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Comparison Between the Effects of High Sevoflurane Concentration during Induction of Anaesthesia Using Vital Capacity Breath and Tidal Breathing Techniques in Adults

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ABSTRACT

Introduction: The aims of this randomised study were to compare the induction characteristics of sevoflurane using vital capacity breath technique to that of tidal breathing technique in adults undergoing day-care surgery, and to compare patients' acceptance of these two techniques. **Methods**: Sixty ASA I and II adult patients undergoing day-care surgery were randomly allocated to receive either the vital capacity breath or tidal breathing technique for induction of anaesthesia with 7.5% sevoflurane in nitrous oxide and oxygen. Haemodynamic changes, induction characteristics and patients' acceptance were compared. **Results**: The mean time for induction was significantly faster with the vital capacity breath technique. There were no significant differences in haemodynamic changes and oxygenation during induction between these two groups. There was a significant increase in incidence of excitatory movement in patients receiving the tidal breathing technique. Either technique was found to be acceptable by most of the patients studied. **Conclusion**: The vital capacity breath technique appears to be better tolerated with shorter onset time and less movement during induction of anaesthesia. As it is well accepted by the patients and has a stable haemodynamic profile, its use should be encouraged.

Keywords: Breath technique, inhalation induction, sevoflurane, tidal breathing technique, vital capacity

INTRODUCTION

In recent years, ambulatory surgery is fast gaining popularity. Its impetus stems from obvious benefits in this era of cost constraints in healthcare. This trend has indirectly brought about changes in the manner in which anaesthesia is administered for these day-care surgery cases. Traditionally, propofol has been the drug of choice for the induction of anaesthesia in the day-care surgery setting, owing to its favourable recovery profile and decreased incidence of side effects.[1] However, use of propofol is often complicated by pain accompanying injection and cardiovascular and respiratory depression. Moreover, it requires an intravenous drug delivery system.

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The advent of new low solubility volatile anaesthetic agents such as sevoflurane and desflurane has brought a shift back to the practice of a single agent inhalational anaesthetic for both induction and maintenance of anaesthesia.. Given the relatively low blood-gas solubility of sevoflurane, it has gained increasing acceptance as an alternative to propofol for induction of anaesthesia in patients undergoing ambulatory surgical procedures.[1,2] Sevoflurane has little odour and is not irritating to the airways.[3,4] While it is particularly useful in patients who fear injection or when intravenous access is difficult, this low solubility anaesthetic also allows for more rapid changes in the depth of anaesthesia, as well as faster anaesthetic washout and recovery, hence avoiding the 'hang-over' associated with most intravenous induction drugs. Together, these properties suggest that sevoflurane would be especially useful for inhalation induction of anaesthesia for patients undergoing day-care surgery.[4]

To achieve the theoretical attraction of a rapid yet smooth inhalation induction, a vital capacity technique, in which the patient exhales to residual volume and then inhales a high concentration of anaesthetic to vital capacity, has been reported to be preferable to the standard induction utilising tidal breathing.[5] However, opinions differ between investigators in Japan and the United States as to which technique is superior.[5,6] Patients' acceptance and side-effects associated with these two induction techniques have been reported in varying degrees.[5,6,7]

With this in mind, we embarked on this study in the local population with the aim of comparing the induction characteristics of sevoflurane using the vital capacity breath technique to that of the tidal breathing technique in adults undergoing day-care surgery. We also compared the patients' acceptance of these two techniques.

METHODS

This was a randomised prospective study. Following institution review committee's approval and patients' informed consent, sixty ASA I and II patients aged between 18 and 60 years scheduled for elective day-care surgery at Hospital Universiti Kebangsaan Malaysia (HUKM), were recruited. Exclusion criteria were patients on any sedative drugs which might influence induction time, patients with known allergy to sevoflurane and known susceptibility to malignant hyperthermia.

Patients were allocated randomly to two groups by toss of coin and each received either the vital capacity breath technique (Group A) or the tidal breathing technique (Group B).

Intravenous access was established upon patient's arrival at the operation theatre (OT). Standard monitoring, applied before induction of anaesthesia, included automated non-invasive blood pressure, electrocardiography (ECG), pulse oxymetry and multi-gas analyser (Datex Ohmeda AS3). The patients were allowed to breathe room air before induction of anaesthesia.

The circle circuit breathing system was primed with sevoflurane 7.5% in a mixture of 67% nitrous oxide and 33% oxygen at a total flow of 4.2 litres per minute (L min^{-1}) for 1 minute to achieve equilibrium and a stable maintenance gas mixture. This gave an inspired concentration of 7.5 % sevoflurane.

Group A patients were instructed to breathe out down to residual volume and an appropriate fitting face mask was then applied gently but firmly. Patients were then instructed to take a vital capacity breath of the anaesthetic gas mixture and hold it as long as possible. Subsequently, they were allowed to breathe the same gas mixture spontaneously for five minutes.

Group B patients were asked to maintain their resting tidal volume and respiratory rate. The anaesthetic system and mask were then applied and the patients were allowed to breathe the gas mixture for up to five minutes.

