Effects of Volatile Anesthetics on Oral Tissue Blood Flow in Rabbits: A Comparison Among Isoflurane, Sevoflurane, and Desflurane

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Purpose: The aim of this study was to compare the concentration-dependent effects of isoflurane, sevoflurane, and desflurane on oral tissue blood flow.

Materials and Methods: Thirty male Japan White rabbits were randomized to receive 1 of 3 volatile anesthetics: isoflurane (group Iso), sevoflurane (group Sevo), or desflurane (group Des). The end-tidal concentration of each volatile anesthetic was regulated to 0.5, 1, and 1.5 minimum alveolar concentrations (MACs). The observed variables were heart rate, systolic blood pressure, diastolic blood pressure, mean arterial pressure, common carotid arterial blood flow, tongue mucosal blood flow, mandibular bone marrow blood flow (BBF), masseter muscle blood flow (MBF), upper alveolar tissue blood flow, and lower alveolar tissue blood flow (LBF).

Results: The blood pressure in each group tended to decrease depending on the concentration of each volatile anesthetic, with the smallest effect in group Des. BBF and MBF in group Iso were higher than those in group Des at 1 MAC, and MBF and LBF in group Iso were highest at 1.5 MAC.

Conclusion: The results of this study suggest that each volatile anesthetic produced unique effects on blood flow in oral tissues and circulatory parameters. Among the 3 volatile anesthetics, desflurane produced the smallest effects on oral tissue blood flow.

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Volatile anesthetics are commonly used for general anesthesia. They increase cerebral blood flow in a concentration-dependent manner.[1-3] Sevoflurane has been reported to decrease blood flow in the rat coronary artery or renal artery more than isoflurane at 0.7 minimum alveolar concentration (MAC).[4] Isoflurane has been found to exhibit a more potent vasodilatory effect in smaller vessels than in larger vessels in isolated dog coronary arteries.[5] Sevoflurane and desflurane have been found to suppress acetylcholine-induced release of endothelium-derived hyperpolarizing factor and decrease the vasodilatory effect on the rabbit carotid artery.[6] Although these studies have investigated effects in large vessels, there is sparse research investigating the effect of volatile anesthetics on regional tissue blood flow.

Several studies have investigated oral tissue blood flow in rabbits.[7-13] Handa et al[7] compared the effect of arterial carbon dioxide partial pressure on oral tissue blood flow during isoflurane and propofol anesthesia and found that oral tissue blood flow was higher with isoflurane. Sazuka et al[9] investigated the effect of dexmedetomidine on oral tissue blood flow during sevoflurane and propofol anesthesia and found

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Table 1. HEMODYNAMIC VARIABLES AND TISSUE BLOOD FLOW

	Isoflurane			
	Control	0.5 MAC	1.0 MAC	1.5 MAC
SBP (mmHg)	127.9 ± 12.3	117.9 ± 14.4*	102.4 ± 11.7*	85.5 ± 10.4*
DBP (mmHg)	67.7 ± 6.4	57.2 ± 10.2*	47.1 ± 9.6*	37.3 ± 8.2*
MAP (mmHg)	87.6 ± 5.7	83.0 ± 8.9	72.5 ± 10.5*	60.1 ± 7.0*
HR (beats/minute)	269.3 ± 33.6	300.6 ± 26.7*	311.2 ± 23.7*	298.4 ± 15.3*
CCBF (mL/minute)	54.8 ± 11.1	54.5 ± 11.0	55.7 ± 12.4	56.9 ± 11.6
TBF (mL/minute)	41.1 ± 7.4	40.6 ± 6.9	42.5 ± 6.0	52.6 ± 10.1*
BBF (mL • min^{-1} • 100 g^{-1})	35.5 ± 4.1	40.6 ± 6.8*	46.5 ± 4.8*	47.0 ± 6.4*
MBF (mL • min^{-1} • 100 g^{-1})	33.1 ± 4.4	34.7 ± 5.1	44.3 ± 5.2*	47.5 ± 4.8*
UBF (mL • min^{-1} • 100 g^{-1})	28.8 ± 4.6	29.0 ± 4.2	30.9 ± 5.3	34.9 ± 8.5*
LBF (mL • min^{-1} • 100 g^{-1})	39.1 ± 5.0	44.9 ± 5.6	51.8 ± 11.6*	62.2 ± 14.5*

