Comparison of Vital Capacity Induction with Sevoflurane to Intravenous Induction with Propofol for Adult Ambulatory Anesthesia

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We compared vital capacity inhaled induction (VC) with sevoflurane with IV induction with propofol for adult ambulatory anesthesia. Patients were randomly assigned to receive either 8% sevoflurane in 75% N₂O/O₂ from a primed circuit (VC, 32 patients) or propofol 2-mg/kg bolus (IV, 24 patients). Times to loss of consciousness (response to command) and induction side effects (airway, hemodynamic, motor) were assessed. Anesthesia was maintained with sevoflurane/N₂O via a face mask for both groups. At the end of surgery, recovery times were measured and psychomotor function tests were performed. Patients were also asked to assess the quality of their anesthesia. Of the VC patients, 59% lost responsiveness in one breath, taking 39 ± 3 s. All VC patients completed the induction, and all measures of induction time were significantly shorter for VC than for IV. Induction side effects were different in the two groups (cough and hiccup for VC versus movement and blood pressure changes for IV), but overall incidences were similar. There were no significant differences in any index of early or intermediate recovery. Mild nausea occurred more often with VC, but no antiemetics were needed, and discharge was not delayed. Patients' assessments of the quality of induction or wake up were not significantly different between VC and IV. Thus, VC induction with sevoflurane is an acceptable alternative to propofol IV induction of general anesthesia for adult ambulatory surgical patients. Implications: A vital capacity induction with sevoflurane produced a faster loss of consciousness and had side effects, recovery times, and patient satisfaction similar to that of a propofol induction in adults undergoing ambulatory surgery.

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Inhaled induction of general anesthesia has not been popular with patients or clinicians because of fear of excitement and respiratory symptoms related to the pungency and speed of available volatile anesthetics. However, sevoflurane has potential advantages—a relatively low blood-gas solubility and a relative absence of pungency—that make the inhaled induction technique a feasible option (1). Sevoflurane has been used to provide an inhaled induction by using a vital capacity breath, which is fast and has few side effects (2,3). In this study, we compared a Vital capacity inhaled induction (VCI) with sevoflurane with an IV induction with propofol in adults undergoing ambulatory anesthesia.

Methods

After institutional human research committee approval, written informed consent was obtained from 56 ASA physical status I or II women undergoing ambulatory surgical procedures. No medication was given before anesthetic induction. Patients were randomized to receive either VCI with sevoflurane (VC) and nitrous oxide or IV induction with propofol.

IV access (20-gauge catheter) was established and an infusion of lactated Ringer's solution was begun in the operating room, and the amount of fluid given before anesthetic induction was recorded. Vital signs were measured once per minute. All patients received oxygen before anesthetic induction using an alternative supplemental O₂ source and a face mask. Patients were randomized using a random number table available to the anesthesiologist giving clinical care. Patients randomized to VC (inhalation group) practiced

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the VCI maneuver once with their anesthesiologist: to exhale fully, inhale fully, and hold their breath as long as possible. Their anesthesia circuit was primed with 8% sevoflurane and 75% N₂O in O₂ at 8 L/min (6:2) until the inspired-limb drug concentration measured >6%. This typically required three fill/empty cycles of the occluded anesthesia circuit (approximately 45 s). At end-expiration, the O₂ mask was removed, and the mask connected to the primed circuit was applied. Patients were encouraged to perform the VCI and to hold their breath. If they exhaled again before losing consciousness, patients were encouraged to take additional deep breaths until they were asleep. Patients randomized to IV received propofol 2 mg/kg with lidocaine by rapid manual injection with a 20-mL syringe into the running IV line. Loss of consciousness (LOC) was assessed repeatedly, every 3–5 s, in both groups using three measures: times to loss of response to command, loss of lash reflex, and loss of hand grip. The occurrence of specific induction side effects—vital sign changes (±20%), purposeful movement, involuntary movement, myoclonus, cough, laryngospasm, bronchospasm, and secretions—were recorded. After LOC, the sevoflurane vaporizer was set to 1%–2% sevoflurane in a mixture of 50% N₂O/O₂ at 2 L/min, titrated to maintain blood pressure within 20% of baseline. Anesthesia was administered via a face mask with a natural or oropharyngeal airway; no muscle relaxant was used.

