Desflurane requirements for laryngeal mask airway insertion during inhalation induction

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Abstract

Purpose. We hypothesized that the simultaneous use of low concentrations (<6%) of desflurane, nitrous oxide (N2O), and fentanyl would allow a laryngeal mask airway (LMA) to be inserted safely with inhalation induction of desflurane, even in nonparalyzed patients. This prospective, observational study was performed to determine the 50% effective concentration (EC50) of desflurane for LMA insertion in such patients.

Methods. Twenty-two adult patients undergoing ambulatory surgical procedures under general anesthesia using an LMA were included in the study. Fentanyl was administered intravenously at 1.5 μg·kg⁻¹, and anesthesia was induced with desflurane in 50% N2O and oxygen, using a normal tidal volume breathing technique. Subsequently, a preselected steady-state end-tidal desflurane concentration was maintained for 10 min before insertion of the LMA. Successful LMA insertion was defined as the absence of adverse airway responses until cuff inflation. Target concentrations of desflurane for LMA insertion were determined using a modified Dixon’s up-and-down method (starting dose, 5%; step size, 0.5%).

Results. All 22 patients completed the study without adverse events related to airway irritation. The EC50 of desflurane for insertion of the LMA was determined to be 3.61 ± 0.31%, and the 95% confidence interval (CI) of the EC50 obtained using probit analysis was 3.13–3.90.

Conclusion. We demonstrated that N2O-desflurane inhalation induction with a normal tidal breathing technique after premedication with fentanyl can be used safely without any adverse airway events in nonparalyzed patients. In such patients, the EC50 of desflurane for successful LMA insertion was 3.61 ± 0.31% (95% CI, 3.13–3.90).

Key words Desflurane · Inhalation induction · Laryngeal mask airway

Introduction

Despite the frequent use of propofol for the induction and maintenance of anesthesia for brief surgical procedures, volatile induction and maintenance of anesthesia (VIMA) remains appealing due to the theoretical advantages of enhanced safety and recovery as a result of monopharmacy [1]. As the least soluble agent (blood gas partition coefficient of 0.42), desflurane is eligible as an ideal inhaled anesthetic in such cases. However, many anesthesiologists feel that its pungent odor and tendency to irritate the upper airway make it unsuitable for maintenance, and more specifically, for induction of anesthesia. However, several studies [2–4] have demonstrated that desflurane can be used in inhalation induction, which may be useful as an alternative to intravenous propofol/neuromuscular blocking drug induction if the maintenance of spontaneous ventilation is preferred or if anesthesia is required for brief procedures in patients with hemodynamic instability or hypovolemia. In such clinical situations, the use of a laryngeal mask airway (LMA) may also be beneficial because it is easy to place and does not require muscle relaxation.

Inhalation induction with desflurane alone causes adverse airway events, such as coughing, bronchospasm, laryngospasm, and copious secretion of varying severity [4,5]. However, these adverse airway responses seem to be related to acute administration at high concentrations [6] and inadequate doses or drugs as adjunctive medication [4,7]. Therefore, we postulated that desflurane inhalation induction in combination with nitrous oxide (N2O) and a moderate dose (1.5 μg·kg⁻¹) of fentanyl would be sufficient to optimize insertion conditions for an LMA and prevent the side effects caused by desflurane alone, when administered using a normal tidal volume breathing technique with a low initial inspired concentration followed by gradual increases. However, the optimal depth of desflurane anesthesia for LMA insertion has not been quantified in previous
studies. Therefore, the present study was performed to determine the 50% effective concentration (EC$_{50}$) of desflurane for successful LMA insertion in such cases.

Patients, materials, and methods

The hospital ethics committee approved the study protocol and written informed consent was obtained from all participants. The participants were 22 adult patients (American Society of Anesthesiologists [ASA] physical status I-II, age 20–60 years) who were scheduled to undergo elective ambulatory surgical procedures under general anesthesia using an LMA. Patients with a history of gastroesophageal reflux, reactive airway diseases, or upper respiratory infection within the previous 2 weeks were excluded, as well as those using medications that may have interfered with the study (e.g., anxiolytics or hypnotics).

