Predicting the outcome of nasal high flow therapy using the Respiratory-Rate-Oxygenation (ROX) index

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Background

In the last decade, nasal high flow (NHF) has become a first-line therapy for patients with acute hypoxemic respiratory failure.1

NHF is a powerful oxygenation tool.2 However, a high FiO₂ can potentially mask deterioration and delay escalation of care.

The risk of delayed intubation

The risk of invasive mechanical ventilation is well understood, although delaying intubation can result in a lengthened hospital stay and increased mortality.3,4 In a retrospective study by Kang et al., patients receiving NHF therapy who were intubated earlier had lower mortality, improved extubation success, and fewer days on a ventilator.5

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How to predict success and failure of NHF using ROX

ROX = $\frac{\text{SpO}_{2}/\text{FiO}_2}{\text{RR}}$

Healthy 30.2 = $\frac{95/0.21}{15}$

Patient 3.0 = $\frac{95/0.85}{37}$

2. The ROX that predicts failure shown in red at 2, 6 and 12 hours and the ROX that predicts success above 4.88.

What is ROX?

Roca and colleagues (2016) first established the ROX index to predict the success of NHF therapy. The ROX index combines three common measurements: FiO$_2$, SpO$_2$, and respiratory rate. NHF of 50 L/min and higher in adults exceeds inspiratory flow and reduces the entrainment of air. This makes delivered FiO$_2$ more precise and it can be used for the ROX calculation. The index is based on two well-known facts: sicker patients require more oxygen and have a higher respiratory rate.

Validating ROX

The index has been validated in a multi-center prospective study on 191 patients with pneumonia. The authors confirmed that a ROX value of ≥ 4.88 predicted the success of NHF. In addition, ROX values were provided that predict NHF failure with a high specificity (98–99%): ≤ 2.85 at 2 hours, ≤ 3.47 at 6 hours, and ≤ 3.85 at 12 hours of NHF use.

“The authors confirmed that a ROX value of ≥ 4.88 predicted the success of NHF”

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The importance of $\text{FiO}_2$

Among components of the index, $\text{SpO}_2/\text{FiO}_2$ had a greater weight than the respiratory rate. This is reflected in Figure 3: an $\text{FiO}_2$ of 0.80 or above will predict a ROX index of less than 4.88, shown in red, and an $\text{FiO}_2$ of 0.50 or below will predict a higher ROX, shown in blue.

What do changes in the ROX mean?

If the respiratory rate and/or $\text{FiO}_2$ requirement is increasing, then the patient is clearly deteriorating. The continuous monitoring of ROX may be particularly helpful when the patient is in an unstable condition.

For example, two patients begin NHF treatment and both have a ROX value of 4.0 – see table below and Figure 4. Because this is only the start of the therapy, the ROX value can be monitored to see whether the index improves. During the first 6 hours, the first patient has a decrease in respiratory rate and the $\text{FiO}_2$ has been lowered; patient 2 has an increase in respiratory rate and the $\text{FiO}_2$ has been increased. As a result, the ROX value at 6 hours for patient 1 is 6.0 and for patient 2 is 3.0. Based on the values provided by Roca et al., patient 1 has a high likelihood of NHF therapy success and can be maintained on NHF. However, patient 2 has a trending decline and low ROX; therefore, escalation of care should be considered.
Putting ROX into practice

The ROX index is a useful tool because it requires only a few data points and can be measured at the patient’s bedside. The index can be used to monitor the patient and predict the likelihood of success or failure of NHF therapy. Furthermore, ROX highlights the importance of the required FiO₂; if the required FiO₂ is high, then the patient may be at greater risk of failure.

Combining the ROX values with the change in the respiratory rate and FiO₂ can indicate whether escalation is required. A proposed XY plot of the key components of ROX may show the direction of changes in vector form – see arrows in Figure 4 above. Vectors towards the upper right indicate a deterioration and towards the lower left, an improvement.

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