Haemodynamic and electroencephalographic response to insertion of a cuffed oropharyngeal airway: comparison with the laryngeal mask airway

L. Versichelen, M. Struys, E. Crombez, K. Fonck, E. Mortier and G. Rolly

Summary
We have compared the cuffed oropharyngeal airway (COPA), a modified Guedel airway device with a specially designed cuff at its distal end, with the laryngeal mask airway (LMA), on haemodynamic and electroencephalographic (EEG) responses to insertion. In addition, we examined the haemodynamic and EEG changes during initiation of the effect-compartment controlled infusion. We studied 35 female patients undergoing ambulatory gynaecological surgery allocated randomly to received an LMA or COPA to manage the airway. After premedication with midazolam 0.03 mg kg⁻¹ i.v. and low-dose alfentanil (0.01 mg kg⁻¹), anaesthesia was induced and maintained with propofol, using an effect-compartment controlled infusion set at an effect-site concentration of 4 μg ml⁻¹. After intercompartmental equilibration, the LMA (group I) or COPA (group II) was inserted and haemodynamic (arterial pressure, heart rate) and EEG (bispectral index (BIS)) responses to insertion studied. The effect-compartment controlled infusion of propofol caused only mild haemodynamic changes during induction. Changes in arterial pressure and heart rate after insertion were similar in both groups and not significantly different from baseline values before insertion. Changes in BIS after insertion were minor and similar between groups. (Br. J. Anaesth. 1998; 81: 393–397).

Keywords: monitoring, bispectral index; equipment, tubes tracheal; cardiovascular system, effects; intubation tracheal; equipment, masks anaesthesia

The use of the laryngeal mask airway (LMA) has become increasingly popular in anaesthesia for maintaining airway patency during spontaneous and controlled ventilation.1 It has the advantage that it does not require laryngoscopy for insertion. The haemodynamic response to insertion of the LMA is significantly less than after laryngoscopy and tracheal intubation.2,3 These responses may be harmful in patients with cardiovascular and cerebral disease.

Recently, the cuffed oropharyngeal airway has been introduced into clinical practice as an alternative to the LMA. It consists of an adapted Guedel airway with an inflatable cuff at the distal end and a circuit connection at the proximal end. The COPA is an airway device intended for “hands free” anaesthesia with spontaneous ventilation.4

When measuring haemodynamic and EEG responses during anaesthesia, it is important to maintain a comparable adequate depth of anaesthesia during the recording period by maintaining a similar pharmacological state in all patients. A pharmacokinetically based technique for administration of propofol (target-controlled infusion, TCI) can offer adequate and adjustable steady-state conditions.5 Target-controlled infusions use a computer which, on the basis of pharmacokinetic data,6 calculates the concentration in plasma or in a theoretical effect-site compartment and adjusts the infusion rate in such a way that a preset concentration is rapidly achieved and maintained.7,8 Effect-compartment modelling is relevant because of a difference between measured plasma concentrations of the drug and simultaneous indices of drug effect (e.g. the processed EEG). Therefore, it becomes appealing to be able to maintain a constant baseline clinical drug effect using an effect-compartment controlled infusion.

When studying responses to insertion of the COPA or LMA, it is important to observe both haemodynamic and EEG variables. A reduced haemodynamic effect response may be beneficial in patients with cardiovascular and cerebral disease.9 The stimulus created during insertion of an airway device may cause arousal and changes in the anaesthetic state but haemodynamic responses to stimulus are not adequate measurements of depth of anaesthesia10–11 and more objective methods should be used. Cerebral responses may be studied by bispectral analysis, a new processed EEG technique. This technique can be a useful measure of anaesthetic drug effect and may be useful as a measure of depth of anaesthesia.12,13 Compared with classical power spectral analysis which uses the frequency and amplitude of the raw EEG signal to compute a processed univariate parameter,14 bispectral analysis uses not only complex Fourier transformation but also information on the influence of inter-relations between different components (phase coupling). The bispectral index (BIS) is a single numeric variable between 0 and 100 derived using an algorithm applying bispectral analyses in combination with other EEG features such as the level of burst suppression.15

We have measured the haemodynamic and EEG responses to insertion of the COPA in spontaneously breathing, healthy, normotensive patients and...
compared these with insertion of an LMA after theoretical cerebral equilibration using propofol effect-compartment controlled infusion. In addition, haemodynamic and EEG changes during initiation of this infusion were examined.

