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Contemporary issues

How do nurses better predict outcomes for adult COVID-19 patients receiving nasal high flow therapy in the emergency care setting?

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The adoption of nasal high flow therapy (NHF) as a form of respiratory support (RS) has steadily increased, particularly since the emergence of COVID-19. Formally RS of the spontaneously breathing adult patient was achieved using non-invasive ventilation (NIV) or conventional oxygen therapy (COT)). Today RS includes the option of NHF therapy. Nasal high flow therapy is used in various clinical settings, including the busy Emergency Care (EC) where it is regarded as a feasible RS option. In patients with acute respiratory failure (ARF) reliable evidence credits NHF use with a possibly lower mortality rate (HR 2.50 (95% CI, 1.31 to 4.78) non-invasive ventilation versus NHF (P=0.006)) [2], this evidence has driven changes to patient care [7]. Whereby based on degree of hypoxemia: mild ARF is (200 mm Hg $<$ $PaO_2/FIO_2 \leq$ 300 mm Hg), moderate (100 mm Hg $< PaO_2/FIO_2 \leq$ 200 mm Hg), and severe ($PaO_2/FIO_2 \leq$ 100 mm Hg) [9]. Emergency Care Nurses are motivated to improve the prediction of outcomes for those receiving NHF therapy. Nurses in EC appreciate that any delay in care escalation is associated with an increase in poor outcomes such as mortality, increased length of hospital stay, and cost [5]. Unstable EC patients require close monitoring and assessment to ensure timely escalation and possible intubation, including those receiving NHF therapy. Additionally, EC nurses should be aware of NHF therapy's potential to mask symptoms such as unstable oxygen saturations, blurring the diagnostic process.

Nasal high flow (NHF) therapy delivers humidified gas (air and oxygen) to the upper airway via a specialist nasal cannula. A humidifier (within the NHF system) warms (up to 37 °C) and adds water to the gas ready for inspiration. This therapy replicates the natural balance of heat and moisture seen in healthy lungs. The NHF system can deliver humidified gas to adult patients at a flow rate between 10 and 60 litres per minute and a fraction of inspired oxygen (FiO_2) between .21 (21% oxygen) and 1.0 (100 % oxygen). The flow rate and the FiO_2 level can be independently adjusted [7].

The benefits of NHF therapy in ARF are attributed to:

- Gas flow rates that a) do prevent the patient from entraining room air thereby reducing the FiO_2 available to them and b) reduce airway dead space by washing out expired CO_2 from the upper airway. Both these factors reduce the patient's work of breathing.
- Delivery of a level of dynamic, positive airway pressure that increases functional residual capacity; this pressure often referred to as a positive end-expiratory pressure (PEEP) in the NHF therapy literature
- Airway humidification that is comfortable for the patient and aids sputum clearance [7].

The most common COVID-19 complication is ARF, secondary to interstitial pneumonia. This ARF (due to interstitial pneumonia) is primarily characterised by fever, cough, dyspnea, bilateral infiltrates on x-ray and a 10 % prevalence of hypoxaemia [6]. Patients may present to the EC with atypical symptoms, such as a moderate increase in respiratory rate and severe hypoxia [10]. These patients can suddenly deteriorate with 15 to 30% progressing within one to two days to severe respiratory failure due to acute respiratory distress syndrome (ARDS) [11].

Patient care strategies for COVID-19 ARF align with the generic patient care strategies for ARF. However, this alignment has not yet been formally established by way of a controlled study. Previously the NHF therapy benefits such as comfort, improved oxygenation, and decreased work of breathing have been reported for patients with ARF [7]. It has been assumed that these benefits may also apply to those with COVID-19 ARF. However, while NHF therapy has been described as beneficial for COVID-19 patients with mild to moderate ARF, the mortality rate is high in severe respiratory failure, and NHF therapy should be cautiously used [11]. Clinicians must be aware that these patients may suddenly deteriorate and require urgent escalation of care.

An evidence-based approach to EC nursing is now even more essential during the COVID-19 pandemic where consequences are high, and resources constrained. Nurses must navigate the swiftly less rigorous and ubiquitous evidence alongside evidence which is reliable

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and valid. Any changes to patient care should not rely only on unreliable evidence sources, e.g. case series, case reports, and anecdotes. An evidenced-based strategy is required to consider the relative disadvantages and advantages that the RS therapies provide for patients and healthcare practitioners. For example, non-invasive RS may reduce the infectious risk to clinicians by avoiding the need for invasive intubation, a procedure known to be highly infectious. However, all forms of RS generate aerosols and seemingly any risk of aerosol-based infection is more influenced by the mechanics of breathing individual rather than specific therapies applied [3].

