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Single-breath vital capacity high concentration sevoflurane induction in children: with or without nitrous oxide?

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Editor's key points

- This study found that for single-breath vital capacity inhalation induction with high concentration sevoflurane in children, the addition of N_2O resulted in faster loss of consciousness and reduced excitatory movements.
- Differences in the time to return of 'regular breathing' and 'conjugate gaze' were not statistically significant.
- Patients receiving N_2O had less excitatory movements.

Background. Single-breath vital capacity inhalation induction with high concentration sevoflurane (SBVC-HC) is a rapid and 'needleless' technique, preferred and well tolerated in the cooperative child. The addition of nitrous oxide may speed up induction by its second gas effects. Previous studies done in children looking at the effect of N_2O on this technique lacked power and showed conflicting results. This study aims to investigate the effect of N_2O on induction time for SBVC-HC sevoflurane induction in children.

Methods. Eighty unpremedicated, ASA I and II children, aged 5–15 yr having elective surgical procedures under general anaesthesia, were recruited and randomized to: Group A: 8% sevoflurane in O_2 6 litre min^{-1}, and Group B: 8% sevoflurane in N_2O 4 litre min^{-1} and O_2 2 litre min^{-1}. The primary outcome was the time to 'loss of eyelash reflex'. The time to return of 'regular respiration' and 'conjugate gaze' were also noted.

Results. The difference in the 'time to loss of eyelash reflex' was small but statistically significant. Group B: mean duration 53.6 s, standard deviation (SD) 16.1, compared with Group A: 63.5 s, SD 16.1 (mean difference 9.9, 95% confidence interval 2.5–17.3, P=0.01). Differences in the time to return of 'regular breathing' and 'conjugate gaze' were not statistically significant. Patients receiving N_2O had less excitatory movements (P=0.007), but incidence of other adverse events was low and did not differ significantly between both groups. More than 94% of children would choose this method of induction again in both groups.

Conclusions. We conclude that for SBVC-HC sevoflurane induction in children, the addition of N_2O resulted in faster loss of consciousness and reduced excitatory movements.

Keywords: anaesthesia, paediatric; anaesthetics gases, nitrous oxide; anaesthetics volatile, sevoflurane; inhalation anaesthesia

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Inhalation induction offers the possibility of 'needleless induction'; hence, it is a preferred technique by many children,[1] especially when cannulation is difficult.

Paediatric anaesthetists use different strategies for inhalation induction, which can vary from volatile agents delivered in a high inspired concentration or incrementally,[2–4] by having the child to take a single vital capacity breath[5] or normal tidal volume (TV) breaths.[6]

The introduction of sevoflurane,[5 7] with its low solubility and good acceptability even at high concentrations (HCs), has popularized the single-breath technique. It has been shown that single-breath vital capacity HC (SBVC-HC) inhalation induction with sevoflurane is more rapid and better tolerated by the cooperative child, compared with the conventional TV technique.[2 6]

As with any other drug, nitrous oxide has its advantages and disadvantages.

Despite its long history, there have been increasing concerns[8] of its possible adverse effects on both patients[9 10] and the environment.[11 12] More recently, it has been implicated in contributing to increased postoperative nausea/vomiting, pulmonary complications,[9] and possibly apoptosis in the developing brain[13] (in animal studies). Previously associated with increased spontaneous abortions in the pre-scavenging era,[14] it is still considered a potential health hazard to healthcare staff, as prolonged exposure may have repercussions on the reproductive, neurological, and haematological systems, by inhibition of methionine synthesis.[15] On the environmental aspect, nitrous oxide also contributes to the greenhouse effect.[16]

Conversely, as an analgesic and weak anaesthetic, nitrous oxide is a useful adjunct to other anaesthetic agents, reducing their consumption, and saving costs. Its anaesthetic-sparing effect also results in a faster recovery.[15] The addition of nitrous oxide can increase the rate of alveolar–capillary uptake of the volatile agent, and also oxygen,[17] by the concentration[18] and second gas effect.[19 20] During inhalation induction, it may contribute to a smoother and marginally quicker induction, as shown by Hall and colleagues.[21] This is especially useful in anaesthetizing children,[22 23] even the uncooperative ones.[3]

While this theoretical advantage has not been demonstrated in some adult studies,[24 25] the uptake of anaesthetic gas in children differs from the adult, due to a larger ratio of alveolar ventilation to functional residual capacity, a larger fraction of cardiac output being delivered to vessel-rich organs,[26] and different blood gas partition coefficients for inhaled anaesthetics.[27 28] Responses to inhalation induction may also differ due to higher MAC requirements in children.[29]

The assessment of concentrating and second gas effects of nitrous oxide may have been underestimated in the past[20] (as end-expired concentrations rather than arterial partial pressures were used). Moreover, previous studies[3 5 6 22] done in children included only small numbers and were not powered to evaluate the effect of nitrous oxide on SBVC-HC method of induction with sevoflurane. We decided to investigate the hypothesis that the concentrating and second gas effects of nitrous oxide can hasten, smoothen, or both this inhalation induction technique in children.