Systolic, diastolic and mean blood pressure (MAP), heart rate (HR) and arterial oxygen saturation were recorded one minute prior to induction of anaesthesia, and at one minute intervals for five minutes post-induction. Induction time was defined as the time between the end of the vital capacity inspiration (Group A) or end of the inspiration of first tidal breath (Group B), till loss of consciousness. Loss of consciousness was defined as the loss of eyelash reflex.

The presence of any unwanted effects during the procedure was recorded. This included coughing, laryngospasm, breath-holding, excitatory limb movement or excessive salivation (defined as enough secretion requiring suction or wetting the hand). The complications were categorised according to Lamberty & Wilson.[8]

Patients' were asked their opinion regarding the characteristics of the anaesthetic: pleasant (subjectively liked or did not mind the smell); unpleasant (pungent or not tolerable); or no comment (other than mentioned above) just before discharge from the OT.

Statistical analysis on categorical data was performed using chi-square test while continuous variables were analysed using the Student's *t*-test. A value of $p< 0.05$ was regarded as statistically significant.

RESULTS

The demographic characteristics of the patients are shown in Table 1. There were no significant differences between the two groups in terms of sex, age, weight and race. At each haemodynamic measurement point, there was no significant difference between Group A and Group B with respect to mean arterial pressure (Figure 1) and heart rate (Figure 2).

Mean (± SD) induction time was significantly shorter with Group A (48.2 ± 3.0 sec) compared with Group B (68.9 ± 3.2 sec) ($p < 0.05$). There was no significant difference in arterial oxygen saturation between the two groups during induction of anaesthesia.

The characteristics of the induction and the subjective opinion of patients towards inhalation induction are depicted in Table 2. The proportion of patients developing cough at induction was not significantly different between the two groups ($p = 0.17$). However, the incidence of motor events, in particular excitatory movements, was significantly lower when using the vital capacity breath technique ($p < 0.01$).

DISCUSSION

The acceptance of inhalation induction into routine clinical practice in adult patients undergoing day-care surgery depends on the smoothness and rapidity of onset of anaesthesia, lack of serious untoward airway complications and minimal impact on cardiovascular stability. Although sevoflurane is not the ideal volatile anaesthetic, its low

Table 1. Demographic data of the patients

	Group A(n = 30)	Group B(n = 30)
Sex (M / F)	13 / 17	14 / 16
Age (year)	30.7 ± 10.5	31.1 ± 10.3
Weight (kg)	65.1 ± 8.8	65.9 ± 9.2
Race (M/C/I/O)	22 / 4 / 2 / 2	20 / 7 / 3 / 0

Data expressed as mean ± SD.

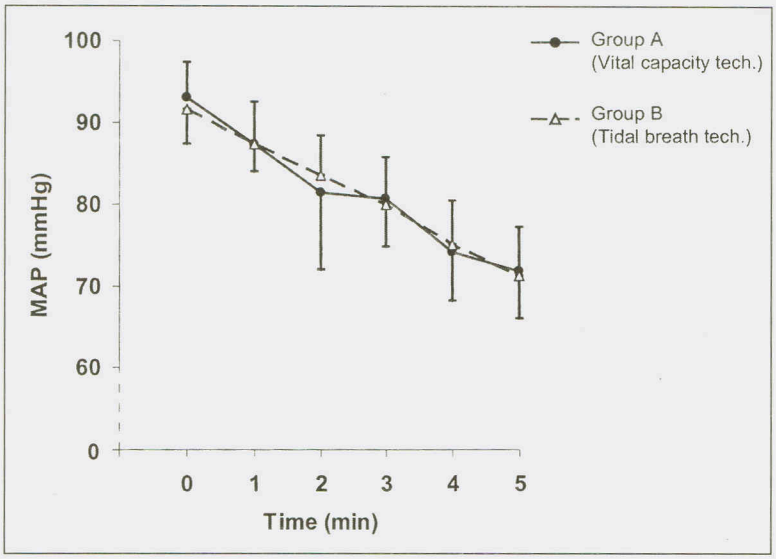

Figure 1. Mean arterial pressure during the first 5 minutes of induction of anaesthesia
Error bars show ± 1 SD

blood-gas solubility in combination with minimal airway irritation allows for smooth and rapid induction of anaesthesia.[6]

In recent years, the conventional step-wise technique, with gradual increases in concentration of sevoflurane, has been replaced by techniques employing high initial inspired concentration because it offers faster induction. The induction time approximates that of the intravenous anaesthetic propofol.[9] It has been postulated that these techniques confer enough overpressure to allow the patients to pass reliably and rapidly through the stage of excitement, hence rendering induction of anaesthesia smoother and with less complications.[5,9,10]

Results from the present study suggest that both the vital capacity breath and tidal breathing techniques have comparable effects on haemodynamic parameters after induction

Table 2. Comparison of characteristics of induction between patients using the vital capacity (Group A) and tidal breath (Group B) techniques

