Desflurane versus sevoflurane for laparoscopic gastroplasty in morbidly obese patients

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Abstract

Study Objective: To determine if desflurane results in a faster emergence as measured by time to eye opening compared to sevoflurane in morbidly obese patients undergoing laparoscopic gastroplasty.

Study Design: Prospective, randomized, double-blinded study.

Setting: Tertiary care hospital.

Patients: 70 patients with a body mass index of 35 or higher undergoing laparoscopic gastroplasty.

Interventions: Patients were randomized into two groups to receive either desflurane or sevoflurane for maintenance of general anesthesia.

Measurements: Intraoperative measured variables included the time from when the inhalation agent was turned off (no agent delivered) to eye opening and the time from when the inhalation agent was turned off to extubation. Postanesthesia care unit (PACU)–measured variables on admission and at 15-minute intervals until discharge included oxygen saturation (SpO2), blood pressure, heart rate, pain and nausea Visual Analog Scale (VAS) scores, emesis, modified Aldrete score, and Mini-Mental Status (MMS) examination score.

Main Results: No differences were noted in demographic data, total surgical operative time, times from turning inhalation agent off to eye opening and extubation, or average length of stay in PACU. No differences were noted with respect to pain VAS, treatment for pain, modified Aldrete scores, emesis, or treatment for postoperative nausea or emesis. Differences were noted in PACU nausea VAS at discharge, and PACU-MMS score at 45 minutes; however, multivariate analysis of variance revealed no differences between groups over the repeated PACU measured time periods in nausea VAS (P = 0.17) or in MMS (P = 0.34). Higher heart rates in the desflurane group were observed during PACU admission (82.3 ± 9.8 vs 74.4 ± 13.4 bpm, P < 0.01) and 15 minutes post PACU admission (79.4 ± 12.1 vs 71.3 ± 13.2 bpm, P = 0.01).
1. Introduction

During the past 20 years, obesity has risen at an epidemic rate in the United States. Results from the 1999 National Health and Nutrition Examination Survey indicate that an estimated 61% of US adults are either overweight or obese.

It is well known that obese patients undergoing general anesthesia and surgery are at increased risk of airway complications in the perioperative setting [1]. Some of these risks include difficult tracheal intubation, aspiration, airway obstruction, atelectasis, decreased functional residual capacity, increased airway resistance, oxygen desaturation, and sleep apnea syndrome, which can further complicate postoperative respiratory recovery [1-6]. Even slight improvement in early or intermediate airway recovery would be beneficial because obese patients would be more apt to maintain higher oxygen saturation ($SpO_2$) after surgery and less likely to have cardiac and respiratory complications in the postoperative period. Both desflurane and sevoflurane have a low blood/gas partition coefficient, giving the advantage of rapid induction and rapid emergence during general anesthesia, resulting in fewer respiratory complications compared with other inhalational agents that have a higher blood/gas partition coefficient and consequently delayed recovery, such as isoflurane and halothane [7-10].

In a prospective, randomized study of morbidly obese patients who underwent laparoscopic gastroplasty, desflurane was shown to result in a significantly shorter emergence time (time to eye opening), higher $SpO_2$ values, less sedation, and better mobility in the immediate postoperative period in comparison to isoflurane and propofol [6]. In another trial, desflurane had shorter emergence times when compared with sevoflurane in morbidly obese patients [11].

The purpose of this study was to compare emergence times as measured by time to eye opening and to observe other recovery characteristics of desflurane and sevoflurane in morbidly obese patients undergoing laparoscopic gastroplasty.

