxygen delivery devices

- Standard oxygen delivery devices include:
 - Nasal cannula: can be used at 1-6 L/minute as an initial strategy for COVID-19 patients with mild hypoxaemia.^{12, 13}
 - Simple (Hudson) mask: can be used to deliver an oxygen flow of 5-10 L/minute. For patients requiring higher oxygen delivery, a non-rebreather mask should be used.^{12, 14}
 - Venturi mask: allows for more precise oxygen titration of up to 50% and should be covered with a surgical mask. Alternatively, a non-rebreather mask can be used.¹⁵

- Non-rebreather mask: delivers oxygen flow at 10-15 L/minute and is preferred over a simple mask as it generates the least aerosol dispersion distances (<10cm) compared to other oxygen modalities.^{16, 17} It should be covered with a surgical mask^{14-16, 18, 19} and, if possible, with a filtered exhalation port.²⁰

Non-invasive ventilation

- Non-invasive ventilation (NIV), also known as non-invasive positive pressure ventilation (NIPPV) or bilevel positive pressure support (BiPAP), is a form of respiratory support in which bilevel positive pressure is delivered by a firm-fitting nasal-face mask. Supplemental oxygen can also be delivered through the device.²
- The Australian National COVID-19 Clinical Evidence Taskforce guidelines conditionally recommend non-invasive ventilation for COVID-19 patients with hypoxaemia, ideally in a negative pressure room.²
- A living systematic review reported that non-invasive ventilation probably reduces mortality and the need for invasive mechanical ventilation, but may increase the risk of COVID-19 transmission to healthcare workers.³
- A systematic review of guidelines for non-invasive ventilation during COVID-19 suggested use in a single room, negative-pressure ward, or a dedicated COVID-19 ward. Healthcare workers should wear full personal protective equipment including eye protection, N95 or higher respirators, gloves, and long-sleeved gowns.²¹
- Non-invasive ventilation should not be used in place of invasive ventilation or endotracheal intubation in patients with deteriorating respiratory status, hemodynamic instability, multiorgan failure, or abnormal mental status.²¹
- A case report on the use of average volume-assured pressure support (AVAPS) in a COVID-19 patient unable to tolerate extubation to high flow nasal cannula found AVAPS successfully supported ventilation and oxygenation non-invasively.²²

Continuous positive airway pressure

- CPAP is a non-invasive form of positive airway pressure ventilation that delivers a constant pressure through the respiratory cycle. CPAP is recommended in COVID-19 patients with severe hypoxaemia who are not suitable for mechanical ventilation.^{4, 5}
- The Australian National COVID-19 Clinical Evidence Taskforce conditionally recommends CPAP for COVID-19 patients with persistent hypoxaemia. Most patients require pressures of 10 to 12 cm and oxygen should be adjusted to maintain SpO₂ in the target range (FiO₂ 0.4-0.6).²
- Guidelines from the UK National Health Service (NHS) suggest that if the patient is oriented and able to tolerate a well-fitted, non-vented face mask, CPAP should be set to 10cmH₂O, with FiO₂ 0.6, and increased to 12–15cmH₂O, with FiO₂ 0.6–1.0 if needed. Other guidelines suggest setting the CPAP value at 10–12cmH₂O and increasing up to 15–20cmH₂O if escalation is needed.²¹
- In an observational study of COVID-19 patients treated with CPAP, CPAP was initiated when oxygen supplementation exceeded 10 litres/minute to maintain oxygen saturation (SpO₂) ≥92%. CPAP was administered with full face masks on a continuous basis until stable improvement in oxygenation or until intubation or death. CPAP had a positive effect on oxygenation and respiratory rate in most patients but the prognosis for elderly patients with high oxygen requirements was poor.⁶
- A pre-print randomised controlled trial found CPAP reduced intubation or death within 30 days compared to conventional oxygen therapy in hospitalised adults with COVID-19.²³ Conversely, an observational study comparing clinical outcomes in COVID-19 patients not suitable for invasive mechanical ventilation found no differences between oxygen therapy alone compared to CPAP.²⁴

