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Review Article

Intubation after inhalational anesthesia with sevoflurane: in search of the optimal induction technique

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ABSTRACT

Intubation after inhalational anesthesia with sevoflurane: in search of the optimal induction technique.

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Volatile induction of anesthesia with sevoflurane is an old and conventional technique. However, there is no consensus on the appropriate mode and duration of sevoflurane administration when attempting inhalational induction to adults in order to achieve acceptable intubating conditions. This article attempts to gather the evidence presented in the literature that dictate the optimal method of sevoflurane inhalational induction until intubation is achieved.

Keywords: sevoflurane induction, inhalational induction, sevoflurane monoinduction

INTRODUCTION

Inhalational anaesthesia induction technique goes back to 1846, when the first public administration of inhaled ether was demonstrated in the Ether Dome of Massachusetts General Hospital. Ever since, there has been a dizzying evolution in anaesthetic practice, but the main objectives of anaesthesia have remained unnegotiable. Inhalational sevoflurane induction is still applied in paediatric cases, non-compliant adult patients and in cases of difficult airway[1].

Inhalational sevoflurane induction offers unique benefits. It quickly causes hypnosis, without being irritating to the airways and bears the major advantage of preserving spontaneous breathing. Maintaining spontaneous breathing upon induction of anesthesia is of utmost importance, especially in cases of difficult airway management. In the event of failing to establish an airway, maintaining spontaneous breathing allows the patient to go back to a state of alertness, avoiding the risk of hypoxia[2].

Despite the evolution in anesthetic pharmacology and equipment, sevoflurane induction endures through time. Although a popular technique, there are limited data dictating the most effective mode of sevoflurane induction, when used as a sole anesthetic in the adult population to achieve acceptable intubating conditions. The present article provides a short update of the data existing in relation to the technique of inhalational induction with sevoflurane, when the goal is intubation and not just induction of anesthesia.

MODES OF SEVOFLURANE ADMINISTRATION DURING INHALATIONAL INDUCTION

There are mainly three techniques to administer sevoflurane during inhalational induction of anesthesia: 1) gradually increasing its concentration in the mixture of fresh gases containing oxygen 100%, 2) administration of a mixture of nitrous oxide / O_2 at a ratio of 70% / 30% and gradually increasing the concentration of sevoflurane, 3) administration of a mixture of O_2 100% and sevoflurane at the maximum possible concentration of 8%. The literature shows that the third technique achieves faster induction of anesthesia. It is worth noting at this point that the vast majority of studies concern paediatric patients and not adults. Also, the majority of the literature investigates the inhalational induction with sevoflurane up to the stage of hypnosis. In the majority of the studies, once hypnosis is established, neuromuscular blockers, opioids or benzodiazepines are administered to facilitate intubation[3].

MODES OF BREATHING DURING INHALATIONAL INDUCTION

There are two breathing techniques for inhalational induction with sevoflurane: 1) tidal volume breathing and 2) vital capacity breathing. During the first technique the patient breathes calmly and gradually deepens the anesthesia, as the alveolar concentration of sevoflurane increases after each inspiration. This technique is time consuming, especially when combined with a gradual increase in the concentration of sevoflurane. During the vital capacity inhalation technique the patient is asked to exhale the maximum and immediately make the maximum inspiratory effort, remaining in end-inspiration time as much as possible. The patient breaths through a primed circuit with sevoflurane, oxy-

gen and/or nitrous oxide. The anesthesiologist encourages the patient and asks him/her to repeat the effort. This technique is faster, especially when combined with the administration of O_2 / sevoflurane mixture at a ratio of 100% / 8%[4].

TECHNIQUE OF INDUCTION WITH SEVOFLURANE

The technique of induction with sevoflurane comprises of the mode sevoflurane is added in the fresh gas flow and the pattern of the patient's breathing at the beginning of the induction. The most promising choice, with regards to the literature, is vital capacity breathing technique, while administering 8% sevoflurane / 100 O_2. This mode of induction causes rapid establishment of hypnosis. Also, it enhances rapid equilibration between administered, inspired and expired sevoflurane concentration. The major disadvantage of this technique is that it may cause a transient apnea (breath holding) to the patient. This may be a major drawback in cases of difficult airway management. Nevertheless, this period of apnea is of minor duration and there is no evidence that it yields any hypoxemia or hypercapnia of clinical relevance[5].

APNEA DURING SEVOFLURANE INDUCTION

Apnea or breath holding is a transient complication of sevoflurane inhalational induction. It has been related to the mode of sevoflurane administration. Apnea occurs more often and in longer duration when administering sevoflurane at a high initial concentration. There have been proposed other methods of sevoflurane administration in order to avoid apnea. These methods are the administration of sevoflurane at decremental or incremental concentration. Apnea still occurs during these modes of sevoflurane administration, but is of minor duration. There is no study up to date reporting hypoxemia events, despite of 14 - 84 seconds of apnea duration[6].