2. Research design and methods

After receiving Magee-Womens Hospital investigational review board approval, 70 patients (35 patients per group) with a body mass index (BMI) of 35 or greater, undergoing laparoscopic gastroplasty with standardized general anesthesia, were enrolled in this randomized, double-blinded study. Patients were randomized using a computer-generated random number table to one of two equal groups (group 1, desflurane, or group 2, sevoflurane). Exclusion criteria included adolescents and children less than 18 years of age, those with a history of coronary artery disease, myocardial infarction, congestive heart failure, chronic obstructive lung disease, drug abuse, history of malignant hyperthermia, or patients who required fiberoptic intubation. Patients requiring fiberoptic intubation and/or failed direct laryngoscopy with subsequent fiberoptic intubation (ie, difficult airway) were excluded because patients with a difficult airway may require a longer emergence time to ensure a patent and protected airway post surgery despite fulfilling extubation criteria. Furthermore, patients requiring fiberoptic intubation would complicate adherence to the standard induction protocol. A dedicated clinical research coordinator without a clinical anesthesia background, who was blinded to the volatile anesthetic agent and randomization process, collected study data. The clinical research coordinator was instructed to collect data away from the head of the table (ie, to stand off to one side of the table) in order to be blinded to the inhalation agent being delivered.

Anesthetic management was standardized in all patients with the exception of the inhalation agent. Because of differing preoperative anxieties in patients with varying mass (BMI), intravenous (IV) midazolam (1-3 mg) was given for preoperative anxiolysis, and IV fentanyl (50-100 μg) was given for preoperative analgesia. After the application of standard monitors, all patients were preoxygenated with 100% oxygen by facemask for three to 5 minutes to obtain 100% $SpO_2$ in the slight head-up position before induction. Real body weight was used of dosing of induction agents: fentanyl (100-250 μg), a defasiculating dose of rocuronium (5 mg), and propofol (2 mg/kg). Succinylcholine (1.5 mg/kg) was given only after establishment of adequate mask ventilation. Maintenance of general anesthesia consisted of either desflurane (approximately 6%) or sevoflurane (approximately 2%) at 1.0 minimum alveolar concentration (MAC).

### Table 1

<table>
<thead>
<tr>
<th>Demographic and intraoperative data</th>
<th>Desflurane</th>
<th>Sevoflurane</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (y)</td>
<td>44.6 ± 9.6</td>
<td>41.4 ± 10.0</td>
<td>0.19</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>164.4 ± 9.2</td>
<td>166.0 ± 9.9</td>
<td>0.53</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>129.5 ± 22.6</td>
<td>131.3 ± 22.8</td>
<td>0.76</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>47.3 ± 6.3</td>
<td>47.6 ± 6.7</td>
<td>0.88</td>
</tr>
<tr>
<td>Operative time (min)</td>
<td>150.9 ± 22.0</td>
<td>151.7 ± 47.7</td>
<td>0.93</td>
</tr>
<tr>
<td>Off-eye open (min)</td>
<td>4.6 ± 3.6</td>
<td>5.6 ± 4.1</td>
<td>0.27</td>
</tr>
<tr>
<td>Off-ext time (min)</td>
<td>7.8 ± 5.1</td>
<td>9.4 ± 5.9</td>
<td>0.23</td>
</tr>
</tbody>
</table>

BMI = body mass index, Off-eye open = time from agent off to eye opening; Off-ext time = time from agent off to extubation. Data are presented as means ± 1 SD.
with 50% oxygen in air mixture and a fresh gas flow at 2 L/min. The Patient State Analyzer 4000 (Physiometrix, Inc, N. Billerica, MA) is a 4-channel processed electroencephalography monitor and was used to ensure adequate anesthesia depth (unconsciousness) during maintenance of general anesthesia in all patients. If the Patient State Analyzer score went below 25 or above 50, the concentration of the inhalation agent was varied to maintain the score between 25 and 50, ensuring adequate anesthetic depth.

Rocuronium was given in titrated doses to maintain adequate abdominal muscle relaxation. Fentanyl was titrated in divided doses and limited to a total of 5 to 7 μg/kg for the entire procedure. In addition, dolasetron (12.5 mg) was given to all patients for prophylaxis of postoperative nausea and emesis.

Upon completion of surgery and initiation of surgical closure, the anesthetic provider decreased the inhalational agent to 0.5 MAC, and turned it off (no inhalation agent delivered) simultaneously with the placement of the last closing suture (ie, “agent off”). The fresh gas flow rate was increased to 6 L/min on 100% oxygen and patients were extubated only after fulfilling the criteria for extubation. Criteria for tracheal extubation included the ability to sustain spontaneous ventilation, a tidal volume greater than 5 mL/kg, reversal of muscular relaxation in all patients (train-of-four ratio >0.75 with sustained tetanus at 50 Hz for 5 seconds on the block monitor), and response to verbal command. Because morbidly obese patients are at risk for postoperative respiratory obstruction, all patients received reversal of muscular relaxation. Reversal of muscle relaxation occurred at the conclusion of the case (placement of the last skin suture/staple) and consisted of glycopyrrolate (20–40 μg/kg) and neostigmine (50–70 μg/kg).