At the end of surgery, both inhaled anesthetics were simultaneously discontinued, and the O₂ flow was set to 8 L/min. Ketorolac 30 mg IV was administered for postoperative analgesia. Recovery times were measured from the end of anesthesia. We assessed wakefulness, discomfort, and nausea by using 100-mm visual analog scales (VAS), and we assessed psychomotor function using digit-symbol substitution (DSST). These tests were administered before anesthesia; on awakening; and 15, 30, 45, 60, 90, and 120 min after anesthesia by an observer blinded to the anesthetic group. Before patients left the facility, they were asked to assess the quality of induction as pleasant or unpleasant and to state whether they were willing to have that induction again (yes or no). They were also asked to assess their wake up and recovery as pleasant or unpleasant. Patients were called at home 24 h after their anesthetic and asked to assess the quality of anesthesia induction, awakening, and overall experience.

Recovery times were compared by using analysis of variance. Patients’ in-facility assessments of quality of anesthesia were compared using the χ² test with Yates’ continuity correction. DSST and VAS data were analyzed by using two-way analysis of variance. P < 0.05 was considered significant.

Results

The 32 patients who underwent VC induction and the 24 who underwent IV induction were similar with respect to demographic characteristics: age 42 ± 12 vs 40 ± 10 yr; weight 63 ± 9 vs 64 ± 12 kg; IV fluid before induction 436 ± 142 vs 366 ± 121 mL, respectively.

All Group VC patients completed the induction. To achieve LOC, 19 patients (59%) took one breath, 5 (16%) took two breaths, 5 (16%) took three breaths, and 3 (9%) took four breaths. All measures of induction time were significantly shorter for Group VC versus Group IV (Table 1). Induction side effects were different with the different techniques (cough and hiccup for VC versus movement and blood pressure changes for IV), but the overall incidence was similar (Table 2). All patients in both groups would have their induction again. Of the patients in Groups VC and IV, 97% (31 of 32) and 100% (24 of 24), respectively, rated the induction as pleasant.

Duration of anesthesia was not different for the two groups. There were no significant differences in any index of early or intermediate recovery between Groups VC and IV (P > 0.05) (Table 3). Patients’ assessments of wake up were pleasant in 91% (29 of 32) of VC and 100% (24 of 24) of IV patients (P > 0.05). DSST and wakefulness and discomfort 100-mm VAS scores during recovery were not different between the two groups. The number of patients experiencing any nausea (VAS >0) was higher in Group VC than in Group IV (78% vs 50%; P < 0.05); the incidence of nausea (VAS >10) was not significantly different (22% vs 13%). The maximal mean nausea VAS scores in Groups VC and IV were 14 and 3, respectively. There was no delay in discharge readiness or actual discharge times from the postanesthesia care unit phases 1 or 2 for those patients who experienced nausea. Vomiting did not occur, and no antiemetics were given. One patient in Group VC experienced a dysphoric reaction to meperidine given for analgesia; her recovery data were not included for analysis. Patients’ assessments of recovery were all pleasant in both groups. At 24 h, there were no significant differences in the patients’ assessments of induction, awakening, or overall experience.

Discussion

Sevoflurane has attributes that facilitate rapid, smooth inhaled induction: low blood-gas solubility, relative absence of pungency, and a vaporizer with high overpressure capability. Delivery of 8% (4 minimum alveolar anesthetic concentration [MAC]) sevoflurane provides 4% (2 MAC) alveolar concentration in the alveoli instantaneously (4). Our data using sevoflurane VCI in adults support the theoretical rapidity of induction. However, speed is not enough to recommend the use
Table 1. Times to Loss of Consciousness Indicators