DURATION OF SEVOFLURANE INDUCTION

There is no study in the international literature efficiently dictating the required duration of inhalational induction to achieve optimal laryngoscopic conditions, when sevoflurane is used as a sole anesthetic. In the Muzi et al study the mean time to successful intubation was 6.4 min, when administering sevoflurane 6-7% / O2 100%. In this study patient breathing was mechanically assisted with bag-mask ventilation, as there was no objective of maintaining spontaneous breathing from the outset or investigating the incidence of apnea[7]. In the study of Katoh et al the duration of induction was at least 10 minutes, before intubation was attempted (with or without fentanyl)[8]. There are studies, such as that of Sigston et al that investigate the appropriate duration of inhalational induction with sevoflurane in children[9]. However, the duration of in-

duction in the paediatric population cannot be compared with that of adults, for reasons of different pharmacokinetics and pharmacodynamics of sevoflurane in the paediatric patient.

OPTIMAL END - TIDAL CONCENTRATION OF SEVOFLURANE FOR INTUBATION

There are only few studies investigating the optimal expired sevoflurane concentration to achieve optimal intubating conditions. The study of Katoh et al, which included 80 patients, found that MAC-TI (50% probability of no response to tracheal intubation) was 3.55% (95% confidence intervals 3,32 - 3,78%)[8]. In the study of Woods and Allam, the authors suggest MAC-TI to be twice the MAC of sevoflurane, i.e. 4% end-tidal concentration[10]. The common feature most authors agree to, is that there should be a period of equilibrium, when a constant concentration of sevoflurane is administered, before any attempt of intubation is made.

DISCUSSION

Sevoflurane inhalational induction is extensively used in pediatric anesthesia. Outside the field of pediatric anesthesia, it is still used in cases of adults with difficult airway and uncooperative patients. It has well replaced halothane for inhalational induction[11].

In difficult airway cases, obstruction of the airway causes cessation of sevoflurane administration and gradual awaking. So, despite the advantages in the equipment for airway manipulation (video-laryngoscopes, fibreoptic-bronchoscopes) and the sedatives (dexmedetomidine, remifentanil), sevoflurane remains a classic choice in the anesthesiologist's armamentarium, especially when sophisticated equipment are off reach[12].

The breathing mode causing rapid sedation is the vital capacity technique, also called the International Vital Capacity Rapid Inhalation Induction (VRII). It is considered to excel others, as it causes anesthesia faster and is rarely accompanied by adverse reactions. Loss of consciousness occurs in less than 60 seconds and there is a more rapid achievement of end-tidal sevoflurane concentration of 4%. Rapid transition of Guedel anesthesia stage 2 is related to less adverse effects and complications. The study of Shigeki et al found that using the VRII method with sevoflurane 8% / oxygen 100%, provided with adequate BIS values during induction, suggesting that it may allow smoother transition from anesthesia induction to maintenance and adequate anesthesia depth for stimuli such as laryngoscopy and tracheal intubation[13].

Apnea is another feature of sevoflurane induction. In the study of Carlo Pancaro et al was shown that sevoflurane induces apnea more frequently and of longer duration if administered at a steady and high concentration, than if administered in decremental/incremental doses[6]. This study does not refer extensively to the

induction or intubation conditions. In the study of Guracha and Drummond, apnea was also a feature of sevoflurane induction in 9 out of 43 patients. In both studies, no hypoxemia events due to apnea were reported[14].

The duration of induction is a major aspect of sevoflurane inhalational induction, especially when the goal is intubation and not LMA insertion or sedation. Reviewing the literature it seems that the minimum duration of induction is 6.4 minutes, but when assisted ventilation is commenced after sedation. In the context of preserving spontaneous breathing during sevoflurane induction, a longer period of induction should be aimed[7].

The end-tidal sevoflurane concentration one should aim is not extensively studied. The three existing studies support that the minimum end-tidal concentration of sevoflurane should be 3,32%-5,21%. That is certainly above the sevoflurane MAC values[8].

The definition "acceptable intubating condition" is rather arbitrary. Most studies define as good conditions the relaxation of the jaw (complete, slight tone, stiff, rigid), the ease of laryngoscopy (easy, fair, difficult, impossible), the vocal cord position (open, moving, closing, closed), coughing (none, slight, moderate, severe)[15]. Some of the studies refer to apnea or breath-holding as a complication of sevoflurane induction, but there is no study up to date reporting any hypoxemia caused by apnea during inhalational induction.