Patients and methods

After obtaining approval from the Institutional Ethics Committee and informed patient consent, we studied 35 female, ASA I and II patients, undergoing ambulatory gynaecological surgery, allocated randomly to one of two groups. Patients weighing 20% more or less than their ideal weight and those receiving cardiovascular or antihypertensive medications were excluded. Non-invasive arterial pressure, electrocardiogram, peripheral oxygen saturation, end-tidal carbon dioxide and EEG were measured. For haemodynamic data, a Datex AS3 monitor (Datex, Helsinki, Finland) was used and for EEG data, an Aspect A-1000 EEG monitor (Aspect, Natick, USA). Electrodes were placed with montages F7 to reference (Fz) and F8 to reference (Fz), applying the international 10–20 system of electrode placement. Electrode impedance was maintained at less than 5000 Ω to ensure adequate signal quality. Artefacts caused by poor signal quality were detected automatically and excluded from further analysis. BIS (calculated for each 4-s epoch) and its trend were displayed on screen. All data were recorded automatically on computer (Toshiba Satellite Pro 430 CDT, Japan) using self-designed software. BIS data were averaged using 30-s time intervals. For the haemodynamic data, values 1 min before premedication with midazolam were defined as pre-induction baseline. Measurements were also recorded at 3 and 2 min before induction, at induction and thereafter every 1 min until 6 min after induction. Haemodynamic values at 4 min after induction were used as pre-stimulus baseline. For BIS, data before premedication with midazolam were used as pre-induction baseline. All EEG variables were recorded every 4 s until 6 min after induction. BIS at 4 min after induction was used as the pre-stimulus baseline.

Patients were allocated randomly to one of two groups using a randomization table. In group I (n=17), patients were managed using an LMA (TDM, Zaventem, Belgium) (initially size 3 and if necessary size 4) and those in group II (n=18) by a COPA (Mallinckrodt, Hennef, Germany) (initially size 10 and if necessary size 11).

After i.v. cannulation of a large forearm vein, all patients were premedicated with midazolam 0.03 mg kg\(^{-1}\) i.v., 5 min before induction. No i.v. volume loading was given before induction. Two minutes before induction, a single i.v. bolus of alfentanil 0.01 mg kg\(^{-1}\) was administered. Anaesthesia was induced and maintained with propofol, using Stanpump, a TCI system. The Stanpump program for TCI on a personal computer was used to control a Graseby 3400 syringe pump. Stanpump was written by Steven L. Shafer, MD (Stanford University, Anaesthesiology Service (112A), PAVAMC, 3801 Miranda Ave, Palo Alto, CA 94304, USA) and is freely available from the author. Stanpump controls effect-compartment controlled infusion. The rate constant \(k_{\text{eq}} = 0.239 \text{ min}^{-1}\), published by Schüttler, Schwilden and Stoeckel,\(^{16}\) was used. The software in Stanpump includes a three-compartment pharmacokinetic model, a specific set of pharmacokinetic variables for propofol\(^{16}\) and algorithms for infusion control. On screen, the anaesthetist can see the desired effect-site concentration and the actual predicted propofol effect-site and plasma concentration during infusion. Before starting Stanpump, individual patient anthropometric data are entered into the computer.

