When continuous monitoring of PaCO₂ is necessary, especially in patients with shunt or V/Q mismatches, tcpCO₂ is more accurate than end-tidal CO₂.

Joseph D. Tobias MD, Vice-Chairman, Dep. of Anesthesiology, University of Missouri
Identify ventilatory events and optimize NIV

tcpCO₂ monitoring documents changes in non-invasive ventilation

The use of non-invasive ventilation (NIV) for treatment of chronic hypercapnic respiratory failure like COPD, ARDS, cystic fibrosis, neuromuscular diseases, etc. has significantly increased. To maintain optimal respiratory gas exchange it is essential to evaluate the adequacy of alveolar ventilation, when patients are ventilated by NIV (BPAP/CPAP/IPPV) [1].

The American Association of Respiratory Care (AARC) states in their Clinical Practice Guidelines that documentation of order for mechanical ventilator settings should include at least one and preferably both of the following: A: (desired range for) PaCO₂, tcpCO₂ and/or (desired range for) PaO₂, SpO₂, tcpO₂ or SaO₂; B: Ventilator variables to initiate or manipulate in order to achieve desired blood gas results [2].

Repeated arterial PaCO₂ (PaCO₂) is obtained by arterial puncture or indwelling catheter. Both methods are intermittent, invasive and require costly equipment, specially trained personnel and in most cases also the clinical environment of an ICU [1,3]. tcpCO₂ monitoring of the ventilatory response in NIV patients with e.g. AECOPD* provides physicians with an alternative to these methods as it continuously and non-invasively estimates the level of CO₂ [3].

**Janssens JP et al. document**

Transcutaneous carbon dioxide monitoring is a reliable, non-invasive alternative to repeatedly invasive arterial gases, because tcpCO₂ monitoring:

- identifies ventilatory events that last more than one minute and which may lead to hypercapnia
- permits clinicians to make the necessary adjustments in ventilatory support during and when initiating or interrupting NIV, particularly in patients receiving oxygen, where SpO₂ has shown to have limited value in diagnosing CO₂ retention [1]

Using combined tcpCO₂ and SpO₂ monitoring during O₂ titration may reduce the number of arterial samples in patients assessed for long-term oxygen therapy [4]. tcpCO₂ detects day- and nighttime hypo- or hyperventilation and monitors the baseline tcpCO₂ in patients during NIV.

* AECOPD = acute exacerbations of chronic obstructive pulmonary disease

Detect hypo- or hyperventilation during weaning and permissive hypercapnia

tcpCO₂ monitoring increases patient safety during weaning
Tobias JD reviewed tcpCO₂ monitoring in general and states: “Several studies have shown previously unrecognized episodes of hypercapnia during spontaneous ventilation that has been identified by tcpCO₂ monitoring” [5].

Johnson DC et al. evaluated tcpCO₂ monitoring in tracheotomized patients with prolonged weaning failure during a daytime spontaneous breathing trial (SBT). The accuracy of tcpCO₂ and ETCO₂ monitoring was compared with PaCO₂. The study documented that tcpCO₂ monitoring is a very helpful tool in assigning and managing SBT patients, as it provides a better reflection of PaCO₂ than ETCO₂ in patients with ventilation–perfusion mismatch [6].

Minimize the risk of hypoventilation during permissive hypercapnia
Traditional mechanical ventilation seeks to achieve normal PaCO₂ levels of 40 mmHg using relatively large tidal volumes to avert atelectasis and prevent hypercapnia. NIV with high airway pressures and/or large tidal volumes may cause and/or propagate lung injury in critically ill patients with e.g. COPD or acute respiratory distress syndrome (ARDS) [7–10]. Smaller tidal volume may prevent baro-trauma and lung injury [11]. Using permissive hypercapnia as a ventilatory strategy calls for an increased focus on reducing the risk of adverse effects like “intentional” respiratory acidosis and severe hypercapnia.

