Relationship between end-tidal and arterial carbon dioxide partial pressure using a cuffed oropharyngeal airway and a tracheal tube

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Summary

We have compared the differences between end-tidal $P_{\text{E}_{\text{CO}_2}}$ and arterial $P_{a_{\text{CO}_2}}$, carbon dioxide partial pressures during general anaesthesia using either a cuffed oropharyngeal airway (COPA) or a tracheal tube (TT) in spontaneously breathing adult patients. After induction of anaesthesia, a COPA was inserted in 20 patients who were allowed to breathe spontaneously. When steady state was reached, $P_{\text{E}_{\text{CO}_2}}$ and $P_{a_{\text{CO}_2}}$ were recorded. The COPA was removed, the trachea intubated with a TT and spontaneous ventilation allowed to resume. After a stable $P_{\text{E}_{\text{CO}_2}}$ was re-established, $P_{a_{\text{CO}_2}}$ was measured again and $P_{\text{E}_{\text{CO}_2}}$ recorded. Mean difference between $P_{a_{\text{CO}_2}}$ and $P_{\text{E}_{\text{CO}_2}}$ with the COPA was 0.72 (± 0.45) kPa and with the TT 0.64 (± 0.40) kPa (ns; paired t test). Our results suggest that $P_{\text{E}_{\text{CO}_2}}$ is a clinically acceptable indicator of $P_{a_{\text{CO}_2}}$ in adults breathing spontaneously via a COPA. (Br. J. Anaesth. 1988; 80: 253–254)

Keywords: anaesthesia, general; equipment, tubes tracheal; equipment, cuffs oropharyngeal; monitoring, carbon dioxide, partial pressure; partial pressure, carbon dioxide

The cuffed oropharyngeal airway (COPA) is a new airway device which is being introduced into clinical practice. It is an oral airway with a cuff to seal the pharynx and lift the tongue. It can also be connected directly to the anaesthesia breathing system. It is similar to the laryngeal mask airway (LMA) in that it is designed predominantly for use in spontaneously breathing patients and enables anaesthetists to avoid tracheal intubation. The advantages of the COPA compared with the LMA may be that placement is easier to learn, less traumatic and less stimulating.

When the trachea is intubated with a tracheal tube (TT), end-tidal carbon dioxide partial pressure ($P_{\text{E}_{\text{CO}_2}}$) is used widely as an indicator of arterial carbon dioxide partial pressure $P_{a_{\text{CO}_2}}$ and hence adequacy of ventilation. However, whether or not this holds true for the COPA is unknown. With the COPA the cuff is opposed to the pharynx and the reliability of the seal is in doubt. Therefore, we have compared the differences between $P_{\text{E}_{\text{CO}_2}}$ and $P_{a_{\text{CO}_2}}$ measured using a COPA or a TT in spontaneously breathing adults during general anaesthesia.

Methods and results

After obtaining approval from the Institutional Human Studies Committee of Teikyo University and informed consent, we studied 20 adult ASA I–II patients undergoing elective surgery. Exclusion criteria were history of cardiac or pulmonary abnormalities, abnormal airway anatomy or any condition which increased the risk of regurgitation of gastric contents or precluded the use of succinylcholine. The study was designed to duplicate the within-group methods described by Chhibber, Kolano and Roberts. Premedication was decided by the anaesthetist in charge. With subjects lying in the supine position, general anaesthesia was induced with propofol 2–3 mg kg⁻¹ i.v. After establishing an adequate level of anaesthesia, the COPA was inserted, positioned and tested according to the manufacturer’s instructions. The cuff was inflated with 30–40 ml of air. In general, sizes 9 and 10 were used for females and males, respectively. Head rotation to the side and neck extension were applied if necessary to ensure clinical airway patency.

Subjects were allowed to stabilize while breathing spontaneously a sevoflurane–oxygen mixture. Total fresh gas flow was set at 6 litre min⁻¹. When $P_{\text{E}_{\text{CO}_2}}$ had been stable for a minimum of 5 min, an arterial blood sample was obtained for measurement of $P_{a_{\text{CO}_2}}$, and $P_{\text{E}_{\text{CO}_2}}$ and tidal volume were recorded. The COPA was then removed and the trachea intubated with a TT after administration of succinylcholine 1–2 mg kg⁻¹ i.v. Correct positioning of the TT was confirmed by capnography and auscultation of the chest to exclude endobronchial intubation. The TT used for females was 7.5 mm internal diameter (id) and for males 8.0 mm id. Subjects were allowed to recover from neuromuscular block and breathe spontaneously. Anaesthesia was maintained with sevoflurane in oxygen. After a minimum of 5 min of stable $P_{\text{E}_{\text{CO}_2}}$, a second blood sample was obtained for measurement of $P_{a_{\text{CO}_2}}$, and $P_{\text{E}_{\text{CO}_2}}$, and tidal volume were again recorded. During this period, no invasive procedures were performed and stable haemodynamic variables were maintained.

