

Title: DISPOSABLE END-TIDAL CO₂ DETECTOR:
TIDAL VOLUME THRESHOLD

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The FEF, a disposable end-tidal (et) CO₂ detector designed to assist in verifying proper endotracheal tube placement, detects etCO₂ down to 0.54% by means of a chemically based color indicator strip.¹ Whether small tidal volume (V_T) limits the usefulness of the FEF is unknown. We studied this possibility.

In a room with fluorescent lighting, the FEF was placed between a lung model with controlled alveolar CO₂ concentration and an anesthesia ventilator circuit. Tests were conducted with etCO₂ concentrations of 0.5%, 1%, and 2% and a respiratory rate of 25 breaths/min with a V_T of 50 ml, 15 breaths/min with 100 ml, and 10 breaths/min with 200, 300, and 500 ml. The etCO₂ concentration was measured with a CO₂ monitor (Novamatrix 1260), and V_T with a pneumotachograph (Fleisch). The three indicator color ranges (A-B) on the FEF were scaled from 1 to 6: A, 1-2 (<≈0.3% etCO₂); B, 3-4 (≈0.5-1% etCO₂); and C, 5-6 (>≈2% etCO₂). Color change on 3 FEFs was rated by 3 independent observers (9 determinations) after 6 breaths at each stable CO₂ concentration and V_T and was compared with the color guide on the dome of the FEF. Data were analyzed by ANOVA (P < 0.01) and Tukey's test for multiple com-

parisons (V_T at each % CO₂).

Low V_T had a significant effect on the color indicator at 0.5% and 1% etCO₂ (P < 0.01), but not at 2% etCO₂ (fig.).

When etCO₂ is > 2%, the FEF is a sensitive indicator of etCO₂, even with a V_T of 50 ml, as demonstrated by a consistent color change at all V_Ts evaluated.

Reference

1. Anesthesiology 7:A359, 1989.

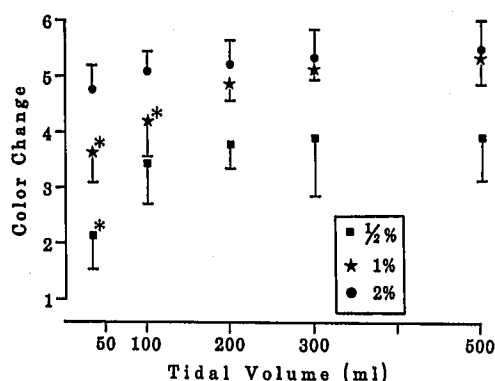


FIG. Color change as an indication of end-tidal CO₂ on a scale from 1 (<≈0.3%) to 6 (>≈2%) at different tidal volumes. *P < 0.01 for tidal volume variance at each % end-tidal CO₂.

A465

TITLE: NITROGEN BUILDUP IN A CLOSED CIRCUIT

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In a closed circuit, all anesthetic and respiratory gases and vapors delivered to the breathing circuit are retained in the patient-breathing circuit combination or removed by the CO₂ absorber. Inspired and expired gas tensions in closed circuit equal those for high flow anesthesia, only the mode of gas delivery differs.

Before anesthesia, tissue pN₂ = 0.79 Atm. During anesthesia, tissues lose nitrogen via circulation and ventilation to the breathing circuit, where it can be monitored and recorded.

METHODS

Charts of patients anesthetized with closed circuit anesthesia and monitored with continuous gas analysis (Rascal™, Albion Instruments, Salt Lake City UT) were reviewed retrospectively from the clinical files of the Technology Operating Room at Brigham and Women's Hospital. All 31 cases with a continuous nitrogen record and at least 15 minutes of continuous leak-free closed circuit anesthesia during 11 months were analyzed.

From this retrospective clinical data, rate of change of circuit nitrogen (Nitrogen Slope) was determined along with end-expired nitrogen at start of closed circuit (Initial Nitrogen) and time from intubation to closed circuit (Start Delay). The relationships among Start Delay, Initial Nitrogen, and Nitrogen Slope were analyzed using ANOVA, T-test, and/or linear regression, and expressed as mean ± SEM.

RESULTS

When closed circuit was initiated immediately after intubation (Delay Time = 0), Initial Nitrogen was 7 ± 3%. When closed

circuit was initiated later, Initial Nitrogen tension was barely positive, 1.4 ± 0.7% (p < 0.08), and lower than when closed circuit began immediately (p < 0.02). There was no relationship between Nitrogen Slope and Delay Time (p < 0.29).

There was a significant relationship between Nitrogen Slope and Initial Nitrogen (p < 0.002). When Initial Nitrogen was zero, Nitrogen Slope was significantly positive, 0.16 ± 0.05 %/min (p < 0.01). When Initial Nitrogen was above zero but below 10%, Nitrogen Slope tended to be positive, 0.08 ± 0.05 %/min, but was not significant (p < 0.12); and when Initial Nitrogen was 10% or more, Nitrogen Slope was not significantly different from zero, -0.14 ± 0.17% (p < 0.4), but tended to be negative. Overall, there was a significant negative relationship (p < 0.002) between Nitrogen Slope and Initial Nitrogen with a zero-slope intercept at Initial Nitrogen = 10% and slope = -0.019 ± 0.006/min.

DISCUSSION AND CONCLUSION

Breathing circuit nitrogen tends toward an equilibrium value of 10% during clinical closed circuit anesthesia. Initial Nitrogen depends on the degree of denitrogenation before closed circuit and equals 7 ± 3% if closed circuit begins immediately. During closed circuit, 10 ± 3 ml/min nitrogen is released from the patient to a 6 L breathing circuit whose actual volume should continuously increase by 10 mL/min.

The linear relationship between Nitrogen Slope and Initial Nitrogen suggests an exponential process of "natural washout" with time constant, τ = 53 ± 19 minutes, not significantly different from 33 minutes, predicted for muscle.

Nitrogen monitoring is useful during closed circuit anesthesia and measures nitrogen elimination from tissues. If nitrogen is not monitored, maintenance of constant circuit volume is an incorrect criterion for closed circuit equilibrium since nitrogen accumulates in the circuit.