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Mini Review

Overview of Sevoflurane as an Volatile Anesthetic

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Abstract

Sevoflurane as an Inhalation anesthetic is one of the most commonly used agents in practice today, for induction and maintenance of general anesthesia in the operating room.

Sevoflurane is a fluorine halogenated volatile anesthetic. It is a non-irritant and rapid induction agent. In the 90s, halothane was replaced as an induction agent, especially, in pediatric anesthesia. It is a volatile anesthetic suitable for induction of anesthesia, especially in children, due to its pleasant smell, non-irritating effect on the respiratory tract, and rapid increase in alveolar concentration. Although it mildly depresses myocardial contractility, it is a volatile agent that least affects tidal volume and respiratory rate. Its respiratory depression and bronchodilator effect are equivalent to isoflurane. It can cause hypotension by lowering arterial blood pressure. It is not nephrotoxic. Sevoflurane undergoes 3% biotransformation. Despite the presence of free fluorine ions and toxic agents (compound A), no clinical or experimental organ damage has been observed in humans. This mini-review is a general overview of sevoflurane.

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INTRODUCTION

Sevoflurane is one of the most widely used inhalation anaesthetic agent for the induction and maintenance of general anesthesia in surgical procedures. Although sevoflurane was synthesized towards the end of the 1960s and used for the first time in 1971, its enterence in clinical use was in the 1990s and its use has become widespread with the completion of clinical studies [1]. It is one of the most commonly used inhalation anesthetics in clinical practice due to the absence of an unpleasant odor, low flammability, little irritation impact to the respiratory tract, and low side effects on organ systems [2]. İn addition, compared to other inhalation anesthetic agents it has lower blood:gas partition coefficient. Correspondingly, sevoflurane has rapid induction and short recovery time from anesthesia [3].

Physical and Chemical Properties of Sevoflurane

Sevoflurane is an inhalation agent containing fluorine. Fluoromethyl-2,2,2-trifluoro-1-(trifluoromethyl) has been chemically formulated. At room temperature and pressure, sevoflurane is a colorless, and non-explosive liquid. Sevoflurane, such as isoflurane, halothane and enflurane, can be used in classical evaporators due to its high welding point and low vapor pressure [1,4]. Sevoflurane is a powerful breath anesthetic that provides fast induction and control of the depth of anesthesia and causes rapid recovery due to its low solubility [5]. The blood:gas partition coefficient of sevoflurane is 0.69 [3]. The fast compilation feature is provided from the patient's operation room and intensive care unit after anesthesia to rapid recovery [1]. The vapor pressure of sevoflurane with a MAX value of 2% is 160 mmHg (20°C) and boiling point is 58.6°C [6]. İt is reported that the minimum alveolar concentration (MAC) of sevoflurane is between 1 .71 % [7] and 2.05% [8]. The MAC for sevoflurane, is similar with other anaesthetics a little higher in children [9].

Metabolism and Biotransformation of Sevoflurane

Sevoflurane, like other fluorinated volatile anesthetics, biotransforms to organic and inorganic fluoride metabolites. Cytochrome p-450 catalyzes the oxidation of sevoflurane [10]. Cytochrome p-450 liver microsomal enzyme (especially the 2E1 isoform) metabolizes sevoflurane at a rate of one-fourth compared to halothane (5% vs. 20%). The primary organic metabolites of sevoflurane are hexafluoroisopropanol (HFIP). HFIP is the only identified organic fluoride metabolite and conjugates rapidly with glucronic acid [11]. Sevoflurane leads to the formation of compounds called Compound A, B, C, D, E, F as a result of a reaction with a carbon dioxide absorber. Compound A has been shown to cause corticomedullary necrosis, which induces renal damage in rats.

The Effect of Sevoflurane on the Respiratory System

Sevoflurane depresses respiratory function dose-dependently; this is followed by a slight increase in PaCO2 and

minute ventilation [5]. As the depth of anesthesia increases, there is a decrease in the tidal volume-carbon dioxide response curve. It inhibits pulmonary vasocontriction dose-dependent. It does not cause airway irritation and does not stimulate the cough reflex. An advantage of sevoflurane is that it does not stimulate airway irritation and cough reflex in children and thus allows for the induction of inhalation anesthesia [12].