- The timing of treatment may be important, with early use (within four days of hospital admission) of CPAP linked to a reduction in mortality.⁷

High flow nasal oxygen therapy

- High flow nasal oxygen therapy is a form of non-invasive ventilation where oxygen is delivered via nasal cannula, often in conjunction with compressed air and humidification. Flow rates can be given up to 60 L/minute with an oxygen/air blender supplying oxygen at 21-100%.²
- The Australian National COVID-19 Clinical Evidence Taskforce guidelines conditionally recommend high flow nasal oxygen therapy as an alternative, if CPAP is not available or tolerated.²
- The National Institute of Health COVID-19 treatment guideline recommends high flow nasal cannula over non-invasive positive pressure ventilation for adults with COVID-19 and acute hypoxemic respiratory failure, despite conventional oxygen therapy. This recommendation is based on clinical trials comparing the outcomes of these two methods.⁸
- High flow oxygen therapy may cause aerosolisation of viral pathogens.^{14, 15, 18, 25-28} However, there is no clear evidence as to whether high flow nasal cannula has lower risk of nosocomial transmission than non-invasive ventilation, or vice versa.⁸
- Recommendations for caring for suspected or confirmed COVID-19 patients include:
 - use the lowest flow necessary²
 - ensure correct placement of the nasal cannula and attach elastic bands to the patient's head securely¹⁷
 - use a surgical mask over the high-flow nasal cannula to reduce viral transmission^{14, 17}
 - maintain a closed-circuit, do not interrupt oxygen supply arbitrarily during high flow oxygen therapy^{17, 18, 26, 29, 30}
 - stay more than 45 centimetres away from the patient's airway, and if clinically appropriate, maintain a physical distance of one metre or more from the patient¹⁸
 - use high-flow nasal cannula in a well-ventilated area^{30, 31}
 - treat in a negative-pressure room, or if unavailable,¹⁴ a single room with door closed^{2, 28} or shared ward spaces with a cohort of suspected or confirmed COVID-19 patients.²
 - minimise patient transfer.²

Principles of weaning respiratory supports

- The ability to successfully wean a COVID-19 patient off ventilation is related to patient outcomes, including mortality rate.³²
- An observational study reported COVID-19 patients with severe acute respiratory distress syndrome (ARDS) required twice as long (11 days) to wean off invasive mechanical ventilation compared to non-severe ARDS (5 days).³³
- In a study of 18 ventilated COVID-19 patients in Israel, 88% were successfully weaned from mechanical ventilation and decannulated in a median time of 10 days.³⁴
- A review on weaning precautions in critically-ill COVID-19 patients suggested patients should have a patent airway, adequate ventilation and gas exchange capacity with minimal or no respiratory stress before extubation. Methods of weaning in COVID-19 patients include progressive reduction of pressure support and daily breathing trials.³⁵
- In two case reports on critical COVID-19 patients, weaning was successfully achieved using a weaning screening test, spontaneous breathing test and an airbag leak test. Patients were transitioned to non-invasive ventilation and high flow nasal cannula oxygen support.³⁶
- An observational study on weaning COVID-19 patients from helmet CPAP included a weaning trial of reduction in support to minimal positive end-expiratory pressure (PEEP≈2 cmH₂O, including

antiviral filters) maintaining a $\text{FiO}_2 \leq 60\%$. Absence of respiratory distress and $\text{SpO}_2 \geq 94\%$ in the subsequent 30 minutes lead to helmet removal and oxygen supplementation with $\text{FiO}_2 \leq 60\%$.³⁷

