Review Article

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Application of sevoflurane inhalation sedation in dental treatment: a mini review

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Sevoflurane is familiar to anesthesiologists as an inhaled anesthetic to induce and maintain anesthesia; however, it has not been widely used for sedation. Recently, the use of sevoflurane for inhalational sedation has been increasing. Moreover, in Korea, the use of sevoflurane for conscious or deep sedation in dental care for children and the disabled is increasing, primarily by dental anesthesiologists. In this article, we reviewed a sedation method using sevoflurane.

Keywords: Dental Care; Disabled Persons; Pediatric; Sedation; Sevoflurane.

INTRODUCTION

Sevoflurane, a fluorinated methyl-propyl ether, is an inhaled anesthetic that acts on the gamma-aminobutyric acid (GABA)-A receptor [1]. It was synthesized by Regan in 1968 at the Travenol Laboratory, Illinois, USA. After being reported to his colleagues in 1971, Maruishi Company, Japan in 1990 developed a clinically usable product [2]. Sevoflurane is familiar to anesthesiologists as an inhaled anesthetic to induce and maintain general anesthesia; however, it has not been widely used for sedation. Intravascular drugs such as midazolam, propofol, and remifentanil were used more frequently when it was necessary to lower the patient's consciousness level or increase the patient's cooperation and comfort [3].

However, the use of sevoflurane for inhalational sedation has recently increased [4]. Sevoflurane is suitable for outpatient dental treatment as it has low solubility in blood, with a fast induction and less recovery time. Moreover, sevoflurane has a minimal effect on respiratory and cardiovascular functions and protective airway reflexes of the patient [5].

Compared to sedation using intravenous drug injection, it has the advantage of being easy to use in pediatric patients with needle phobia or intellectual disabilities who cannot cooperate with venous catheterization [6]. Based on these advantages, it is anticipated that the demand for sedation in dental treatment using sevoflurane will increase further.

PHARMACOLOGY OF SEVOFLURANE

Sevoflurane is a fluorinated methyl-propyl ether that enhances GABA inhibitory neurotransmission via the GABA-A receptor. The blood/gas partition coefficient is 0.65, which is slightly more soluble than desflurane. The

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minimum alveolar concentration (MAC) is 3.3% in infants and 1.7% in adults aged 65 years or above. The blood:gas partition coefficient is 0.69 in adults and 0.66 in newborns, and its lower solubility allows faster recovery from deep sedation. Therefore, it can be used in pediatric patients and emergencies [7-10].

1. Pharmacodynamics

1) Cardiovascular system

Sevoflurane decreases myocardial contractility and mean arterial pressure with minimal effects on heart rate [11].

2) Respiratory system

Sevoflurane is non-irritant, sweet-smelling, and bronchial smooth muscle relaxant that increases respiratory rate without changing minute ventilation. It decreases response to hypoxia and hypercapnia [12].

3) Central nervous system

Sevoflurane is sedative and amnesic. Increasing the depth of sedation with increasing concentration leads to a state of general anesthesia. It raises intracranial pressure and dicrease cerebral vascular resistance and metabolic rate [12].

2. Pharmacokinetics

Sevoflurane is metabolized by cytochrome P450 IIEI, and its metabolites are glucuronidated. Only approximately 3% of the absorbing capacity is metabolized [9,12,13].

APPLICATION OF SEVOFLURANE SEDATION IN DENTAL TREATMENT

1. Indication of sevoflurane sedation in dental treatment

The indications for using sevoflurane are as follows: failure to control the behavior, patients requiring short procedures lasting less than an hour, the patient can breathe through the nasal cavity, and there is no condition posing difficulty in airway management [5].

However, there are no absolute contraindications for sevoflurane sedation. If the treatment time is longer than 1 h, it may not be suitable for the following reasons: the sevoflurane gas may be diluted by the air in the cannula or by the patient's breathing before administration, and airway management may have to be performed in case of excessive sedation induction, making sevoflurane sedation less advantageous for long procedures.

2. Advantage of sevoflurane sedation in dental treatment

The action is fast, recovery is quick, titration for the desired effect is easy, and the dose is reduced when the respiratory rate is reduced; therefore, protection against respiratory depression is feasible, with a slight anesthetic effect [14].