<table>
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<tr>
<th></th>
<th>Command</th>
<th>Lash</th>
<th>Grip</th>
</tr>
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<tbody>
<tr>
<td>Inhaled induction</td>
<td>39 ± 3</td>
<td>43 ± 4</td>
<td>36 ± 3</td>
</tr>
<tr>
<td>1</td>
<td>69 ± 11</td>
<td>77 ± 4</td>
<td>74 ± 19</td>
</tr>
<tr>
<td>2</td>
<td>66 ± 8</td>
<td>66 ± 8</td>
<td>60 ± 13</td>
</tr>
<tr>
<td>3</td>
<td>73 ± 23</td>
<td>88 ± 21</td>
<td>65 ± 18</td>
</tr>
<tr>
<td>4</td>
<td>51 ± 4</td>
<td>56 ± 4</td>
<td>48 ± 5</td>
</tr>
<tr>
<td>IV induction</td>
<td>81 ± 12</td>
<td>92 ± 12</td>
<td>69 ± 9</td>
</tr>
<tr>
<td>P</td>
<td>0.01</td>
<td>0.004</td>
<td>0.04</td>
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Values are mean ± se in seconds.

of inhaled induction for ambulatory anesthesia. These data demonstrate that the quality of induction, as assessed by side effects and patient satisfaction, is also comparable to a standard IV technique.

The time to loss of response to command in those patients who held one breath was 39 ± 3 (mean ± se) seconds, using a primed circuit with 8% sevoflurane and 75% N₂O. This result compares well with the 41 ± 16 seconds reported by Yurino and Kimura (2) using a VCI with 7.5% sevoflurane and 66% N₂O, also in a circle system. We chose propofol as the comparator induction drug because of its widespread popularity for ambulatory anesthesia (5). The induction times with propofol in this study (81 seconds to LOC) are within the range of times reported in the literature (6,7), although shorter times have been reported (8). Differences in IV catheter size, site of drug injection near the catheter versus into running IV line, speed of injection, and use of premedication may influence the time to propofol induction.

We used several technical factors to produce this rapid inhaled induction: a primed circuit filled before the induction began, the initial use of 8% rather than lower concentrations of sevoflurane, and the use of a VC breath rather than a tidal breathing technique. Yurino and Kimura (2) found that the time to LOC with 7.5% sevoflurane was 41 ± 16 seconds with a VC breath and significantly longer, 52 ± 13 seconds, with a tidal breathing induction. In an earlier study, they used 4.5% sevoflurane and obtained induction times of 53.8 ± 9.6 seconds (9). The combined use of 8% sevoflurane, primed circuit, and VCI technique in this study may explain the differences in induction times compared with previous reports evaluating inhaled induction with sevoflurane (6,8,10–12).

The inclusion of N₂O in the induction mixture can aid the speed of induction via the second gas and concentration effects. The sevoflurane inductions previously reported by others also included N₂O to speed induction. Inhaled inductions can be analyzed by computer simulation (4) to assess the role of N₂O. The reported value for sevoflurane MAC-Awake is 0.33 MAC (13). When inductions are simulated and analyzed, the time to 0.33 MAC sevoflurane in the brain is 30 seconds with N₂O and 38 seconds without N₂O (Fig. 1). The ability of N₂O to shorten induction time is corroborated by Hall et al. (14), who found the time to loss of lash reflex to be 71 ± 37 seconds with 8% sevoflurane in O₂ and 61 ± 24 seconds with 8% sevoflurane in 2:1 N₂O/O₂.

Rapidity of induction is desirable, but the quality of induction is also important. The distribution of induction side effects was different with the two techniques. There were more airway-related events (cough, hic-cough) in the sevoflurane group and more hemodynamic and motor events in the propofol group. Mild laryngospasm (increased airway tone) occurred in both groups. The overall incidence of side effects was similar: 16% with sevoflurane and 33% with propofol. Pain on injection was not recorded as a side effect. Earlier studies reported a higher incidence of airway side effects with sevoflurane induction when using lower initial concentrations, slower induction techniques, and/or nonprimed circuits (2,8,9,11). In this study, we suggest that the incidence of airway side effects can be reduced by maximizing the rapidity of induction. The results of this study also indicate that the low incidence of airway side effects seen when a similar induction technique was administered to volunteers (12) can also be obtained in unpremedicated ambulatory surgery patients.