As per our hospital gastric bypass surgery clinical care plan protocol, postoperative postanesthesia care unit (PACU) pain management consisted of IV fentanyl (25 μg) every three to 5 minutes and morphine patient-controlled analgesia (PCA) (IV morphine, 2- to 4-mg loading dose every 5 minutes for a maximum of 3 doses, one mg patient-administered dose every 6 minutes, with a 4-hour lockout of 30 mg).

In addition to demographic data (age, gender, and BMI), measured variables included time to eye opening and time to extubation. For the purpose of data collection, time zero (0) was defined as placement of the last surgical suture and turning off of the inhalation anesthetic agent (no inhalation agent delivered). A Mini-Mental Status (MMS) examination (0 = lowest score, 30 = highest score) was given to all patients preoperatively before the day of surgery to establish a baseline, then again on arrival to the PACU, and at 15-minute intervals thereafter until discharge from the PACU or until a return to baseline. Other variables measured on PACU admission and at 15-minute intervals until PACU discharge included SpO₂, blood pressure (BP), heart rate (HR), pain and nausea Visual Analog Scale (VAS) scores (0 = no pain or nausea, 100 = worst pain or nausea imaginable), presence of emesis, and modified Aldrete score, which is used to determine PACU discharge readiness. The modified Aldrete score can vary between 0 to 10 points (0-2 points are assigned to 5 different physiological variables, including respiration, circulation, consciousness, activity, and SpO₂). Patients achieving a modified Aldrete score of 8 or more are

### Table 2 Mean total intraoperative anesthetic adjuvants

<table>
<thead>
<tr>
<th></th>
<th>Desflurane</th>
<th>Sevoflurane</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fentanyl (μg)</td>
<td>578.1 ± 177.8</td>
<td>544.0 ± 154.3</td>
<td>0.43</td>
</tr>
<tr>
<td>Propofol (mg)</td>
<td>205.2 ± 37.5</td>
<td>209.0 ± 41.7</td>
<td>0.70</td>
</tr>
<tr>
<td>Succinylcholine (mg)</td>
<td>176.7 ± 34.6</td>
<td>176.9 ± 41.5</td>
<td>0.98</td>
</tr>
<tr>
<td>Rocuronium (mg)</td>
<td>85.5 ± 28.4</td>
<td>82.9 ± 17.4</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Data are presented as means ± 1 SD.

![Graph](image_url)  
**Fig. 1** Mean Mini-Mental Status (MMS) examination score. PreMMS = preoperative MMS examination score; Postanesthesia Care Unit (PACU) AdMMS = PACU admission MMS score; PACU 15 MMS = 15-minute PACU MMS score, and so on. *P < 0.05 compared with desflurane group. Error bars depict 1 SD.
considered ready for PACU discharge (ie, stable vital signs with minimal pain, nausea, and emesis).

3. Data collection and statistical considerations

Our primary end point was time to eye opening. In a study by De Baerdemaeker et al., [11] who compared desflurane to sevoflurane, they found time to eye opening to be $4.75 \pm 2.43$ minutes in the desflurane group and $6.98 \pm 2.80$ minutes in the sevoflurane group ($P < 0.05$). A sample size of 26 patients per group was estimated using a two-sided $t$ test to determine sample size, with an $\alpha = 0.05$ powered at 80%, a difference of means to be detected of 2.23 minutes, and an expected standard deviation (SD) within groups of 2.80 minutes. To allow for patients who may not complete the study, 35 patients per group were enrolled in the study. Interval data were analyzed using the two-sample $t$ test. Multivariate analysis of variance (MANOVA) was used to model the possible treatment effect on repeated postoperative PACU measurements over time. $P < 0.05$ was considered statistically significant.

