Adsorption of Sevoflurane by Soda-limes

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Dry soda-lime adsorbs significant quantities of halothane, thus influencing on the speed of the induction of anaesthesia with the agent and also on the recovery from anesthesia.

Sevoflurane is a new inhaled anesthetic. Although the chemical degradation of sevoflurane with soda-lime has been studied, no information is available about its adsorption by soda-lime. This issue can not be neglected clinically.

Two different soda-limes were placed in saturated vapour of sevoflurane for 17 hours to weigh adsorbed sevoflurane. Then soda-limes adsorbing sevoflurane was sealed in a test tube after air-drying for 1) 0 min, 2) 10 min, 3) 30 min and 4) 17 hours. The vapour phase of sevoflurane in the test tube at various temperatures were determined using gas chromatography.

Sevoflurane vapour concentrations in the test tubes increased in a temperature-dependent manner. Those in the conventional soda-lime were higher than those in the new soda-lime under any experimental conditions. Sevoflurane was released from soda-limes even after air-drying for 17 hours.

These results show that much amount of sevoflurane is adsorbed by soda-limes and is released easily in the air. Thus there is a possibility for our patients to inhale unexpected inhaled anesthetics, if we use our anesthetic machine repeatedly. (Key words: adsorption, sevoflurane, soda-lime)

(Kudo M, Kudo T, Matsuki A: Adsorption of sevoflurane by soda-limes. J Anesth 6: 312–315, 1992)

Adsorption of inhaled anesthetics by soda-lime has definite disadvantages in a clinical practice. Grodin and Epstein[1,2] reported that dry soda-lime adsorbs significant quantities of halothane. The use of dry soda-lime can slow the induction with halothane and also result in a slow recovery from anesthesia because of the release of adsorbed halothane from the soda-lime.

Recently a new soda-lime consisting of only two components of $Ca(OH)_2$ and NaOH has been commercially available in Japan.

No information is available about whether or not sevoflurane is adsorbed by soda-lime and if so, how much amount of sevoflurane is adsorbed. This study was undertaken to find out answers to above mentioned questions using two kinds of soda-lime.

Methods and Materials

Sevoflurane was provided by

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Maruishi Pharmaceutical Co. Ltd. The conventional soda-lime, the new soda-lime and any other reagents used in this study were purchased from Wako Pure Chemical Industries Ltd.

Experiment I

About 6g samples of soda-limes were taken in weighing bottles and weighed accurately. These samples were placed in the upper chamber of a desicater where they could be exposed to a saturated sevoflurane vapour for 17 hours. The saturated sevoflurane vapour was 197 mmHg (25.9% at 25°C and under 1 atm) in the chamber of the desicator. Just after the end of the test period the soda-limes reweighed. An increased weight of the soda-limes would be the quantity of sevoflurane adsorbed by the soda-limes. This procedure was repeated at least twelve times.

Experiment II

For the next step of experiment, two kinds of soda-lime in individual dishes were placed in the upper chamber of the desicator and exposed to saturated sevoflurane vapour for 17 hours as in the experiment I. The 6g samples of soda-lime were taken from each dish and placed in an open container to expose to room air for drying periods of time: 0 min, 10 min, 30 min, 17 hours. The samples were then sealed in 20 ml test tubes, respectively.

The test tubes were maintained for 10 min at room temperature, 40°C and 60°C. The vapour phase of sevoflurane in the test tube was sampled after maintaining at each temperature and the sevoflurane concentrations were measured using gas chromatography as follows.

A gas chromatograph equipped with a flame ionization detector and a stainless steel column (2m × 0.3 cm i.d.) packed with dioctylphthalate were used for the analysis. Injection temperature was maintained at 60°C, column temperature at 100°C and the detector at 180°C. Helium 20 ml·min^{-1} was used as a carrier gas.

Sevoflurane concentrations were calculated from the peak height response as compared with the standard curve. Results were expressed as mean ± S.E. Student's t-test was used for statistical analysis and $P < 0.05$ was considered significant.

Results

Experiment I

The adsorbed weight of sevoflurane was 4.6 ± 0.6 mg g^{-1} for the conventional soda-lime, and was 3.9 ± 0.2 mg g^{-1} for the new soda-lime, respectively. There was no significant difference between them.

Experiment II

Sevoflurane vapour concentrations in the test tubes increased in a temperature-dependent manner when the two kinds of soda-limes were maintained at room temperature, 40°C and 60°C. Table 1 shows that sevoflurane was adsorbed by both soda-limes and was rapidly released in the air in a time-dependent manner. Sevoflurane from the conventional soda-lime increased markedly in comparison with those from the new soda-lime in any experimental conditions as shown in table 1.

Even when the soda-limes were heated at 60°C after air-drying for 17 hours, sevoflurane concentrations of 10 ± 2.7 ppm for the conventional soda-lime and 15 ± 5.1 ppm for the new soda-lime, could still be detected in the vapour phase, respectively.

Discussion

A mechanism of sevoflurane adsorption by soda-limes might be explained by two hypotheses. Two different adsorption processes, namely physical and chemical are proposed. The surface of soda-limes is coated

Table 1. Sevoflurane concentrations (ppm) after air-drying at different temperature

soda-lime \ drying time and temperature	air-drying duration (min.)	temperature 25°C	40°C	60°C
conventional soda-lime	0	4212 ± 163	110923 ± 13122*	148397 ± 9476*
	10	691 ± 237#	1583 ± 7*	1679 ± 141*
	30	69 ± 13#	72 ± 6	633 ± 3*
new soda-lime	0	2248 ± 194	2895 ± 79*	2951 ± 321
	10	59 ± 9#	45 ± 2	96 ± 42
	30	12 ± 2#	16 ± 3	18 ± 2

#significant difference vs air-drying duration 0
*significant difference vs room temperature

with sevoflurane physically because of uneven surface of crystalline. This process of adsorption allows removal of large amounts of sevoflurane after heating, as observed in the experiment.

Considering that sevoflurane could be detected even after 17 hours air-drying in our experiment II, a weak chemical interaction between sevoflurane and the surface of soda-limes would be strongly speculated.

Numerous pores on the crystalline surface of the soda-limes exist to capture sevoflurane molecules. Chemical adsorption can generally occur when compatible molecular species in size, polarity, or carbon-bond saturation can move into the pores and be captured within the crystals. Molecules only small enough to enter the pores can be chemically adsorbed with the crystals. Since sevoflurane is a small and polar molecule, it seems likely to be adsorbed to soda-limes.

Sevoflurane concentrations from the conventional soda-lime were higher than that from the new soda-lime. The significant differences between them would be caused by the different components of these two carbon dioxide absorbents, surface area, and water contents. The conventional soda-lime contains $Ca(OH)_2$, NaOH, KOH, silicon dioxide and the new soda-lime consists of $Ca(OH)_2$ and NaOH only. The water content of the two soda-limes may not be homogenous. Water molecules are also a major factor in the adsorptive process. On the surface of soda-lime they plug up pores in crystalline structures. KOH and silicon dioxide capture easily water molecules, so that the pores are blocked by water, thus preventing adsorption of sevoflurane molecules. This suggests that large amounts of sevoflurane are adsorbed physically to the surface of soda-limes and the remaining small amount is chemically adsorbed in the crystalline solid.

Conclusion

We observed that conventional soda-lime adsorbs much more sevoflurane and releases it more quickly as compared with the new soda-lime.

As sevoflurane was detected in the two soda-limes even after air-drying for 17 hours, there is a possibility for our patients to inhale anesthetics contaminated with other unexpected inhaled agents.

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