An evidence-based approach to nursing care is informed by bedside physiology and supported by clinically significant outcome data. An index which uses bedside physiology is the ROX (Respiratory rate-OXygenation) index. This index also considers the clinically significant outcome, which is the need to escalate care of patients receiving NHF therapy.

The ROX index was founded on the premise that sicker patients have higher oxygen needs and higher respiratory rates. The index involves three common physiological measurements: FiO_2, oxygen saturation via pulse oximetry (SpO_2), and respiratory rate (RR). The ROX index is the first validated scoring system (SS) used in adults receiving NHF therapy who have ARF due to pneumonia alone [8].

Post commencing NHF therapy ROX index should be calculated at three specific time points 2, 6 and 12-hours. The index is validated at these time points. The ROX index is determined by dividing the SpO_2 by the FiO_2 and dividing this result by the respiration rate (RR) (SpO_2/FiO_2)/RR. If the patient has a normal SpO_2 of 96% whilst breathing room air (FiO_2 0.21) and a respiratory rate of 18, their ROX index would be 25.3 (see Table 1). Table 1 also shows the ROX index calculation for a hypoxaemic patient. This patient has a SpO_2 of 90%, with a FiO_2 of .80 and a RR of 30, which results in a ROX index of 3.75.

The hypoxaemic patient presented in Table 1 with a ROX score of 3.75, therefore categorises them as requiring consideration for escalation of care. In contrast, those with an index of $\geq$4.88 measured after 12 hours of NHF therapy are deemed at a lower risk and suggesting continuation NHF therapy [8].

Index values $\leq$ 2.85 at 2 hours, $\leq$ 3.47 at 6 hours, or $\leq$ 3.85 at 12 hours of NHF use, suggests that the patient may be failing, and escalating care should be considered along with more intensive monitoring (see Table 2).

The ROX index is one of the over 250,000 scoring systems (SS) in use across all clinical domains. EC nurses regularly use scoring systems to inform the safety, diagnosis, treatment, and prognosis of their patients, including those receiving NHF therapy). In addition to informing the early detection of patient deterioration, the ROX index may also help determine which EC patients can be discharged safely. Determining who should be hospitalised is essential when dealing with a rapidly spreading global COVID-19 pandemic, that has the potential to overwhelm hospital capacity. Quick and easy tools such as the ROX index may support EC nurses to make these critical clinical decisions.

Since 2016 both the clinical and the research communities have both adopted the ROX index. Use of the index has been described in differing patient groups and settings. The index has recently been used to consider patients' success or failure with COVID-19 related ARF receiving NHF therapy. In these patients, a ROX index calculated at 6-hours (ROX-6) of $\geq$3.7 (ROX-6 $\geq$3.7) predicted patient success on NHF therapy 80% of the time. Alternatively, a ROX-6 of 2.2 predicted patient failure on NHF therapy, 74% of the time [1].

Researchers have also piloted modifications to the original index. A modified index which incorporates heart rate (HR) is known as ROX-HR was tested by Goh et al. [4]. The ROX-HR index may also be useful for early prediction of patient outcomes in those with Acute Hypoxic Respiratory Failure (AHRF) and those following planned extubation.

The ROX index is simple to calculate and is easily interpreted by EC nurses in practice in an often-chaotic environment with multiple interruptions. Online ROX index calculators have been developed and are now available for clinicians to use https://www.mdcalc.com/rox-index-intubation-hfnc.

Table 1
ROX index explained at 12 h after NHF commencing.

$$\frac{SpO_2/FiO_2}{RR} = \text{ROX Index}$$

Healthy Adult	Hypoxaemic Adult
Calculated at 12 hours post-NHF commencing	Calculated at 12 hours post-NHF commencing
$\frac{96/0.21}{18} = 25.3$	$\frac{90/0.80}{30} = 3.75$
ROX index is 25.3	ROX index is 3.75
Suggests continuing with NHF	Suggests consideration of escaltion of patient care

Table 2
thresholds suggesting consideration of patient care required at three time points

ROX value thresholds suggesting consideration of patient care required	
Calculated at 2 hours post-NHF commencing	$\leq$2.85
Calculated at 6 hours post-NHF commencing	$\leq$3.47
Calculated at 12 hours post-NHF commencing	$\leq$3.85

In the busy EC environment now inundated with COVD-19 patients, the ROX index may compliment EC nurses' clinical decision-making when delivering NHF therapy. Further study is necessary, to demonstrate that the use of ROX index can improve EC clinical outcomes, and not only predict them.

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Declaration of Competing Interest

The authors declare that they have no conflict of interest.

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