4. Results

From December 2004 through May 2005, 70 patients were recruited into the study. One patient in the desflurane group who was admitted directly to the intensive care unit (ICU) for postoperative ventilation, failed to complete the study. Five patients failed to complete the study in the sevoflurane group; two patients had their procedure cancelled for insurance reasons; two patients were admitted to the ICU because they required postoperative ventilation; and one patient required fiberoptic intubation. Hence, 34 patients in desflurane group and 30 patients in sevoflurane group completed the study.

Table 1 presents demographic and intraoperative data. No differences were noted with respect to mean total intraoperative anesthetic adjuvants (Table 2). Patient State Analyzer scores at the moment of stopping the volatile agent, the time from reducing the agent to 0.5 MAC, and shutting down the vaporizer as well as end tidal CO$_2$ concentration when the agent was turned off, were similar in both groups.

No differences were noted in demographic data (age, height, weight, BMI) or duration of surgery between the two groups (Table 1). No differences were noted with respect to mean total intraoperative anesthetic adjuvants (Table 2). Patient State Analyzer scores at the moment of stopping the volatile agent, the time from reducing the agent to 0.5 MAC, and shutting down the vaporizer as well as end tidal CO$_2$ concentration when the agent was turned off, were similar in both groups.

Table 3 presents PACU data. The average length of PACU stay was comparable between the two groups (160.2 ± 41.4 minutes in the desflurane group vs 144.3 ± 24.7 minutes in the sevoflurane group, $P = 0.08$). No differences were noted with respect to modified Aldrete scores, pain VAS, and nausea VAS in the PACU, except for a higher nausea VAS score at 15 minutes and at PACU discharge in the desflurane group (Table 3). In addition, no differences were noted with respect to emesis, treatment for postoperative nausea or emesis (PONV), or treatment for pain in all observed PACU time periods between the two groups.

Fig. 2 presents PACU vital signs [systolic blood pressure (SBP), heart rate (HR), and respiratory rate (RR)] during the observed time periods. No differences were noted in SBP. Higher HRs were observed at PACU admission and at 15 minutes after PACU admission in the desflurane group. The desflurane group had a lower RR at PACU discharge (Fig. 2).

Given that we observed a significant difference between groups with respect to PACU nausea and MMS, MANOVA was performed on the repeated PACU measurements to determine if this difference between treatment groups...
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prevailed over time. The MANOVA model is designed to look at repeated measurements over time (ie, dependent variables) simultaneously. We found no differences in the repeated postoperative measurements using MANOVA with PACU-nausea \( (P = 0.17) \) and PACU-MMS \( (P = 0.34) \).

5. Discussion

Morbidly obese patients are at increased risk for complications from general anesthesia and surgery [1-6]. In comparing desflurane with sevoflurane in morbidly obese patients undergoing laparoscopic gastroplasty, recovery characteristics between the two agents were comparable.

Studies have demonstrated a more rapid awakening after desflurane versus sevoflurane anesthesia, as determined by the time to eye opening, regaining of orientation, and ability to follow commands [11-15]. In a study comparing desflurane, propofol, and isoflurane anesthesia among morbidly obese patients undergoing laparoscopic gastroplasty, Juvin et al [6] determined that no one in the desflurane-treated group, compared with 45% each in the propofol and isoflurane treated groups, had an \( \text{SpO}_2 \) value below 95%. Strum et al [16] compared desflurane with sevoflurane in obese patients who underwent open laparotomy and found that, on PACU admission, the desflurane group had a higher \( \text{SpO}_2 \). However, we did not find any appreciable difference in postoperative oxygen saturation because all patients maintained their \( \text{SpO}_2 \) at 98% or higher.

Although there are comparative studies reporting recovery characteristics of desflurane vs sevoflurane in morbidly obese patients [16,17], only De Baerdemaeker et al [11] and our study compared patients in whom all studied patients underwent laparoscopic gastroplasty. Strum et al [16] compared patients who underwent open laparotomy (not laparoscopy) with epidural anesthesia. Arain et al [17] compared patients whose surgical procedure was not standardized; they included patients who underwent multiple surgical procedures. De Baerdemaeker et al bolused patients with 16% desflurane or 8% sevoflurane for inadequate anesthesia (depth of consciousness) [11]. In our study, we maintained the level of inhalational agent at 1.0 MAC, which is consistent with standard clinical practice. In addition, all three of the aforementioned studies based their results on a smaller sample size than was used in our study [11,16,17].