Prone positioning

- Prone positioning is a technique used to help patients with acute respiratory distress syndrome (ARDS) breathe better by placing them on their stomach. Prone positioning is generally used for sedated patients requiring a ventilator but may be beneficial in awake patients with COVID-19.³⁸
- Evidence from randomised controlled trials of prone positioning for intubated, critically-ill patients with non-COVID-19 ARDS have demonstrated that prolonged prone positioning sessions significantly decreased 28-day and 90-day mortality.⁹
- The Australian National COVID-19 Clinical Evidence Taskforce guidelines recommend prone positioning for more than 12 hours per day in mechanically ventilated adults with COVID-19 and hypoxaemia. Prone positioning for at least three hours per day is conditionally recommended for adults with COVID-19 and respiratory symptoms receiving any form of supplemental oxygen therapy and who have not been intubated.²
- The WHO guidelines recommend prone ventilation for 12–16 hours per day for adult patients with severe acute respiratory infection with COVID-19.¹⁰
- Two systematic reviews on the effectiveness of prone positioning in patients with COVID-19 reported potential benefits associated with improved oxygenation parameters and reduced mortality.^{39, 40} One reported a decreased intubation rate,³⁹ while the other found no significant effect on incidence of intubation or critical care admission.⁴⁰ Prone positioning had no significant effect on respiratory rate.³⁹
- Two observational studies of patients with COVID-19 found alternating supine and prone positioning was associated with increased lung recruitability,⁴¹ and prone positioning provides better ventilation of the dorsal lung regions.⁴²
- Awake prone positioning may cause patient discomfort and pain.⁴³ Complications can occur during transitions to and from prone positioning, including:
 - device displacement
 - vomiting
 - loss of venous access
 - accidental extubation
 - endotracheal tube displacement and obstruction
 - hemodynamic instability
 - brachial plexus injury and pressure ulcers.⁴⁴
- Some studies have reported the development of pressure injuries (skin and underlying tissue) in patients with ARDS who were placed in a prone position.^{45, 46} One study demonstrated that having a certified wound and skin care nurse lead pressure injury prevention on a prone positioning team was significantly associated with lower odds of pressure injuries developing in COVID-19 patients.⁴⁷

Aerosol generating procedures

- Aerosol-generating procedures (AGPs) increase transmission risk for respiratory pathogens because they produce aerosols.⁴⁸ Airborne transmission of COVID-19 may occur during aerosol-generating procedures.⁴⁹
- The World Health Organization lists the following as AGPs associated with an increased risk of COVID-19 transmission:
 - tracheal intubation
 - non-invasive ventilation (e.g. BiPAP, CPAP)

- tracheotomy
- cardiopulmonary resuscitation
- manual ventilation before intubation
- bronchoscopy
- sputum induction induced by using nebulised hypertonic saline
- autopsy procedures.

The association between nebuliser therapy or high-flow oxygen and COVID-19 transmission is unclear as data is limited.¹¹

- The US Centers for Disease Control and Prevention guidance considers the following procedures AGPs:
 - open suctioning of airway secretions
 - sputum induction
 - cardiopulmonary resuscitation
 - endotracheal intubation and extubation
 - non-invasive positive pressure ventilation (e.g. BiPAP, CPAP)
 - bronchoscopy
 - manual ventilation
 - autopsy procedures
 - medical/surgical procedures.⁵⁰
- The Clinical Excellence Commission classifies high-flow nasal cannula and non-invasive ventilation as high risk AGPs.²⁸
- A rapid systematic review classified 39 procedure groups associated with aerosol generation:
 - intubation and extubation
 - bronchoscopy
 - sputum induction
 - manual ventilation
 - airway suctioning
 - cardiopulmonary resuscitation
 - tracheostomy and tracheostomy procedures
 - non-invasive ventilation
 - high-flow oxygen therapy
 - nebulised or aerosol therapy.⁵¹
- A separate systematic review found endotracheal intubation, non-invasive ventilation, and administration of nebulised medications, increased the odds of healthcare workers being infected with COVID-19.⁵²
- A pre-print study comparing emissions from ten healthy subjects during respiratory ‘activities’ (quiet breathing, talking, shouting, forced expiratory manoeuvres, exercise, and coughing) with respiratory therapies found that talking, exertional breathing and coughing generate substantially more aerosols than respiratory therapies.⁵³

To inform this brief, a series of Critical Intelligence Unit evidence briefs were used as the base information for the document. Supplementary PubMed and Google searches were conducted using terms related to respiratory therapies, oxygen therapy, aerosol-generating procedures, prone positioning, non-invasive ventilation, continuous positive airway pressure, weaning, and COVID-19 on 11 and 12 October 2021.