CONCLUSIONS

The majority of the studies that investigate various aspects of sevoflurane inhalational induction of anesthesia, do so until lack of consciousness, bag mask ventilation or LMA insertion is achieved. Very few studies investigate the technique of sevoflurane induction until intubation. This would comprise of investigating: 1. the mode of sevoflurane administration (incremental/decremental/steady doses), 2. the mode of breathing at the initiation of induction (tidal breathing, vital capacity breathing), 3. the duration of induction, 4. the maintaining or not of spontaneous breathing, 5. the MAC-TI and 6. the intubating conditions[10].

Reviewing the data found in the literature, certain conclusions can be made. The administration of sevoflurane in incremental doses induces shorter periods of apnea. To obtain acceptable intubating conditions one should aim: a) mean duration of induction more than 8 minutes, b) end-tidal sevoflurane concentration > 4% (MAC-TI=2 MAC). Future studies should engage BIS monitoring and cardiorespiratory parameters of sevoflurane inhalational mono-induction, especially in cases of difficult airway management, when preserving spontaneous breathing during the induction is of paramount importance.

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REFERENCES

1. McClelland SH, Hardman JG. Inhalational induction of anaesthesia in adults: time for a breath of fresh air?. Anaesthesia 2007 ;62:1087-9, doi 10.1111/j.1365-2044.2007.05343.x.

2. Likhvantsev VV, Mironenko AV, Grebenchikov OA, et al. Inhalation induction anesthesia: special indications or a routine procedure? Khirurgiia (Mosk). 2013; 9:54-9.

3. Boonmak P, Boonmak S, Pattanittum P, et al. High initial concentration versus low initial concentration sevoflurane for inhalational induction of anaesthesia. Cochrane Database Syst Rev. 2012 Sep 12:CD006837. doi: 10.1002/14651858.CD006837.

4. Suntheralingam Yogendran S, Prabhu A, Hendy A, et al. Vital capacity and patient controlled Sevoflurane inhalation result in similar induction characteristics. Can J Anaesth 2005 Jan; 52: 45-9. doi: 10.1007 / BF03018579.

5. Thwaites A, Edmends S, Smith I, et al. Inhalation induction with sevoflurane: a double-blind comparison with propofol. Br J Anaesth 1997 ;78:356-61. doi: 10.1093/bja/78.4.356.

6. Carlo Pancaro, Giovannoni S, Toscano A, et al. Apnea during induction of anesthesia with sevoflurane is related to its mode of administration. Can J Anesth 2005;52(6):591-4. doi: 10.1007/BF03015767.

7. Muzi M, Robinson BJ, Ebert TJ, et al. Induction of anesthesia and tracheal intubation with sevoflurane in adults. Anesthesiol 1996;85:536-43. doi: 10.1097/00000542-199609000-00012.

8. Katoh T, Nakajima Y, Moriwaki G, et al. Sevoflurane requirements for tra-

cheal intubation with and without fentanyl. Br J Anesth1999; 82 : 561-5. doi: 10.1093/bja/82.4.561.

9. Singston PE, Jenkins AM, Jackson EA, et al. Rapid inhalation induction in children:8% sevoflurane compared wirh 5% halothane. Br J Anesth 1997;78:362-5.
10. A. W. Woods, S. Allam. Tracheal intubation without the use of neuromuscular blocking agents. 2005, British Journal of Anaesthesia 94 (2): 150–8. doi: 10.1093/bja/aei006.
11. Roodneshin F. Sevoflurane as the Single Anesthetic Agent for Management of Anticipated Pediatric Difficult Airway Tanaffos 2012; 11(4): 69–72.
12. Mostafa SM, Atherton AMJ. Sevoflurane for difficult tracheal intubation. Br J Anesth1997; 79: 392-393. doi: 10.1093/bja/79.3.392.
13. Yurino M et al. "Induction of Anesthesia with Sevoflurane, Nitrous Oxide, and Oxygen: A Comparison of Spontaneous Ventilation and Vital Capacity Rapid Inhalation Induction (VCRII) Techniques. Anesth Analg 1993; 76:598-601.
14. K. Guracha Boru, G.B. Drummond. Comparison of breathing methods for inhalational induction of anesthesia. BJA 1999;83 (4): 650-3.
15. Eui-Kyoung Goo, Jong Seok Lee, Jae Chul Koh. The optimal exhaled concentration of sevoflurane for intubation without neuromuscular blockade using clinical bolus doses of remifentanil. Medicine (Baltimore) 2017; 96(9):e6235doi.10.1097/MD.0000000000006235

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