Methods

After ethics committee approval, informed written consent was obtained from the parent or legal guardian, and written assent from the child, if old enough. Eighty unpremedicated, ASA I and II paediatric patients, aged 5–15 yr undergoing elective day surgery procedures, for example, circumcision, herniotomy, and orchidopexy, under general anaesthesia, were recruited. Patients with a history of malignant hyperthermia, reactive airway disease, upper respiratory tract infection, or full stomach were excluded. Patients who preferred an i.v. induction or who could not tolerate the facemask were also not included.

Upon recruitment, each child was taught the SBVC inhalation technique. He/she was instructed to take a vital capacity breath, and then breathe out fully, at the end of which, a facemask was applied; and the child was then told to inhale maximally and hold his/her breath for at least 20 s. This was practiced until the child was confident, in performing the technique. Once ready, the child was brought to the operating theatre and arterial pressure, ECG. and pulse oximetry monitoring were applied. Induction was performed using a circle-absorber breathing circuit primed with sevoflurane 8% with 6 litre min^{-1} of fresh gas flow (FGF).

Recruited patients were randomized into two groups by sealed envelope assignment: Group A without nitrous oxide (8% sevoflurane in O_2 6 litre min^{-1}), and Group B with nitrous oxide (8% sevoflurane in N_2O 4 litre $min^{-1}$and O_2 2 litre min^{-1}). The Datex-Ohmeda (GE) Aespire 700 anaesthetic machine (breathing system volume of 2.7 litre), with integrated haemodynamic and airway gas monitor system, was used in all cases. Before the facemask was placed on the patient's face at the end of exhalation, the circle-absorber breathing circuit was primed with the required gas mixture by completely emptying the reservoir bag, and flushing the circuit with 6 litre min^{-1} of FGF and 8% sevoflurane delivered by a Datex Ohmeda Tec 7 vaporiser, with the patient's Y piece occluded.

The volatile concentration was monitored by a Datex Ohmeda (GE) infra-red multi-gas analyser, with side-stream sampling at 200 ml min^{-1}, from the Y piece at the patient's end. A constant sevoflurane concentration of >7% with FGF 6 litre min^{-1} was ensured before proceeding.

For our study, the endpoints chosen were the loss of eyelash reflex, establishment of regular breathing, and return of conjugate gaze. The loss of eyelash reflex is most commonly used to identify the loss of consciousness and induction of anaesthesia, whereas regular tidal breathing and the return of conjugate gaze, in combination with other clinical signs such as heart rate (HR) and arterial pressure, are used to gauge the depth of anaesthesia. Based on experience, these endpoints are chosen because they are useful in identifying time to certain events during a paediatric inhalation induction. For example, it may be timely to send a parent out of the induction room with the 'loss of eyelash reflex'. I.V. cannulation, jaw manipulation, and insertion of airway device[30] may be timed with the establishment of 'regular respiration' and 'return of conjugate gaze'.

For our study, three endpoints were chosen. The primary outcome was the time (in seconds) to 'loss of eyelash reflex', and secondary outcomes were the time to 'return of regular breathing' and 'return of conjugate gaze'. Outcomes were assessed by an independent observer, familiar with the identification of all three endpoints and blinded to the gas mixture delivered. The 'loss of eyelash reflex' was assessed every 5 s by gentle brushing of the eyelashes of one eyelid with a finger. Breathing was considered regular once five regular tidal breaths were captured on capnography, in the absence of breathholding or apnoea. Conjugate gaze was assessed by lifting the eyelids to observe for centralization of pupils. All timings were measured from the time the facemask (connected to the primed circuit) was applied onto the child's face (i.e. at the start of maximal inspiration from residual volume).

The onset of anaesthesia was taken as the time when eyelash reflex was lost. Therefore, the time to 'loss of eyelash reflex' defined induction time.

Vital signs such as systolic arterial pressure (SAP), HR, saturation (Sp_{O_2}), inspired sevoflurane concentration ($F_{I_{Sevo}}$), and end-tidal sevoflurane concentration (E'_{Sevo}) were recorded just before induction, then at 1 min intervals. Adverse events such as excitatory movements, coughing, laryngospasm, breath-holding/apnoea, and the presence of secretions were also noted with graded severity (0, none; 1, mild; 2, moderate; 3, severe). In addition, desaturation