	Group A (n = 30)	Group B (n = 30)
Complications:		
All types	7 [23.3%]	12 * [40.0%]
Cough	7 [23.3%]	12 [40.0%]
Laryngospasm	0	0
Breath holding (>20 sec)	0	0
Excitatory movement	0	7 # [23.3%]
Desaturation (<94%)	0	0
Excessive secretion	0	0
Smell:		
Pleasant	26 [86.6%]	21 [70.0%]
No comment	4 [13.3%]	7 [23.3%]
Unpleasant	0	2 [6.6%]
Agreeable to same inductiontechnique at next anaesthetic	29 [96.6%]	28 [93.3%]

* Some patients may have more than one type of complication
\# $p < 0.05$ comparing Group A with Group B

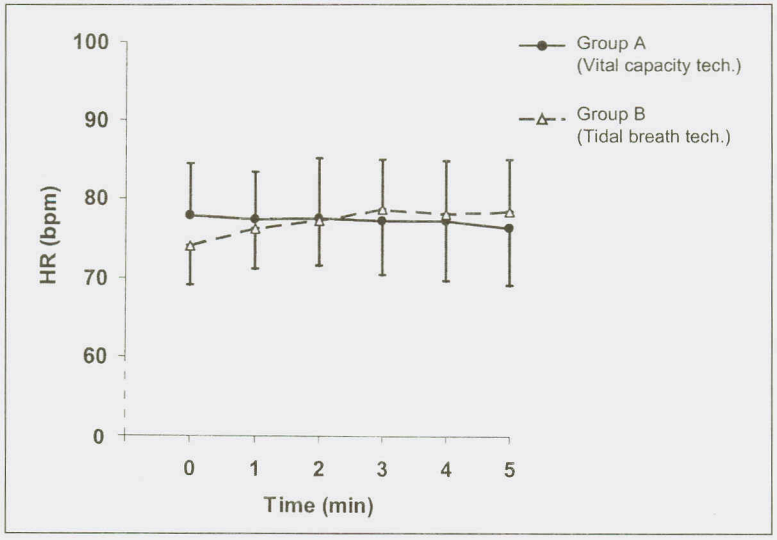

Figure 2. Mean heart rate during the first 5 minutes of induction of anaesthesia
Error bars show ± 1 SD

of anaesthesia. There were no significant differences in the MAP or HR at any time point between the groups. These results are in agreement with Yurino *et al* and Lejus *et al* who compared the haemodynamic effects of these two techniques.[5,7] Although there is some concern about the possibility of a more pronounced reduction in systemic vascular resistance and blood pressure with induction using a high inspired concentration of sevoflurane, studies done indicate otherwise.[9,11] For example, Djaiani *et al* reported comparable haemodynamic responses to a vital capacity inhalation induction with sevoflurane versus intravenous induction with etomidate in patients undergoing cardiac surgery.[11]

The vital capacity breath technique produced a more rapid induction of anaesthesia, as assessed by the loss of eyelash reflex. This is in agreement with the findings of Yurino *et al* and Lejus *et al*.[5,7] We also found the mean time to loss of eyelash reflex was comparable to other published studies.[5,7,12,13,14]

We investigated the quality of induction, as assessed by induction side effects. The overall incidence of induction complications was 23.3% with the vital capacity breath technique, and 40% with the tidal breathing technique. These complications were thought to be related to the initial alveolar concentration of the anaesthetic immediately after amnesia ensued.[5] It was hypothesised that the vital capacity breath technique acts like a 'bolus' injection of an intravenous agent given via the lung, and the tidal breathing technique acts like an 'infusion'.[1,5] Thus, the vital capacity breath technique induces the patient rapidly through the light stages of anaesthesia to the desired deeper plane and the problems associated with inhalation induction are seldom noted.[10] Yurino *et al.* and Lejus *et al.* reported that the faster vital capacity induction is associated with fewer side effects.[5,7,10] Similarly, we found the incidence of excitatory movements to be significantly lower in the vital capacity breath technique. Sloan *et al.* performed a similar study on a small group of patients and found no statistical difference between the two techniques in terms of complications and side effects.[12]

In this study, patients in both groups generally found inhalation induction with sevoflurane to be a pleasant experience. However, a higher proportion of patients using the vital capacity breath technique indicated that they would be happy to have the same anaesthetic again. Patient satisfaction with inhalation induction has also been reported to be as high as in other reports.[12,13]

This study has its limitations. It is a small study conducted on a select group of patients undergoing ambulatory surgery; hence one may argue that the low number of patients might have resulted in certain comparisons not reaching statistical significance. However, most of the findings obtained are consistent with reports published in Japan and the United States.[5,6,7,12] The authors hope to conduct a more extensive study on a larger and broader range of patients. This future study will include a sophisticated cost-benefit calculation and a more detailed evaluation of patient satisfaction, in order to achieve a more meaningful comparison of the use of these two anaesthetic techniques.

CONCLUSION

This study showed that there is a small but significant reduction in mean induction time when using the vital capacity breath technique, as compared to the tidal breathing technique. More importantly, the vital capacity breath technique appears to be better tolerated, albeit

showing less excitatory motor events at induction. As the technique is also associated with a stable haemodynamic profile and good patient acceptance, its use should be encouraged.

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