No premedication was given to any of the patients in this study. After an intravenous cannula had been inserted, the patients were monitored via electrocardiography, pulse oximetry, and a noninvasive arterial blood pressure monitor. Baseline blood pressure and heart rate were measured before induction of anesthesia, and both values were also measured every 1 min from immediately before the LMA insertion attempt to 3 min after the LMA insertion attempt. The end-tidal concentrations of CO$_2$ (P$_{ETCO2}$) and desflurane were measured continuously at the elbow of the breathing circuit with a precalibrated gas monitor (Datex-Ohmeda airway module for Aestiva/5 M-CAiovx-S5; Datex-Ohmeda, Helsinki, Finland) at a sampling rate of 200 ± 20 ml·min$^{-1}$. Its accuracy for desflurane was ±0.2% at 0–5% and ±0.5% at 5%–10%.

All patients were given fentanyl (1.5 μg·kg$^{-1}$) and denitrogenated with 100% oxygen for 3 min. The patients were then asked to maintain normal tidal breathing while induction was carried out with the desflurane setting at 3% in oxygen at 3 l·min$^{-1}$ and N$_2$O at 3 l·min$^{-3}$ for 2 min. Desflurane was increased by 1% every 1 min, to a maximum of 6%. When 90% or more of the preselected end-tidal desflurane concentration had been achieved, the inspired concentration of desflurane was adjusted to maintain the measured end-tidal concentration at a constant preselected value. Subsequently, a steady-state end-tidal desflurane concentration was maintained for 10 min before insertion of the LMA, to allow equilibrium between the alveolar and brain concentrations [8,9]. To ensure a leak-proof fit and prevent potential entrainment of room air during the study period, a face mask was firmly applied to the patient’s face. We used a semiclosed breathing system, keeping the adjustable pressure-limiting valve open until no response occurred in the eyelid test. The consciousness of each patient was checked using the eyelid reflex every 10 s during induction. If the P$_{ETCO2}$ exceeded 45 mmHg during induction, ventilation was assisted to maintain the P$_{ETCO2}$ at 30–40 mmHg. The following complications were noted during induction: cough, gag, excitatory movement, breath-holding, and laryngospasm. If such events occurred, the patient was withdrawn from the study.

Three anesthesiologists participated in anesthetic induction. All LMA (LMA-Classic; Intavent Orthofix, Maidenhead, UK) insertions were performed in a blind manner by a single anesthesiologist with experience in more than 100 previous LMA insertions. The LMA was inserted upon instruction from a second anesthesiologist controlling the inspired desflurane concentration. Size 4 and 5 LMAs were used for female and male patients, respectively. The patients’ responses to LMA insertion were classified as either “failure” or “success” by a third anesthesiologist, who was also blind to the desflurane concentration. Failure was defined as coughing, bucking, inability to keep the mouth open, resistive tongue movement against LMA placement, or gross purposeful muscular movement. Success was defined as the absence of the above responses until cuff inflation. If the first insertion attempt failed, or if the airway was ineffective, the LMA was reinserted after an intravenous bolus injection of 1 mg·kg$^{-1}$ propofol, and the subject was withdrawn from the study. After LMA insertion, anesthesia was maintained with desflurane in 50% N$_2$O and oxygen titrated in response to surgical stimulation. Ventilation was assisted or controlled to maintain the P$_{ETCO2}$ between 30 and 40 mmHg. One hour after anesthesia, all patients were interviewed by an anesthetic nurse, who was blinded to the protocol, to ascertain the patient’s level of satisfaction with the anesthetic induction experience. An 11-point numerical rating scale was used, in which 0 was defined as “unpleasant” and 10 as “extremely pleasant.”

The target end-tidal concentration for each patient was chosen using a modification of Dixon’s up-and-down method [10]. We estimated the EC$_{50}$ and its SD at 5% and 0.5%, respectively, based on our previous experience, and these values were used as the starting dose and step size, respectively. The first patient was tested at a 5% end-tidal desflurane concentration and subsequent patients were tested at a concentration defined by the previous patient’s response to LMA insertion. If LMA insertion failed, the desflurane end-tidal concentration was increased by 0.5%. If LMA insertion was successful, the concentration was decreased by 0.5%. Testing of different concentrations of desflurane continued for consecutive patients until an a-priori sample size of 22 patients was reached. Simulation studies for the up-and-down method have established that the estimator of EC$_{50}$ usually converges on a stable