Carbon dioxide monitoring during laparoscopic-assisted surgery in severely obese patients: transcutaneous versus end-tidal techniques

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Abstract

Background: Arterial blood gas analysis for carbon dioxide (PaCO₂) is the gold standard measure of ventilation. End-tidal (ET) CO₂ is a non-invasive continuous surrogate, but many factors lead to inaccuracies in ETCO₂ monitoring. Transcutaneous (TC) CO₂ monitoring is an alternative to ET techniques.

Methods: Carbon dioxide was measured with both ET and TC devices during laparoscopic bariatric surgery and compared to the simultaneous PaCO₂ value.

Results: There was no difference in the absolute difference between the TC-CO₂ and PaCO₂ (3.2 ± 3.0 mmHg) and the ETCO₂ and PaCO₂ (3.7 ± 2.5 mmHg). The bias and precision were 0.3 mmHg and 4.3 mmHg for TC versus PaCO₂ and 3.2 mmHg and 3.2 mmHg for ET versus PaCO₂.

Conclusions: Both TC and ET-CO₂ monitoring can be used to effectively estimate PaCO₂ in the severely obese patient undergoing laparoscopy. The correlation of PaCO₂ to TC-CO₂ is good and similar to the correlation with ETCO₂.

Background

- The standard for assessing mechanical ventilation remains PaCO₂; although this is intermittent and invasive. ETCO₂ monitoring is the standard of care during general anesthesia and intraoperative care.
- Many factors which disrupt the normal matching of ventilation and perfusion may interfere with the accuracy of ETCO₂ monitoring including severe obesity (body mass index or BMI > 35 kg/m²), a decrease in functional residual capacity, or the physiological alterations due to insufflation from laparoscopy.¹⁻⁷
- TC-CO₂ devices can be used for the continuous and non-invasive monitoring of PaCO₂. Used most commonly in the neonatal population, these technologies may also be successful in older pediatric patients, adolescents, and adults.²⁻²²
- The accuracy of TC-CO₂ monitors has been questioned in obese adult patients and at extremes of PaCO₂.¹⁸⁻²⁴, but other studies suggest that TC-CO₂ may be a more representative indication of PaCO₂ than ETCO₂.²⁻²³
- The current study prospectively compares TC and ETCO₂ monitoring during laparoscopic-assisted bariatric surgery in severely obese adolescents and young adults.

Methods

Study Design: Prospective Cohort: 25 adolescents and young adults (BMI ≥ 40 kg/m²) presenting for laparoscopic bariatric surgery.

Anesthetic technique:
- Premedication, induction and endotracheal intubation standardized.
- Maintenance with desflurane titrated to a bispectral index of 40-60.
- Dexamethasone (0.2-0.25 µg/kg/hour) and remifentanil infusions.
- Ventilation parameters: Tidal volume 6-8 ml/kg, I:E ratio 1:2-3, PEEP 5 cmH₂O, F₂O₂ 0.5, inspiratory time 1.5 seconds, respiratory rate to maintain normocarbia.

Study Protocol:
- ETCO₂ was measured via infrared analyzer with side-stream sampling (Datex-Ohmeda Avance CO₂ infrared sensor, GE Healthcare, Madison, WI)
- TC-CO₂ was measured via Sentec Digital Monitoring System placed after induction (Sentec AG, Threliv, Switzerland).
- Arterial blood samples were collected as clinically indicated, and simultaneous PaCO₂, ETCO₂ and TC-CO₂ were recorded.
- Data analysis included non-paired t-test, Fisher’s exact test and Bland-Altman analysis.

Results

- | Number of patients | 25 |
- | Age (years) | 17.2 ± 2.1 |
- | Weight (kg) | 133.1 ± 31.1 |
- | Body mass index (kg/m²) | 50.2 ± 11.0 |
- | Gender (male - female) | 4 - 21 |

- Absolute difference between:
  - TC-CO₂ and PaCO₂: 3.2 ± 3.0 mmHg (P=NS)
  - ETCO₂ and PaCO₂: 3.7 ± 2.5 mmHg (P=NS)

- Values ≤ 3 mmHg different from the actual PaCO₂:
  - 39 of 63 TC-CO₂ values
  - 32 of 73 ETCO₂ values (P=0.04)

Bland-Altman Analysis: Bias, precision, and 95% LOA:
- 0.3, 4.3, and -8.2 to +8.8 mmHg (TC-CO₂ vs. PaCO₂)
- 3.2, 3.2 and -3.1 to +9.4 mmHg (ETCO₂ vs. PaCO₂)

Discussion

- Both ET and TC-CO₂ showed clinically acceptable accuracy as surrogates for PaCO₂ monitoring during laparoscopic bariatric surgery.
- TC-CO₂ monitoring displayed closer accuracy to PaCO₂ than ETCO₂, Bland-Altman analysis displayed less precision with TC-CO₂ monitoring.
- TC-CO₂ lacks the indispensable utilities of ETCO₂ but offers continuous and reliable PaCO₂ monitoring during clinical scenarios which interfere with the accuracy of ETCO₂.
- TC-CO₂ monitoring could provide an early warning of respiratory depression in patients without an artificial airway in whom ETCO₂ monitoring is impractical.