For induction, the target effect-site concentration of propofol, was set at 4 μg ml\(^{-1}\). After 4 min, theoretical intercompartmental equilibration was reached between effect-site and plasma. At this moment, the LMA or COPA was inserted. The same anaesthetist inserted all airway devices and assessed ease of insertion on the basis of an established scale.\(^{17}\) The conditions of insertion were scored as follows: excellent (jaw relaxed, no cough, no diaphragmatic movement, insertion of the device very easy); good (moderate relaxation of the jaw, slight coughing, no movement of diaphragm or limbs, insertion of the LMA possible); poor (moderate jaw relaxation, moderate coughing, movement of diaphragm or limbs, insertion of the LMA difficult); and unable to insert (jaw tightly closed, insertion of the LMA impossible). To minimize a learning effect in the COPA group, because of more experience with the LMA, clinical experience in inserting the COPA was gained in 40 patients in this trial before starting this study.

To study the haemodynamic and EEG response during and after insertion of the COPA or LMA, measurements were recorded until 6 min after induction. It was intended that all patients breathe an oxygen–air mixture spontaneously.

Data are presented as mean (SD) or as individual results. Data were analysed using repeated measures analysis of variance (ANOVA). When statistical significance (\(P<0.05\)) was found, the difference for each variable between two different measures was analysed using the Student’s two-tailed \(t\) test for paired data. Where necessary, Bonferroni correction was applied. Data were compared between groups using a two-sample \(t\) test. Categorical data were analysed using Fisher’s exact test.

Results

There were no significant differences between groups for weight, age or height. In group I, all patients received an LMA size 3. The LMA was inserted in one attempt in all 17 patients. In group II, 13 patients received a COPA size 10 and five a COPA size 11. The COPA was inserted in 16 of 18 patients in one attempt; in the two other patients a second attempt was necessary. Quality of insertion was compared between groups (table 1).

Table 1  Quality of insertion of the LMA or COPA (see text for details)

<table>
<thead>
<tr>
<th></th>
<th>LMA</th>
<th>COPA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Excellent</td>
<td>11/17</td>
<td>13/18</td>
</tr>
<tr>
<td>Good</td>
<td>3/17</td>
<td>5/18</td>
</tr>
<tr>
<td>Poor</td>
<td>3/17</td>
<td>0/18</td>
</tr>
<tr>
<td>Unable</td>
<td>0/17</td>
<td>0/18</td>
</tr>
</tbody>
</table>
Haemodynamic measurements (systolic arterial pressure, diastolic arterial pressure and heart rate) (figs 1–3) were recorded for all patients. Pre-induction (baseline) haemodynamic values were similar in the two groups. After induction of anaesthesia, there was a significant, but clinically moderate, decrease in systolic and diastolic arterial pressures compared with pre-induction baseline. Although values at 3 min after induction were still below pre-induction baseline, systolic and diastolic arterial pressures were stable 3–4 min after induction. The decreases in arterial pressures were similar for both groups until 4 min after induction. There were no changes in heart rate from baseline until 4 min after induction.

After insertion of the LMA (group I) or COPA (group II), we measured maximum changes in systolic and diastolic arterial pressures from pre-stimulus baseline, just before insertion at 4 min after induction. These maximum changes were compared between groups. Changes in systolic arterial pressure were 4 (10) mm Hg in group I and 9 (8) mm Hg in group II (ns between groups). Changes in diastolic arterial pressure were 10 (10) mm Hg in group I and 3 (9) mm Hg in group II (P<0.05 between groups). Maximum changes in heart rate after insertion (4–6 min after induction) from pre-stimulus baseline were not statistically significant (group I, 2 (9) beat min⁻¹; group II, 7 (8) beat min⁻¹). Subsequently, there were no significant changes in heart rate between groups.