Of our patients, 59% were able to hold one breath until they lost consciousness. These patients had the most rapid induction. The remainder of patients required two or more breaths, and induction times were longer. Data from Yurino and Kimura (2) suggest that faster VCI induction is associated with fewer side effects; side effects in our study were too infrequent to stratify by breath number. We learned the importance of carefully instructing patients how to take a deep breath, with one room-air practice, for patients to understand and be able to complete the VCI.

The incidence of airway-related induction side effects with sevoflurane in these unpremedicated patients was low, even with the use of 8% and the VCI technique. The airway irritation from brief inhalation (15 seconds) of halothane, enfurane, isoflurane, and sevoflurane at 1 and 2 MAC has been compared in adult volunteers (15). Among these anesthetics,
sevoflurane produced the least change in respiratory pattern, the least cough (none), and the least subjective airway irritation. Among the available inhaled anesthetics, sevoflurane has the least airway irritant effects, supporting its choice for VCI.

The times to early recovery and to postanesthesia care unit phase 1 and 2 discharge were similar in both groups. Objective assessments of recovery (wakenfulness and discomfort VAS and DSST scores) were also not different. All patients had sevoflurane/N₂O for maintenance, which may have outweighed any difference due to the induction drugs. Using VCI sevoflurane for anesthetic induction neither hastened normal delayed recovery compared with propofol IV induction after sevoflurane maintenance.

We also assessed quality of anesthesia from the patients’ perspective and found it comparable in the two groups. All patients in both groups would be willing to have the induction technique again, and all but one in the inhalation group rated the induction as pleasant. Patients’ assessments of wake up were rated as pleasant (91% and 100% for Groups VC and IV, respectively), and recovery was rated as pleasant by all patients in both groups. Quality of anesthesia was also assessed by patients at the 24-hour home telephone call, and median quality scores for induction, wake up, and overall experience were not different between the two groups.

There may be concern that priming the circuit with a delivered N₂O/O₂ of 6:2 with 8% sevoflurane would lead to the delivery of a hypoxic gas mixture. To assess this, we analyzed the early induction data. Of the 32 patients who received VCI induction, 17 (53%) had data that contained inspired and expired concentrations recorded during the first 20 seconds of inhaled drug administration. The data of these 17 patients were analyzed. The inspired O₂ concentration was 28.2% ± 0.9%, and the inspired N₂O concentration was 58.6% ± 1.1% (mean ± SE). The inspired and expired sevoflurane concentrations at this time were 6.2% ± 0.2% and 4.3% ± 0.2%, respectively.

The cost of priming the circuit for VCI can be calculated. Priming was accomplished by filling the 3-L reservoir bag three times; based on our institution’s acquisition cost of sevoflurane, the cost was $2.79. Not all patients took only one breath to LOC, and the mean additional cost of sevoflurane used in the 51-second mean induction time for Group VC was $2.30. We do not recommend and no longer use 8 L/min for priming or induction; instead, we use and recommend 4 L/min (3:1), which reduces the cost to $1.15. In comparison, based on our acquisition cost of propofol, the cost of the propofol induction was $5.89, plus possible $3.75 waste per patient.

This study has several deficiencies. 1) The observer who assessed induction side effects was not blinded to the induction technique because of the numerous visual and auditory differences. 2) Hemodynamic measurements were recorded once per minute during induction; perhaps episodes of hypotension or hypertension were missed with this assessment interval. This study was not intended to assess hemodynamic responses from airway instrumentation which may be associated with the two induction techniques, because anesthesia was administered via a face mask only. 3) A more sophisticated cost-benefit calculation, including a value for patient satisfaction, would be useful. Additional cost could be attributed to the time taken to instruct the patient how to perform the technique and the time to prime the circuit, although we performed these activities while completing other set up tasks.

In conclusion, sevoflurane VCI is faster than (51 ± 4 vs 81 ± 12 seconds) and provides patient satisfaction.
similar to propofol IV induction in unpremedicated adult ambulatory surgery patients. Induction side effects are different with the two techniques, and the overall incidence of side effects is similar. Measures of recovery, including time and satisfaction, are similar with both induction techniques after a sevoflurane maintenance anesthetic. Sevoflurane VCI can be offered to patients as an acceptable alternative to IV induction of general anesthesia for adult ambulatory surgery.

References