Sevoflurane displays minimal effects on respiration, cardiovascular function, and protective reflexes [15,16]. Therefore, it may be useful in patients with a high possibility of adversely affecting cardiopulmonary function by positive pressure ventilation, such as pulmonary artery hypertension [17]. The potency of sevoflurane is high, and it can be administered using a nasal cannula. Owing to the small volume of the administration equipment itself, it reduces the challenge of operating the instrument during dental treatment and makes it easy to secure a field of view, which has many advantages for small children (Fig. 1). It is a good alternative to intravenous administration of sedation using inhaled anesthetics and is particularly useful for patients with needle phobia [6].

3. The disadvantage of sevoflurane sedation in dental treatment

Sevoflurane sedation has certain disadvantages. The characteristic smell may be difficult to tolerate in certain patients, possibly causing nausea, and leading to malignant hyperthermia [4,18]. It may be necessary to secure the airway due to excessive sedation. Since anesthetic gas may spread to the treatment room and contaminate the

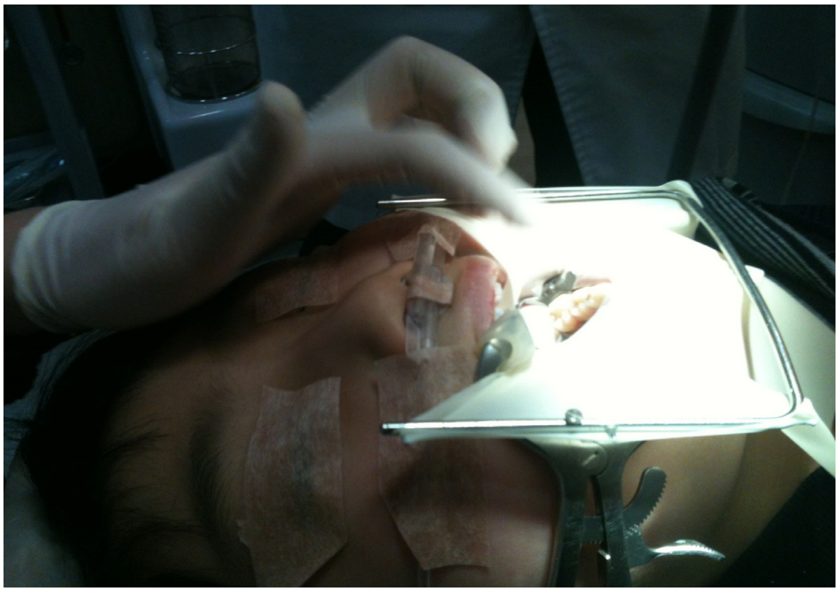

Fig. 1. Nasal cannula has the small volume size; it reduces the difficulty of operating the instrument during dental treatment

treatment environment, an appropriate ventilation system is essential [5].

4. Administration of sedation using sevoflurane

1) Conscious sedation with sevoflurane

Conscious sedation is a sedative therapy at the level of minimal and moderate sedation [19]. According to the American Society of Anesthesia, Conscious sedation is a drug-induced depression of consciousness during which patients respond purposefully to verbal commands, either alone or accompanied by light tactile stimulation. No interventions are required to maintain a patent airway, and spontaneous ventilation is adequate. Cardiovascular function is generally maintained [19].

An important principle is that, as in all general anesthesia, monitoring and resuscitation equipment must be fully equipped, and end-tidal carbon dioxide ($EtCO_2$) and anesthetic concentrations must be properly monitored [20]. The concentration of sevoflurane at the time of conscious designation differs slightly depending on the patient and the procedure; however, the initial concentration should be initiated at 0.3–0.5% and gradually titrated up to avoid loss of consciousness. Philip et al. covered basic anesthesia systems and techniques that could be used when closed circuits were available. The O_2 per minute was set to 2 L, and the sevoflurane vaporizer was set to 2% to initiate sedation. When the patient begins to show comfortable drowsiness, surgery or procedure is initiated, and the concentration of sevoflurane is reduced to 1%. As the procedure progresses, the drug is titrated according to the patient's needs. Using this method, oral communication was possible during the procedure, and the mean end-tidal sevoflurane was 0.52 [21].