Effect of Sevoflurane on the Cardiovascular System and Hemorheology

A number of volatile anesthetics, such as sevoflurane and nonvolatile anesthetics is known to affect the overall cardiovascular functions and microcirculatory hemodynamics. Sevoflurane depresses myocardial contraction and reduces systemic vascular resistance. This decrease in arterial blood pressure is slightly less than that of isoflurane and desflurane. At high sevoflurane concentrations, blood pressure decreases progressively, as with other inhaled anesthetics [13]. Sevoflurane does not change heart rate. It does not potentiate epinephrine-induced cardiac arhythmias. Although myocardial blood flow decreases, it does not affect myocardial perfusion [14]. It may cause prolongation of the QT [15]. It has been shown to be cardioprotective in patients undergoing cardiac surgery [16,17]. Landoni et al., emphasized that desflurane and sevoflurane reduce mortality and cardiac morbidity in cardiac surgery patients [16].

The rheological properties of blood are also important in maintaining circulatory homeostasis during the conditions of health and disease. To have a knowledge of blood rheology is useful fort he anesthesiologist in most situations. Some alterations in blood rheology during anesthesia have been observed. For example, during cardiopulmonary bypass , dramatic changes in the rheological properties of blood may occur, this changes which can influence the overall perfusion pressure and regional blood distribution and oxygenation [18].

The alteration in the deformability of erythrocytes is one of the main crucial factors that should be taken into account during the surgeries to improve the tissue perfusion including the cerebral perfusion. A number of studies revealed that, sevoflurane does not indicate the hemodynamic side effects that desflurane and the other volatile anesthetics cause [19]. As seen in our prior study on rats in 2006, it shown that the volatile anesthetics, desfluran and sevoflurane impairs the deformability of erythrocytes, especially in aged animals, whereas it had not any significant effect in young ones which may be due to the flexibility of the young erythrocytes leading them to tolerate to the environmental changes [20-22]. This may be due to the alterations in membrane structure with age. These results reveal that the inhalation anesthetics have similar effects on erythrocyte deformability and may cause more serious problems, especialy in the elder people ,during the surgery and anesthesia.

The Effect of Sevoflurane on the Hepatic System

Sevoflurane reduces portal blood flow, but increases hepatic blood flow. Thus, the total hepatic blood flow and oxygen supply are preserved [15]. Drug-dependent liver damage may occur on a spectrum ranging from asymptomatic alanine transaminase elevation due to volatile anesthetics to fatal hepatic necrosis. There are limited studies on modern inhalational anesthetic agents in the literature. It has been reported that drug-dependent liver damage is more common, especially in trauma patients. Again, in this study, no significant difference was found between Decflurane and sevoflurane in terms of causing liver damage [23]. In addition, cases of hepatic damage developed after sevoflurane exposure have been reported in the literature [24,25].

The Effect of Sevoflurane on the Urinary System

Sevofurane reduces renal blood flow [15]. Carbon dioxide absorbent alkalis such as sodalime or barium hydroxide can cause the destruction of sevoflurane, a nephrotoxic component called Compound A can be released. An increase in respiratory gas temperature, low-flow anesthesia, dry barium hydroxide absorbant, high sevoflurane concentration and a long duration of anesthesia may increase Compound A level [15]. According to Gonsowski et al. [26,27], showed that Compound A causes corticomedullary necrosis, which induces renal damage in rats. They found that renal damage was observed when dose-related and compound A concentrations were 50 ppm and above. However, although the long-term effects of sevoflurane are unknown, the renal toxicity effect is controversial. In some studies conducted in humans; renal dysfunction did not occur after anesthesia. Some researchers recommend that fresh gas flow should be at least 2 lt/min for anesthesia that will last longer than a few hours, and sevoflurane should not be used in patients with previous renal dysfunction [10]. The nephrotoxicity potential is associated with an increase in inorganic fluoride. Renal dysfunction was not clinically significant with sevoflurane anesthesia in patients whose serum fluoride concentration exceeded 50 μmol/L during sevoflurane administration (about 7% of patients) [15].

The Effect of Sevoflurane on the Central Nervous System

As with Isoflurane and Desflurane, sevoflurane causes an increase in cerebral blood flow and intracranial pressure in normocapnia, but some studies have shown a decrease in cerebral blood flow. Autoregulation of cerebral blood flow may be impaired at high sevoflurane concentrations. It decreases cerebral metabolic oxygen consumption and it dose not causes seizure activity [15,28]. Sevoflurane also has anti-inflammatory and neuroprotective effects. It has been reported to reduce neurological injury, cerebral infact volume and inflammatory factor levels. A comprehensive understanding of Sevofluran's neuroprotective effect will help open new I/R treatment ways, enable physicians to make new clinical treatment solutions, and help for effective treatment [29].

The Effect of Sevoflurane on the Neuromuscular System

Sevoflurane depresses the neuromuscular junction. It

potentiates the effect of neuromuscular blockers depending on the dose, sensitizes the neuromuscular junction [30]. Sevoflurane provides sufficient muscle relaxation for intubation after inhalation induction in children [15].

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