References

1. Díaz Lobato S, Carratalá Perales JM, Alonso Íñigo JM. Can we use noninvasive respiratory therapies in COVID-19 pandemic? *Medicina clinica* (English ed). 2020;155(4):183-. DOI: 10.1016/j.medcle.2020.05.005
2. Australian National COVID-19 Clinical Evidence Taskforce. Australian guidelines for the clinical care of people with COVID-19 [Internet]. Australia: Australian National COVID-19 Clinical Evidence Taskforce; 2021 [cited 14 October 2021]. Available from: <https://app.magicapp.org/#/guideline/L4Q5An/section/jOoM9j>
3. Schünemann HJ, Khabisa J, Solo K, et al. Ventilation Techniques and Risk for Transmission of Coronavirus Disease, Including COVID-19: A Living Systematic Review of Multiple Streams of Evidence. *Ann Intern Med*. 2020;173(3):204-16. DOI: 10.7326/M20-2306
4. Sykes DL, Crooks MG, Thu Thu K, et al. Outcomes and characteristics of COVID-19 patients treated with continuous positive airway pressure/high-flow nasal oxygen outside the intensive care setting. *ERJ Open Res*. 2021;7(4):00318-2021. DOI: 10.1183/23120541.00318-2021
5. British Thoracic Society. BTS/ICS Guidance: respiratory care in patients with acute hypoxaemic respiratory failure associated with COVID-19 [Internet]. UK: British Thoracic Society; 18 January 2021 [cited 14 October 2021]. Available from: <https://www.brit-thoracic.org.uk/covid-19/covid-19-information-for-the-respiratory-community/>
6. Kofod LM, Nielsen Jeschke K, Kristensen MT, et al. COVID-19 and acute respiratory failure treated with CPAP. *Eur Clin Respir J*. 2021;8(1):1910191-. DOI: 10.1080/20018525.2021.1910191
7. Ashish A, Unsworth A, Martindale J, et al. CPAP management of COVID-19 respiratory failure: a first quantitative analysis from an inpatient service evaluation. *BMJ Open Respir Res*. 2020;7(1):e000692. DOI: 10.1136/bmjresp-2020-000692
8. COVID-19 Treatment Guidelines Panel. Coronavirus Disease 2019 (COVID-19) treatment guidelines: National Institutes of Health; 2021 [cited 30 July 2021]. Available from: <https://www.covid19treatmentguidelines.nih.gov/management/critical-care/oxygenation-and-ventilation/>
9. Guérin C, Reignier J, Richard J-C, et al. Prone Positioning in Severe Acute Respiratory Distress Syndrome. *NEJM*. 2013;368(23):2159-68. DOI: 10.1056/NEJMoa1214103
10. World Health Organization. Clinical management of severe acute respiratory infection when novel coronavirus (nCoV) infection is suspected [Internet]. WHO, Switzerland, Jan 2020. [cited 12 Oct 2021]. Available from <https://www.who.int/publications/i/item/10665-332299>
11. World Health Organization. Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed [Internet]. World Health Organization, Switzerland, Oct 2021. [cited 12 Oct 2021]. Available from: <https://apps.who.int/iris/bitstream/handle/10665/332879/WHO-2019-nCoV-IPC-2020.4-eng.pdf>
12. Nicholson TW, Talbot NP, Nickol A, et al. Respiratory failure and non-invasive respiratory support during the covid-19 pandemic: an update for re-deployed hospital doctors and primary care physicians. *BMJ*. 2020;369:m2446. DOI: 10.1136/bmj.m2446
13. George L Anesi. COVID-19: Respiratory care of the nonintubated critically ill adult (high flow oxygen, noninvasive ventilation, and intubation): UpToDate; 2021 [cited 30 July 2021]. Available from: <https://www.uptodate.com/contents/covid-19-respiratory-care-of-the-nonintubated-critically-ill-adult-high-flow-oxygen-noninvasive-ventilation-and-intubation#H301509741>
14. Montrieff T, Ramzy M, Long B, et al. COVID-19 respiratory support in the emergency department setting. *Am J Emerg Med*. 2020;38(10):2160-8. DOI: 10.1016/j.ajem.2020.08.001
15. Long B, Liang SY, Hicks C, et al. Just the Facts: What are the roles of oxygen escalation and noninvasive ventilation in COVID-19? *CJEM*. 2020 Sep;22(5):587-90. DOI: 10.1017/cem.2020.396
16. Whittle JS, Pavlov I, Sacchetti AD, et al. Respiratory support for adult patients with COVID-19. *JACEP Open*. 2020;1(2):95-101. DOI: <https://doi.org/10.1002/emp2.12071>