BIS results from pre-induction baseline until 6 min after induction are shown in figures 4 and 5 for groups I and II, respectively. At 4 min after induction (pre-stimulus baseline), BIS values were 48 (7) and 51 (9) for groups I and II, respectively (ns). BIS response to insertion of the airway device was recorded until 2 min after insertion (4–6 min after induction) and results were compared with pre-stimulus baseline. Maximum changes in BIS response to insertion of the airway device from pre-stimulus baseline were significant for both groups (12 (11) in group I and 15 (10) in group II). Comparison between groups for maximum BIS response was not significant.

Discussion

Laryngoscopy and tracheal intubation during anaesthesia are frequently associated with transient hypertension, tachycardia and arrhythmias. These haemodynamic responses reflect the increase in sympathetic and sympathico-adrenal activity in response to oropharyngeal, laryngeal and tracheal stimulation. The LMA is used widely in airway management. Wood and Forrest recommended the use of the LMA as a means of avoiding the haemodynamic response to tracheal intubation in circumstances where such a response might be undesirable. This was also proved by Hollande and colleagues who found no significant changes in heart rate or non-invasive arterial pressure after insertion of the LMA during continuous propofol anaesthesia.

The recently developed COPA device is inserted in the mouth of the patient facing the hard palate and then turned 180° to rest finally in position with the ventral surface along the tongue and the dorsal surface along the pre-vertebral mucosa of the pharynx, similar to insertion of a Guedel airway. It can effectively support the airway in spontaneously breathing anaesthetized patients and oropharyngeal and laryngeal stimulation may be less with insertion of the COPA than with the LMA. The aim of this study was to compare the COPA with the LMA and to measure the haemodynamic and EEG responses to insertion of these devices in spontaneously breathing, healthy, normotensive patients.

We found minor haemodynamic changes in the LMA group but these were not statistically significant. Similar results were found in the COPA group. Although insertion of the laryngeal mask was qualitatively less successful than insertion of the COPA (table 2), this did not result in greater haemodynamic changes.
Differences in arousal level between insertion of different devices are of interest. Haemodynamic changes are adequate for measuring the sympathetic response to stimulus but are ineffective for studying changes in hypnotic level. Therefore, BIS was used to monitor changes in depth of anaesthesia after insertion of the LMA or COPA. Bloom, Greenwald and Day have shown that BIS reacts to arousal caused by stimulus, and this reaction is less when higher doses of analgesics are used.

The level of depth of anaesthesia is important when measuring haemodynamic changes. The sympathetic response to stimulus may increase significantly more when the level of anaesthesia is insufficient. Therefore, we used an intercompartmental equilibrated concentration of propofol 4 μg ml⁻¹ combined with low-dose alfentanil to provide adequate and comparable depths of anaesthesia. Cerebral effects were also measured using BIS which showed adequate levels of anaesthesia of approximately 50 before insertion of the airway device. In a previous study, we found that a combination of an effect-site controlled infusion of propofol and a BIS of 40–60 provided an adequate level of anaesthesia.

Acalovschi, Miculescu and Bugov studied the effects of the induction agent (propofol or thiopental) on laryngeal reactivity and haemodynamic response to LMA insertion, and concluded that insertion conditions were better after induction with a propofol bolus dose compared with thiopental. Propofol also prevented the cardiovascular effects of insertion of the LMA more effectively. In our study, pre-stimulus differences in arousal level between insertion of these devices in spontaneous breathing, healthy, normotensive patients. There were no significant differences in haemodynamic state for both devices compared with baseline values. A minor cerebral response, measured by BIS, was noted in both groups. There were no differences in haemodynamic or cerebral responses between devices. Regarding stimulus on insertion, the COPA was a valuable, but no better, alternative to the LMA.

Acknowledgements
We thank the Department of Gynecology (dir. Prof. Dr. M. Dhont) for cooperation during the clinical measurements, Mr Frank Schoonjans for help with statistical analyses and Ir. Tom De Smet for providing the data management software.

References
4. Kay NH, Greenberg RS. The buffered oropharyngeal airway
(COPA) as an adjunct to fiberoptic endotracheal intubation. Anesthesiology 1997; 87: A484.


