Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

A nomogram for use of non-invasive respiratory strategies in COVID-19

Published Online
February 8, 2021
https://doi.org/10.1016/S2589-7500(21)00006-6

See Articles page e166

Non-invasive respiratory strategies (NIRS) include non-invasive ventilation (NIV) and high-flow nasal cannula (HFNC). Although neither are invasive, the physiological effects of NIV and HFNC differ. The maturity of evidence supporting the use of these approaches also differs. For example, clinical practice guidelines support the use of NIV to treat exacerbation of chronic obstructive pulmonary disease, but evidence in de novo acute hypoxaemic respiratory failure is less robust.[1] HFNC is recommended for acute hypoxaemic respiratory failure,[2] but available evidence from randomised controlled trials is not sufficiently mature to recommend the use of HFNC for chronic obstructive pulmonary disease. This uncertainty demands prudence on the part of the clinician when selecting NIV, HFNC, or neither for an individual patient.

Given the lack of consensus regarding the use of NIRS in the setting of acute hypoxaemic respiratory failure, there was initial skepticism related to its use in hypoxaemic patients with COVID-19 infection. Early in the pandemic, NIRS was infrequently used in the USA.[3] This reluctance was related to several concerns, including perceived high failure rates of NIRS, risk of patient self-inflicted lung injury associated with a high respiratory drive, and infections in clinical staff due to the aerosol-generating potential of these therapies. NIRS was used more commonly in China.[4] The use of HFNC has subsequently increased in other parts of the world, although skepticism regarding use of NIV remains.

In general, the reported failure rates of NIV and HFNC vary. Furthermore, mortality is high in people who do not respond to NIRS and require intubation. Thus, the clinician needs to promptly recognise failure of these strategies. A scale based on heart rate, acidosis, consciousness, oxygenation, and respiratory rate has been proposed to predict NIV failure.[5] Tidal volume (>9 mL/kg predicted body weight) and the ratio of partial pressure of arterial oxygen to fraction of inspired oxygen (≤200 mmHg) at 1 h after initiation of therapy have also been shown to predict failure of NIV.[6] The respiratory rate–oxygenation (ROX) index ([pulse oximetry oxygen saturation/fraction of inspired oxygen]/respiratory rate) is beneficial in predicting HFNC failure.[7]

Against this background is the Article by Ling Liu and colleagues.[4] The aim of their study was to identify early predictors of failure of NIRS. A robust training cohort of 652 adult patients (≥18 years) with COVID-19 who were receiving NIRS for acute respiratory failure was used. Age, number of comorbidities, ROX index, Glasgow coma score, and use of vasopressors on the first day of NIRS were independent risk factors for NIRS failure (defined as subsequent need for invasive mechanical ventilation or death within 28 days after intensive care unit admission) in a multivariable regression. A nomogram and online calculator were developed to determine the probability of NIRS failure in individual patients with COVID-19. This model was validated both internally (by cross-validation) in the training cohort, and externally in a validation cohort of 107 patients. Their nomogram should prove useful for early determination of which patients are likely to fail NIRS, allowing early escalation of therapy (endotracheal intubation) and improved patient outcomes. Notably, the prediction nomogram can be applied for NIV or HFNC.

Liu and colleagues report high failure rates of NIV, with the therapy providing no improvement in 211 (74%) of 286 patients in the training cohort and 48 (81%) of 59 patients in the validation cohort.[4] These findings might create hesitation about whether NIV should be used at all in this setting. Although not as high as those for NIV, Liu and colleagues also report high failure rates for HFNC (in 204 [56%] of 366 patients in the training cohort and 26 [54%] of 48 patients in the validation cohort). Franco and colleagues,[8] however, have reported lower rates of subsequent intubation in patients with COVID-19, in 47 (29%) of 163 patients on HFNC, 82 (25%) of 330 on continuous positive airway pressure, and 49 (28%) of 177 on NIV. Guidelines recommend use of HFNC over NIV and use of NIV only if HFNC is not available.[9] Regardless, success rates for these therapies are not 100% and thus a validated and simple nomogram such as that reported by Liu and colleagues is welcome.

Gershengorn and colleagues[10] constructed dynamical (deterministic) simulation models to predict mortality risk with the use of HFNC and mechanical ventilation in patients with COVID-19 in the USA. From their modelling, they concluded that use of HFNC and early mechanical ventilation, when supply is sufficient, results in reduced deaths and increased ventilator availability—ie, because HFNC can decrease the need for endotracheal intubation, stresses on the supply of available ventilators can be avoided. Although their findings support the use of HFNC during the pandemic, identifying probable failure of the therapy remains important.

Clinicians caring for patients with COVID-19 should consider use of the nomogram created by Liu and colleagues when NIRS is used, to identify patients in whom the therapy is likely to fail. Additional research should be done to determine whether the nomogram can also be used in the setting of NIRS for patients with hypoxaemic respiratory failure not related to COVID-19.

I declare personal fees from Ventec Life Systems, Daedalus Enterprises, Jones and Bartlett, McGraw-Hill, and UpToDate, outside of the submitted work.

Dean R Hess
dhess@mgh.harvard.edu

Massachusetts General Hospital, Northeastern University, Boston, MA 01923, USA

1 Rochwerg B, Brochard L, Elliott MW, et al. Official ERS/ATS clinical practice guidelines: noninvasive ventilation for acute respiratory failure. *Eur Respir J* 2017; **50:** 1602426.

2 Rochwerg B, Einav S, Chaudhuri D, et al. The role for high flow nasal cannula as a respiratory support strategy in adults: a clinical practice guideline. *Intensive Care Med* 2020; **46:** 2226–37.

3 Ziehr DR, Alladina J, Petri CR, et al. Respiratory pathophysiology of mechanically ventilated patients with COVID-19: a cohort study. *Am J Respir Crit Care Med* 2020; **201:** 1560–64.

4 Liu L, Xie J, Wu W, et al. A simple nomogram for predicting failure of non-invasive respiratory strategies in adults with COVID-19: a retrospective multicentre study. *Lancet Digit Health* 2021; published online Feb 8. https://doi.org/10.1016/S2589-7500(20)30316-2.

5 Duan J, Han X, Bai L, Zhou L, Huang S. Assessment of heart rate, acidosis, consciousness, oxygenation, and respiratory rate to predict noninvasive ventilation failure in hypoxemic patients. *Intensive Care Med* 2017; **43:** 192–99.

6 Frat JP, Ragot S, Coudroy R, et al. Predictors of intubation in patients with acute hypoxemic respiratory failure treated with a noninvasive oxygenation strategy. *Crit Care Med* 2018; **46:** 208–15.

7 Roca O, Caralt B, Messika J, et al. An index combining respiratory rate and oxygenation to predict outcome of nasal high-flow therapy. *Am J Respir Crit Care Med* 2019; **199:** 1368–76.

8 Franco C, Facciolongo N, Tonelli R, et al. Feasibility and clinical impact of out-of-ICU noninvasive respiratory support in patients with COVID-19-related pneumonia. *Eur Respir J* 2020; **56:** 2002130.

9 Alhazzani W, Møller MH, Arabi YM, et al. Surviving sepsis campaign: guidelines on the management of critically ill adults with coronavirus disease 2019 (COVID-19). *Crit Care Med* 2020; **48:** e440–69.

10 Gershengorn HB, Hu Y, Chen JT, et al. The impact of high-flow nasal cannula use on patient mortality and the availability of mechanical ventilators in COVID-19. *Ann Am Thorac Soc* 2020; published online Oct 13. https://doi.org/10.1513/AnnalsATS.202007-803OC.