Note: Data are expressed as mean ± standard deviation.
Abbreviations: BBF, bone marrow blood flow; CCBF, common carotid artery blood flow; DBP, diastolic blood pressure; HR, heart rate; LBF, lower alveolar tissue blood flow; MAC, minimum alveolar concentration; MAP, mean arterial pressure; MBF, masseter muscle blood flow; SBP, systolic blood pressure; TBF, tongue mucosal blood flow; UBF, upper alveolar tissue blood flow.
*$P < .05$ versus control.

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less oral tissue blood flow with sevoflurane. These studies suggest that volatile anesthetics also affect regional tissue blood flow. However, the effects of changes in volatile anesthetic concentrations on oral tissue blood flow have not been adequately clarified.

This study investigated the effects of volatile anesthetics on oral tissue blood flow and systemic circulation and the concentration dependence of these effects. The authors measured circulatory variables during isoflurane, sevoflurane, or desflurane inhalation and assessed changes in common carotid artery blood flow (CCBF), tongue mucosal blood flow (TBF), mandibular bone marrow blood flow (BBF), masseter muscle blood flow (MBF), upper alveolar tissue blood flow (UBF), and lower alveolar tissue blood flow (LBF).

Materials and Methods

The study was approved by the animal experiments committee at Tokyo Dental College (Tokyo, Japan; approval number 252501). Thirty male Japan White rabbits, each weighing approximately 2.5 kg, were used. Anesthesia was induced by inhalation of oxygen and 3.0% isoflurane (Forane, Abbott Japan, Tokyo, Japan) through a mask. After infiltration anesthesia using 0.5 mL of 1% lidocaine hydrochloride (Xylocaine, AstraZeneca, Osaka, Japan), a tracheotomy was performed and a 20-Fr pediatric tracheal tube was inserted and fixed. The right femoral artery was exposed, and an indwelling 20-gauge catheter was inserted. Blood pressure was recorded continuously with a pressure transducer (P231D, Gould, Oxnard, CA). Heart rate (HR) was calculated from the pressure waveform. An indwelling 22-gauge catheter was inserted into the auricular marginal vein and acetated Ringer solution containing 1% glucose was infused at 10 mL/kg per hour. Muscle relaxation was achieved through continuous infusion of rocuronium bromide (Eslax, Schering-Plough, Tokyo, Japan) at 14 μg/kg per minute.[11] Ventilation was controlled at approximately 50 mL per breath and a rate of 30 to 40 breaths/minute, and end-tidal carbon dioxide partial pressure ($ETCO_2$) was maintained at 35 to 40 mmHg. $ETCO_2$ and anesthetic gas concentration were monitored continuously using an anesthetic gas monitor (Capnomac Ultima, Datex, Helsinki, Finland).

The probe (type 3SB) of an ultrasonic blood flowmeter (T108, Transonic, Ithaca, NY) was attached to the left common carotid artery that had been separated from the surrounding tissues. The inferior margin of the left mandible was excised without the use of local anesthetic and the masseter muscle and periosteum of the mandibular body were exposed. The periosteum was detached to expose the bone surface and a round burr (ISO 008, Morita, Saitama, Japan) was used to make a hole in the cortical bone to provide access to the bone marrow. The probe of a hydrogen clearance tissue blood flowmeter (UHE-100, Unique Medical, Tokyo, Japan) was inserted into the left mandibular bone marrow, left masseter muscle, and alveolar mucosal tissue in the left maxilla and mandible on the labial side of the incisors. The probe (type C) of a laser Doppler blood flowmeter (ALF21, Unique Medical) was tightly attached to the dorsal mucosa on the left side of the tongue.