2) Deep sedation using sevoflurane

Deep sedation is a drug-induced depression of consciousness during which patients cannot be easily aroused; however, respond purposefully after repeated verbal or painful stimulation. Reflex withdrawal from a painful stimulus is not considered a purposeful response and is more consistent with a state of general anesthesia. The ability to independently maintain ventilatory function may be impaired. Patients may require assistance in maintaining a patent airway, and spontaneous ventilation may be inadequate. Cardiovascular function is generally maintained. A state of deep sedation may be accompanied by partial or complete loss of protective airway reflexes. Patients may pass from a state of deep sedation to a state

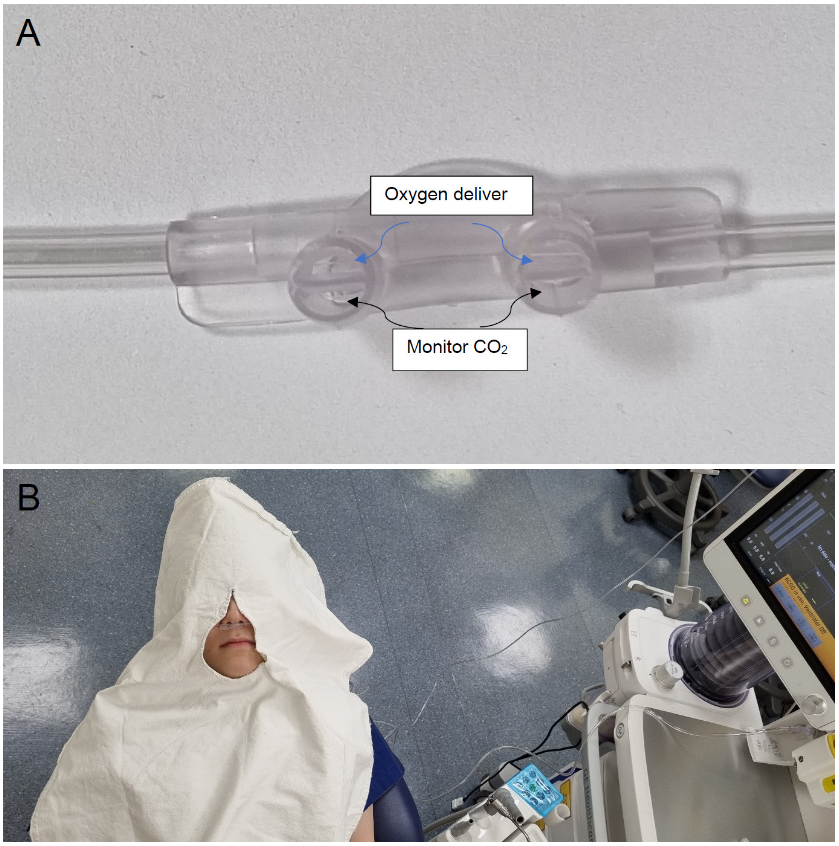

Fig. 2. Insufflation system by connecting a nasal cannula. (A) The nasal prong structure of the nasal cannula (Softech BI Cannula, Hudson RCI, USA) was designed to enable simultaneous oxygenation (blue arrow) and carbon dioxide measurement (black arrow). (B) An open circuit that is insufflation with atmospheric gas by connecting a nasal cannula to the supplementary O_2 delivery system of the anesthesia machine.

of general anesthesia [19,22].

In controlling the patient's level of consciousness using drugs, the deep sedation state is ambiguous from the shallow general anesthesia state where complications occur. Therefore, most serious complications related to sedation are related to deep sedation. Therefore, since deep sedation is equivalent to general anesthesia, the specialized training course must be completed and implemented cautiously. Therefore, deep sedation using sevoflurane is not preferred over conscious sedation, and related studies are rare. However, if deep sedation can be safely performed, there is a clear advantage in children or disabled patients for whom conscious sedation alone is insufficient for treatment. In this review, we summarized and presented the method of deep sedation using sevoflurane, which was reported in previous studies.