A return to consciousness is not necessarily accompanied by restoration of protective airway reflexes, and the choice of the inhalational anesthetic can influence the time to restoration of these reflexes [12]. McKay et al [12] found that the time from first response to command to the ability to swallow 20 mL of water without coughing or drooling was longer after sevoflurane than for desflurane in that at two minutes after responding to command, all patients given desflurane were able to swallow without coughing or drooling, whereas 55% of patients given sevoflurane coughed and/or drooled. McKay et al concluded that desflurane allows an earlier return of protective airway reflexes than does sevoflurane.

Obese patients have a higher total fat content, which can serve as a reservoir for volatile anesthetics [16]. This higher total fat content can increase emergence time and also lead to residual airway obstruction [1,16]. It also appears that the type of fat is important in recovery from anesthesia. The fat that lies adjacent to the vessel-rich group receives anesthetic by intertissue diffusion and affects awakening more so than does bulk fat [18]. In addition, the change in concentration from the time the agent is turned off to the end of anesthesia in relation to the maintenance concentration is equally important in determining emergence time. When the concentration, at the time the agent is turned off, is \( \leq 80\% \) of the maintenance dose, the difference in emergence time between desflurane and sevoflurane is minimal [18]. However, when the concentration at the time the agent is turned off is \( \geq 80\% \) of the maintenance dose, a difference becomes apparent [18]. The reason we did not notice a statistical difference in emergence time was most likely that, upon initiation of surgical closure, the inhalation anesthetic was decreased to 0.5 MAC (50%), and therefore, the decrement from 0.5 MAC to changing the agent off was not \( \geq 80\% \).

Juvin et al [6] found no difference in postoperative MMS examination scores comparing desflurane, propofol, and isoflurane in morbidly obese patients undergoing laparoscopic gastroplasty. In our study, we found that the MMS examination score was significant only at 45 minutes post–PACU admission. It is entirely possible that the MMS examination score may not be sensitive enough to demonstrate cognitive differences between desflurane and sevoflurane.

When there is a rapid increase in end-tidal concentration to greater than one MAC, desflurane can cause sympathetic stimulation [19,20]. At more than one MAC, sevoflurane is associated with a slower HR, and desflurane, with a faster HR [19,20]. We have observed that sympathetic stimulation in HR can last up to 15 minutes after PACU admission (Fig. 2), and we are unaware of any published data regarding postoperative desflurane sympathetic stimulation. This observation in HR is statistically important and not clinically relevant. It is possible that glycopyrrolate could have caused the increase in HR noticed in the desflurane group. However, all patients received glycopyrrolate, including the sevoflurane group, which did not have an increased HR (Fig. 2). Additionally, there were no differences noted with respect to the use of \( \beta \)-blockers, which could have resulted in a decreased HR in the sevoflurane group.

In a study comparing post operative nausea and vomiting (PONV) for desflurane, sevoflurane, and isoflurane after breast surgery, Karlsen et al [21] found that the frequency of PONV was higher in the desflurane group (67%), compared with sevoflurane (36%) and isoflurane (22%). Strum also noticed a higher rate of nausea in the PACU [16]. Although there were no differences with respect to emesis and treatment for postoperative nausea or emesis in all observed PACU time...
periods, we did find a higher rate of nausea at 15 minutes in the PACU and, again at PACU discharge, with desflurane compared with sevoflurane. We did not use risk stratification for PONV, such as gender, history of smoking, and history of PONV in our study. Furthermore, the use of neostigmine and dolasetron could be confounding PONV factors. However, because both groups received dolasetron and neostigmine, no differences between groups would be expected.

In conclusion, in morbidly obese patients undergoing laparoscopic gastroplasty, emergence, as measured by time to eye opening did not differ between desflurane and sevoflurane, with similar recovery characteristics.

Acknowledgments

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References