“When compared with end-tidal carbon dioxide (ETCO₂) monitoring techniques, transcutaneous (tcpCO₂) monitoring has shown to be equally as accurate in patients with normal respiratory function and more accurate in patients with shunt or ventilation–perfusion inequalities. tcpCO₂ monitoring can be applied in situations that generally preclude ETCO₂ monitoring such as high frequency ventilation, apnea testing and non-invasive ventilation.”[5]

Reliable monitoring of patients with V/Q mismatch, shunt or diffusion defects

**Postsurgery respiratory complication**
The combination of a sedative and analgesia with opioids is commonly used for patients during e.g. abdominal or thoracic surgery. Patients are ventilated to secure optimal inflation of the lungs. A common postsurgery complication is drug-induced atelectasis, which increases the alveolar death space and strengthens the ventilation-perfusion mismatch that may result in ARDS with hypercapnia [12].

**High frequency ventilation may induce undetected hypoventilation**

<table>
<thead>
<tr>
<th>tcpCO₂ is more reliable in patients with respiratory shunt or V/Q mismatch</th>
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<tr>
<td>As ETCO₂ tends to dilute CO₂ levels from parts of the healthy lungs (having normal ventilation perfusion ratio) with CO₂ from the abnormal area of the lungs, the technique thereby underestimates PaCO₂ [13]. As tcpCO₂ trends follow PaCO₂ through the skin, it is not influenced by ventilation-perfusion mismatches and it will therefore monitor the PaCO₂ more accurately [5].</td>
</tr>
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</table>

Hypoventilation is well described during high frequency jet ventilation (HFJV) and high frequency oscillatory ventilation (HFOV) [14,15]. It is advised to monitor oxygen saturation and carbon dioxide levels in patients during these treatments [16]. A combined SpO₂/tcpCO₂ monitoring indicates and thus reduces the risk of hypoventilation [14]. This is especially interesting during treatments where other non-invasive CO₂ measurements and clinical assessment can be difficult or impossible [15].

**Respiratory testing**
Measurements of non-specific bronchial hyperreactivity caused by inhaled bronchia constrictor agents (BCA) provide important research and diagnostic aid. tcpCO₂ monitoring is a reliable tool for analysis of the slope of dose-response curves to inhaled BCA in adult asthmatic patients [17,18]. Palmisano BW and Severinghaus documented that tcpCO₂ is just as reliable in patients with cystic fibrosis as in other ventilated patients with normal skin conditions [19]. This has been confirmed during sleep studies and pre-exercise tests [20].

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Transcutaneous monitoring is a valuable tool in situations that generally preclude CO₂ monitoring such as non-invasive ventilation, oxygen titration, permissive hypercapnia, etc.

Radiometer’s portfolio includes sensors for measuring tcpCO₂, tcpO₂, and SpO₂. The sensors can easily be applied on various sites such as the thorax, the forearm or, for increased patient comfort, on the earlobe.

In addition to the sensor portfolio, Radiometer’s TCM monitor provides trend measurements of both tcpCO₂ and tcpO₂ and the option of marking clinical events as they occur. Features like the USB port for export and printing of data, patient data management system, nurse call and video-guided tutorials make the TCM monitor from Radiometer easy to operate and the best choice for increased patient safety in respiratory departments.

<table>
<thead>
<tr>
<th>Sensor</th>
<th>Parameter</th>
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<tr>
<td>tc Sensor 92</td>
<td>tcpCO₂ and SpO₂</td>
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<tr>
<td>tc Sensor 54</td>
<td>tcpCO₂</td>
</tr>
<tr>
<td>tc Sensor 84</td>
<td>tcpCO₂ and tcpO₂</td>
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</tbody>
</table>

Did you know?

- tcpCO₂ detects hypo- or hyperventilation in patients and monitors tcpCO₂ baseline
- tcpCO₂ supports a change in ventilator settings and weaning from ventilator
- tcpCO₂ diagnoses hypoventilation and optimizes oxygen titration during NIV
- tcpCO₂ delivers reliable trends on patients with respiratory shunt or V/Q mismatch
- tcpCO₂ is the best-suited CO₂ monitoring technique during HFJV/HFOV treatment
Radiometer’s tcpCO₂ handbook

A unique guide to understanding the relevance of monitoring tcpCO₂ in different clinical settings.

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