17. Ferioli M, Cisternino C, Leo V, et al. Protecting healthcare workers from SARS-CoV-2 infection: practical indications. *Eur Respir Rev.* 2020;29(155):200068. DOI: 10.1183/16000617.0068-2020
18. Fink JB, Ehrmann S, Li J, et al. Reducing Aerosol-Related Risk of Transmission in the Era of COVID-19: An Interim Guidance Endorsed by the International Society of Aerosols in Medicine. *J Aerosol Med Pulm Drug Deliv.* 2020 Dec;33(6):300-4. DOI: 10.1089/jamp.2020.1615
19. Braude D, Lauria M, O'Donnell M, et al. Safety of air medical transport of patients with COVID-19 by personnel using routine personal protective equipment. *J Am Coll Emerg Physicians Open.* 2021 Apr;2(2):e12389. DOI: 10.1002/emp2.12389
20. Rabec C, Gonzalez-Bermejo J. Respiratory support in patients with COVID-19 (outside intensive care unit). A position paper of the Respiratory Support and Chronic Care Group of the French Society of Respiratory Diseases. *Respir Med Res.* 2020 Nov;78:100768. DOI: 10.1016/j.resmer.2020.100768
21. Wang Z, Wang Y, Yang Z, et al. The use of non-invasive ventilation in COVID-19: A systematic review. *International journal of infectious diseases : IJID: official publication of the International Society for Infectious Diseases.* 2021;106:254-61. DOI: 10.1016/j.ijid.2021.03.078
22. Mittal A, Forte M, Leonard R, et al. Refractory Acute Respiratory Distress Syndrome Secondary to COVID-19 Successfully Extubated to Average Volume-assured Pressure Support Non-invasive Ventilator. *Cureus.* 2020;12(4):e7849-e. DOI: 10.7759/cureus.7849
23. Perkins GD, Ji C, Connolly BA, et al. An adaptive randomized controlled trial of non-invasive respiratory strategies in acute respiratory failure patients with COVID-19. *medRxiv.* 2021:2021.08.02.21261379. DOI: 10.1101/2021.08.02.21261379
24. Bradley P, Wilson J, Taylor R, et al. Conventional oxygen therapy versus CPAP as a ceiling of care in ward-based patients with COVID-19: a multi-centre cohort evaluation. *EClinicalMedicine.* 2021:101122-. DOI: 10.1016/j.eclinm.2021.101122
25. Dagens A, Sigfrid L, Cai E, et al. Scope, quality, and inclusivity of clinical guidelines produced early in the covid-19 pandemic: rapid review. *BMJ.* 2020 May 26;369:m1936. DOI: 10.1136/bmj.m1936
26. Wang H, Zeng T, Wu X, et al. Holistic care for patients with severe coronavirus disease 2019: An expert consensus. *Int J Nurs Sci.* 2020 Apr 10;7(2):128-34. DOI: 10.1016/j.ijnss.2020.03.010
27. Kovacs G, Sowers N, Campbell S, et al. Just the Facts: Airway management during the coronavirus disease 2019 (COVID-19) pandemic. *CJEM.* 2020 Jul;22(4):440-4. DOI: 10.1017/cem.2020.353
28. Clinical Excellence Commission. COVID-19 infection prevention and control manual for acute and non-acute healthcare settings. Version 1.1. Clinical Excellence Commission [Internet]. 2021 May 21. [cited 24 May 2021]. Available from: https://www.cec.health.nsw.gov.au/_data/assets/pdf_file/0018/644004/COVID-19-IPAC-Manual.pdf
29. Lu X, Xu S. Therapeutic effect of high-flow nasal cannula on severe COVID-19 patients in a makeshift intensive-care unit: A case report. *Medicine (Baltimore).* 2020 May 22;99(21):e20393. DOI: 10.1097/md.00000000000020393
30. Mohrsen S. COVID-19: experiences of roadside logistics from a UK air ambulance service. *Journal of Paramedic Practice.* 2020;12(7):263-8. DOI: 10.12968/jpar.2020.12.7.263
31. World Health Organization. Infection prevention and control during health care when COVID-19 is suspected: interim guidance. World Health Organization [Internet]. 2020 March 19. [cited 11 May 2021]. Available from: <https://www.who.int/publications/i/item/10665-331495>
32. Zhao H, Su L, Ding X, et al. The Risk Factors for Weaning Failure of Mechanically Ventilated Patients With COVID-19: A Retrospective Study in National Medical Team Work. *Frontiers in Medicine.* 2021;8:678157-. DOI: 10.3389/fmed.2021.678157
33. Bordon J, Akca O, Furmanek S, et al. Acute Respiratory Distress Syndrome and Time to Weaning Off the Invasive Mechanical Ventilator among Patients with COVID-19 Pneumonia. *J Clin Med.* 2021 Jun 30;10(13). DOI: 10.3390/jcm10132935

