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# tc*p*$CO_2$ monitoring improves respiratory care

"When continuous monitoring of $PaCO_2$ is necessary, especially in patients with shunt or V/Q mismatches, tc*p*$CO_2$ is more accurate than end-tidal $CO_2$"

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# Identify ventilatory events and optimize NIV

## tc$pCO_2$ 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) $PaCO_2$, tc$pCO_2$ and/or (desired range for) $PaO_2$, $SpO_2$, tcp$O_2$ or $SaO_2$; B: Ventilator variables to initiate or manipulate in order to achieve desired blood gas results [2].

Repeated arterial $pCO_2$ ($PaCO_2$) 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]. tc$pCO_2$ 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 $CO_2$ [3].

### Janssens JP *et al.* document

**Transcutaneous carbon dioxide monitoring is a reliable, non-invasive alternative to repeatedly invasive arterial gases, because tc$pCO_2$ 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 $SpO_2$ has shown to have limited value in diagnosing $CO_2$ retention[1]**

Using combined tc$pCO_2$ and $SpO_2$ monitoring during $O_2$ titration may reduce the number of arterial samples in patients assessed for long-term oxygen therapy [4]. tc$pCO_2$ detects day- and nighttime hypo- or hyperventilation and monitors the baseline tc$pCO_2$ in patients during NIV.

***** AECOPD = acute exacerbations of chronic obstructive pulmonary disease

**1.** Janssens JP, Howarth-Frey C, Chevrolet JC, Abajo B, and Rochat T. Transcutaneous $pCO_2$ to monitor noninvasive mechanical ventilation in adults - assessment of a new transcutaneous $pCO_2$. Chest 1998; 113: 768-73. **2.** AARC Clinical Practice Guideline, Patient-Ventilator System Checks; Reprinted from the August 1992 issue of Respiratory Care Respir Care 1992; 37(8): 882–86. **3.** Cox M, Kemp R, Anwer S *et al.* Non-invasive monitoring of $CO_2$ levels in patients using. NIV for AECOPD. Thorax.bmjjournals.com 2005; Postscript; doi: 10.1136/thx.2005051664. **4.** Török SS, Leuppi D *et al.* Combined oximetry-cutaneous capnography in patients assessed for long-term oxygen therapy. Chest 2008; 133: 1421-25.

# Detect hypo- or hyperventilation during weaning and permissive hypercapnia

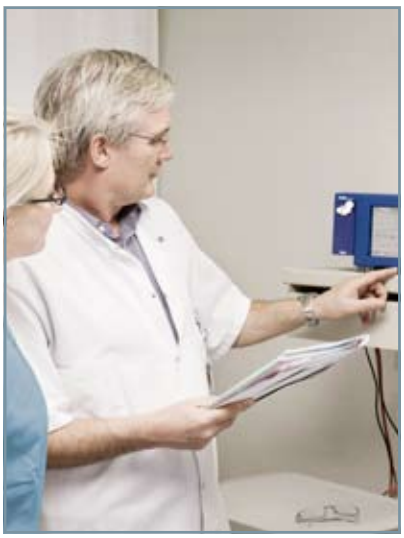
## tc*p*$CO_2$ monitoring increases patient safety during weaning

Tobias JD reviewed tc*p*$CO_2$ monitoring in general and states: "Several studies have shown previously unrecognized episodes of hypercapnia during spontaneous ventilation that has been identified by tc*p*$CO_2$ monitoring" [5].

Johnson DC *et al.* evaluated tc*p*$CO_2$ monitoring in tracheotomized patients with prolonged weaning failure during a daytime spontaneous breathing trial (SBT). The accuracy of tc*p*$CO_2$ and $ETCO_2$ monitoring was compared with $PaCO_2$. The study documented that tc*p*$CO_2$ monitoring is a very helpful tool in assigning and managing SBT patients, as it provides a better reflection of $PaCO_2$ than $ETCO_2$ in patients with ventilation–perfusion mismatch [6].

## Minimize the risk of hypoventilation during permissive hypercapnia

Traditional mechanical ventilation seeks to achieve normal $PaCO_2$ 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.



### Tobias JD reviewed tc*p*$CO_2$ monitoring in general and states

"When compared with end-tidal carbon dioxide ($ETCO_2$) monitoring techniques, transcutaneous (tc*p*$CO_2$) 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. tc*p*$CO_2$ monitoring can be applied in situations that generally preclude $ETCO_2$ monitoring such as high frequency ventilation, apnea testing and non-invasive ventilation."[5]