Depending on the degree of cooperation for sedation, two methods can be applied. If cooperation is relatively good, sedation is first performed with a face mask using N_2O and O_2, followed by sevoflurane to induce deep sedation. In the case of inducing rapid sedation due to poor coordination and forced suppression, the respiratory sac and tract are pre-filled with high concentrations of sevoflurane (8 vol%), O_2 4 L/min, and N_2O 4 L/min, instantly inducing rapid sedation using a face mask. When the patients close their eyes and there is no movement, they are judged to be in a state of deep sedation, and a nose hood or nasal cannula is selected and used to maintain sedation. Currently, two methods are widely used in the Korean Chungnam Dental Clinic Center for Disabled [16,23]. First, the inhalation method, is directly connected to the semi-closed circuit of the anesthesia machine using the nasal hood of the traditional N_2O-O_2 administration equipment. The other is an open circuit that is insufflation using atmospheric gas by connecting a nasal cannula to the supplementary O_2 delivery system

Table 1. Summary of papers on sedation treatment using sevoflurane conducted at the Dental Treatment Center for the Disabled in Chungnam, Korea

Title	author	Administration method	Patient numbers	Side effect	Mean sevoflurane end-tidal concentration (vol%)	Publication year
Sevoflurane sedation using a nasal cannula in pediatric patients [25]	Ji SE, et al.	nasal cannula	14	1 case, SpO_2 < 94%	1.9 vol%	2013
A survey of general anesthesia, sevoflurane sedation and intravenous sedation in chungnam dental clinic for the disabled [14]	Kim SO	Nasal cannula	20	-	1.8 vol%	2013
A Survey of Non-Emergency and Emergency Deep Sedation using Sevoflurane Inhalation for Pediatric or Disabled Patients [26]	Kim SO	Nasal cannula	121	-	1-2 vol%	2014
Deep Sedation With Sevoflurane Inhalation via a Nasal Hood for Brief Dental Procedures in Pediatric Patients [23]	Kim SO, et al.	Nasal hood	2	-	1.5-2 vol%	2014

of the anesthesia machine. Although the concentration at which the vaporizer is administered and that reaches the patient are almost similar to the mask or nose hood (Fig. 2). As an open-circuit cannula, it must be considered that the insufflation is diluted to the patient due to the mixing of atmospheric gases. Respiratory volume and O_2 dose affected the formation of the intraalveolar concentration. In children, when 3–4 vol% sevoflurane concentration is administered using O_2 at 2 L/min, the intraalveolar concentration is maintained at approximately 1%. According to a recent study, the end-tidal sevoflurane concentration to achieve 95% of patients with deep sedation, determined through more than 500 observations of the MAC for deep sedation using sevoflurane in the intensive care unit, is the level of sevoflurane achieved at 0.8% of the exhaled fraction or an age-adjusted MAC of 0.5 [24].

Monitoring $EtCO_2$ is needed to confirm ventilation in the sedation state. The sedation depth is monitored by attaching a bispectral index or electroencephalography-entropy, which can measure the patient's sedation depth. A monitoring device equivalent to general anesthesia is attached, and the $EtCO_2$, end-tidal sevoflurane concentration, oxygen saturation, respiration rate, heart rate, and blood pressure are continuously monitored and recorded every 5 min [23].

Table 1 summarizes the studies related to sedation using sevoflurane conducted at the Dental Treatment Center for the Disabled in Chungnam, Korea.

CONCLUSION

Dental treatment using various sedation methods, ranging from sedation to general anesthesia, is being performed for children or persons with disabilities who have difficulty controlling behavior. Recently, sevoflurane inhalation sedation has been used as a method of sedation for children and the disabled, and it has advantages compared with general anesthesia or sedation using other drugs. We believe that appropriate application according to the patient's condition and procedure is the key to treatment, and additional research is needed in the future.

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AUTHOR CONTRIBUTIONS

Seungoh Kim: Conceptualization, Validation
Keoungah Kim: Writing – original draft, Writing – review & editing

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