34. Ovadya D, Bachar K, Peled M, et al. Weaning of Severe COVID-19 Mechanically Ventilated Patients: Experience within a Dedicated Unit in Israel. *Isr Med Assoc J.* 2020 Dec;22(12):733-5.
35. Luo M, Mei Z, Wei L, et al. Precautions for weaning from invasive mechanical ventilation with critically ill COVID-19. *Heart & lung : the journal of critical care.* 2020 Nov-Dec;49(6):869-71. DOI: 10.1016/j.hrtlng.2020.07.005
36. Peng M, Ren D, Liu Y-F, et al. Two mechanically ventilated cases of COVID-19 successfully managed with a sequential ventilation weaning protocol: Two case reports. *World journal of clinical cases.* 2020;8(15):3305-13. DOI: 10.12998/wjcc.v8.i15.3305
37. Radovanovic D, Pini S, Saad M, et al. Predictors of weaning from helmet CPAP in patients with COVID-19 pneumonia. *Critical care (London, England).* 2021;25(1):206-. DOI: 10.1186/s13054-021-03627-0
38. Hadaya J, Benharash P. Prone Positioning for Acute Respiratory Distress Syndrome (ARDS). *JAMA.* 2020;324(13):1361-. DOI: 10.1001/jama.2020.14901
39. Behesht Aeen F, Pakzad R, Goudarzi Rad M, et al. Effect of prone position on respiratory parameters, intubation and death rate in COVID-19 patients: systematic review and meta-analysis. *Scientific Reports.* 2021 2021/07/13;11(1):14407. DOI: 10.1038/s41598-021-93739-y
40. Fazzini B, Page A, Pearse R, et al. Prone position for non-intubated spontaneously breathing patients with hypoxic respiratory failure: a systematic review and meta-analysis. *British Journal of Anaesthesia.* DOI: 10.1016/j.bja.2021.09.031
41. Pan C, Chen L, Lu C, et al. Lung Recruitability in COVID-19-associated Acute Respiratory Distress Syndrome: A Single-Center Observational Study. *American Journal of Respiratory and Critical Care Medicine.* 2020;201(10):1294-7. DOI: 10.1164/rccm.202003-0527LE
42. Caputo ND, Strayer RJ, Levitan R. Early Self-Prone in Awake, Non-intubated Patients in the Emergency Department: A Single ED's Experience During the COVID-19 Pandemic. *Acad Emerg Med.* 2020 May;27(5):375-8. DOI: 10.1111/acem.13994
43. World Health Organization. COVID-19 Clinical management: living guidance [Internet]. Switzerland: World Health Organization; 25 January 2021 [cited 11 October 2021]. Available from: <https://www.who.int/publications/i/item/WHO-2019-nCoV-clinical-2021-1>