**5.** Tobias JD. Transcutaneous carbon dioxide monitoring in infants and children. Paediatr Anaesth 2009; 19: 434–44. **6.** Johnson DC, Batool S, Dalbec B. Transcutaneous carbon dioxide monitoring in a specialized weaning unit. Respir care 2008 Aug; 53 (8): 1042–47. **7.** Parker JC, Hernandez LA, Longenecker GL, Peevy KJ, Johnson W. Lung edema caused by high peak inspiratory pressures in dogs: role of increased microvascular filtration pressure and permeability. Am Rev Respir Dis 1990; 142: 321-28. **8.** Dreyfuss D, Soler P, Basset G, Saumon G. High inflation pressure pulmonary edema: respective effects of high airway pressure, high tidal volume, and positive end-expiratory pressure. Am Rev Respir Dis 1988; 137: 1159-64. **9.** Hernandez LA, Peevy KJ, Moise AA, Parker JC. Chest wall restriction limits high airway pressure-induced lung injury in young rabbits. J Appl Physiol 1989; 66: 2364-68. **10.** Dreyfuss D, Saumon G. Ventilator-induced lung injury: lessons from experimental studies. Am J Respir Crit Care Med 1998; 157: 294-323. **11.** American Thoracic Society, European Society of Intensive Care Medicine, Societe de Reanimation de Langue Fran-caise. International Consensus Conferences in Intensive Care Medicine: ventilator-associated lung injury in ARDS. Am J Respir Crit Care Med 1999; 160: 2118-24.

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

## Postsurgery respiratory complication

The combination of a sedative and analgesia with opiods 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

### tc*p*$CO_2$ is more reliable in patients with respiratory shunt or V/Q mismatch

**As $ETCO_2$ tends to dilute $CO_2$ levels from parts of the healthy lungs (having normal ventilation perfusion ratio) with $CO_2$ from the abnormal area of the lungs, the technique thereby underestimates $PaCO_2$ [13]. As tc*p*$CO_2$ trends follow $PaCO_2$ through the skin, it is not influenced by ventilation-perfusion mismatches and it will therefore monitor the $PaCO_2$ more accurately [5].**

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 $SpO_2$ /tc*p*$CO_2$ monitoring indicates and thus reduces the risk of hypoventilation [14]. This is especially interesting during treatments where other non-invasive $CO_2$ 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. tc*p*$CO_2$ 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 tc*p*$CO_2$ 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].

**12.** Ahmad. Pre & post operative complications of anesthesia. The Professional 1995; 2: 1-5. **13.** Gerald J. Kast. Principles & practice of point of care testing. Philadelphia: Lippincott Williams & Wilkins, 2002. **14.** Hautmann H, Gamarra F *et al.* High Frequency Jet Ventilation in interventional fiberopctic bronchoscopy. Anesth Analg. 2000; 90: 1436-40. **15.** Rowley DD, Walsh BK *et al.* Evaluation of a new digital transcutaneous tc*p*$CO_2$ and $SpO_2$ combination sensor and its correlation to ABG $PaCO_2$ measurements. AARC 51st international respiratory congress, Program from the open forum no. 1. 2005; OF-05-106: 69. **16.** Biro P, Layer M *et al.* Carbon dioxide elimination during high-frequency jet ventilation for rigid bronchoscopy. Br Journal Anaesth 2000; 80; 5: 635-37. **17.** Fontana GA, Lavorini F, Boddi V *et al.* Comparison of dose-response slopes obtained by simultaneous assessment of changes in FEV1 and transcutaneous oxygen partial pressure during methacholine challenges in asthmatic patients. J Asthma 1995; 32, 4: 301-407. **18.** Fontana GA, Cardellicchio S, Camiciottoli G *et al.* Changes in transcutaneous oxygen partial pressure as an index of response to inhaled methacholine in asthmatic patients. Chest 1993; 103,5: 1375-80. **19.** Palmisano BW, Severinghaus JW. Transcutaneous $pCO_2$ and $pO_2$ A multicenter study of accuracy. J Clin Monit 1990; 6: 189-95. **20.** Bradley S, Solin P, Wilson J *et al.* Hypoxemia and hypercapnia during exercise and sleep in patients with cystic fibrosis. Chest 1999; 116(3): 647-54.

# Transcutaneous monitoring from Radiometer

Transcutaneous monitoring is a valuable tool in situations that generally preclude $CO_2$ monitoring such as non-invasive ventilation, oxygen titration, permissive hypercapnia, etc.

Radiometer's portfolio includes sensors for measuring tc*p*$CO_2$, tc*p*$O_2$and $SpO_2$. 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 tc*p*$CO_2$ and $SpO_2$ 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.

| Sensor | Parameter |
|---|---|
| tc Sensor 92 | tc*p*$CO_2$ and $SpO_2$ |
| tc Sensor 54 | tc*p*$CO_2$ |
| tc Sensor 84 | tc*p*$CO_2$ and tc*p*$O_2$ |

## Did you know ?

- tc*p*$CO_2$ detects hypo- or hyperventilation in patients and monitors tc*p*$CO_2$ baseline
- tc*p*$CO_2$ supports a change in ventilator settings and weaning from ventilator
- tc*p*$CO_2$ diagnoses hypoventilation and optimizes oxygen titration during NIV
- tc*p*$CO_2$ delivers reliable trends on patients with respiratory shunt or V/Q mismatch
- tc*p*$CO_2$ is the best-suited $CO_2$ monitoring technique during HFJV/HFOV treatment

# Radiometer's tc$pCO_2$ handbook

A unique guide to understanding the relevance of monitoring tc$pCO_2$ in different clinical settings.

To order your copy of Radiometer's tc$pCO_2$ handbook, contact your local Radiometer TC representative today.



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