The respiratory gas was sampled at the Y connector and $P_{\text{E}_{\text{CO}_2}}$ was monitored with an infrared gas monitor (Ultima SV, Datex, Helsinki, Finland) which had been calibrated before each study. Its stated accuracy is ± 0.15 kPa. The anaesthesia breathing system used was the adult non-rebreathing system with unidirectional valves. Tidal
volume was measured with a spirometer (Respirimeter RM121, Ohmeda, Mississauga, Ontario) placed at the end of the expiratory limb of the anaesthesia system. Arterial blood samples were analysed immediately with a Stat Profile 9 (Nova Biomedical, Waltham, MA). The analyser underwent two-point calibration before each study. Its accuracy is within 0.02 kPa and coefficient of variance is 3% for carbon dioxide.

Tidal volumes and ventilatory frequencies were analysed using a paired *t* test. $P_{a\text{CO}_2}$ and $P_{e\text{CO}_2}$ data were compared using two-way analysis of variance with repeated measures. A paired *t* test was performed to establish differences between arterial and end-tidal partial pressures with the COPA and TT. All values are mean (sd). $P<0.05$ was considered statistically significant.

We studied 20 patients (five males, 15 females), weighing 44–85 kg (mean 59.3 kg), aged 21–68 yr (mean 45.2 yr). Three patients were active smokers.

The results are summarized in table 1. There was no significant difference in tidal volume, ventilatory frequency, $P_{a\text{CO}_2}$ or $P_{e\text{CO}_2}$ before and after intubation. As would be expected, $P_{a\text{CO}_2}$ was greater than $P_{e\text{CO}_2}$ in all cases. The mean difference between $P_{a\text{CO}_2}$ and $P_{e\text{CO}_2}$ with the COPA was 0.72 (0.45) kPa and with the TT 0.64 (0.40) kPa (ns; paired *t* test).

**Comment**

Differences between $P_{a\text{CO}_2}$ and $P_{e\text{CO}_2}$ were 0.72 (0.45) kPa for the COPA and 0.64 (0.40) kPa for the TT, which are comparable with values obtained in previous studies. As with the TT and LMA, the use of the COPA also allows $P_{e\text{CO}_2}$ to function as a predictor of $P_{a\text{CO}_2}$.

The use of within-group design excluded multiple confounding factors. Although the sample size in our study appeared to be small, power analysis demonstrated that our sample size had 98% power to detect a difference of 0.40 kPa or greater in $P_{a\text{CO}_2} - P_{e\text{CO}_2}$ between COPA and TT. Therefore, the similarity in the differences between $P_{a\text{CO}_2}$ and $P_{e\text{CO}_2}$ for the COPA and TT is unlikely to have resulted from a type II error.

We did not randomize the order of observations, but systematically made the COPA measurements first in order to avoid unnecessary tracheal intubation in surgical patients. This lack of randomization may lead to alteration of ventilation by administration of succinylcholine, stimulus of intubation and a longer anaesthetic when breathing through a TT. However, all respiratory variables (tidal volume, ventilatory frequency, $P_{a\text{CO}_2}$, and $P_{e\text{CO}_2}$) were similar before and after intubation using repeated measures analysis of variance (table 1). The lack of randomization is not considered to have altered respiratory state.

The COPA is designed to be used in spontaneously breathing patients and the use of controlled ventilation via the COPA has not been reported. In common with the LMA, controlled ventilation via the COPA may place patients at increased risk of aspiration of gastric contents, as gases may be insufflated into the stomach. To avoid this risk of aspiration, we allowed subjects to breathe spontaneously.

In summary, in anaesthetized adults breathing spontaneously via a COPA, $P_{e\text{CO}_2}$ was as useful in evaluating the adequacy of ventilation as when a TT was used.

**References**