44. Guérin C, Albert RK, Beitler J, et al. Prone position in ARDS patients: why, when, how and for whom. *Intensive Care Medicine.* 2020 2020/12/01;46(12):2385-96. DOI: 10.1007/s00134-020-06306-w
45. Lucchini A, Bambi S, Mattiussi E, et al. Prone Position in Acute Respiratory Distress Syndrome Patients: A Retrospective Analysis of Complications. *Dimens Crit Care Nurs.* 2020 Jan/Feb;39(1):39-46. DOI: 10.1097/dcc.0000000000000393
46. Mora-Arteaga JA, Bernal-Ramírez OJ, Rodríguez SJ. The effects of prone position ventilation in patients with acute respiratory distress syndrome. A systematic review and metaanalysis. *Med Intensiva.* 2015 Aug-Sep;39(6):359-72. DOI: 10.1016/j.medin.2014.11.003
47. Johnson C, Giordano NA, Patel L, et al. Pressure Injury Outcomes of a Prone-Positioning Protocol in Patients With COVID and ARDS. *American Journal of Critical Care.* 2021:e1-e8. DOI: 10.4037/ajcc2022242
48. Klompas M, Baker M, Rhee C. What Is an Aerosol-Generating Procedure? *JAMA Surgery.* 2021;156(2):113-4. DOI: 10.1001/jamasurg.2020.6643
49. World Health Organization. Transmission of SARS-CoV-2: implications for infection prevention precautions [Internet]. Switzerland: World Health Organization; 9 July 2020 [cited 13 October 2021]. Available from: <https://www.who.int/news-room/commentaries/detail/transmission-of-sars-cov-2-implications-for-infection-prevention-precautions>
50. Centers for Disease Control and Prevention. Which procedures are considered aerosol generating procedures in health care settings [Internet]. USA: Centers for Disease Control and Prevention; March 2021 [cited 12 October 2021]. Available from: <https://www.cdc.gov/coronavirus/2019-ncov/hcp/faq.html>
51. Jackson T, Deibert D, Wyatt G, et al. Classification of aerosol-generating procedures: a rapid systematic review. *BMJ Open Respir Res.* 2020 Oct;7(1). DOI: 10.1136/bmjresp-2020-000730

52. Chan VW, Ng HH, Rahman L, et al. Transmission of Severe Acute Respiratory Syndrome Coronavirus 1 and Severe Acute Respiratory Syndrome Coronavirus 2 During Aerosol-Generating Procedures in Critical Care: A Systematic Review and Meta-Analysis of Observational Studies. Crit Care Med. 2021 Jul 1;49(7):1159-68. DOI: 10.1097/ccm.0000000000004965
53. Wilson NM, Marks GB, Eckhardt A, et al. The effect of respiratory activity, ventilatory therapy and facemasks on total aerosol emissions. medRxiv. 2021:2021.02.07.21251309. DOI: 10.1101/2021.02.07.21251309

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