Comparing the washout profiles of desflurane in various anesthesia workstations

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Abstract

Background: Malignant hyperthermia can be induced by halogenated anesthetics that are inadvertently retained in the anesthetic circuit. Therefore, we compared the desflurane washout times of three different anesthesia workstations.

Methods: The Aisys™, Fabius GS™, and Pro-next™ workstations were selected and each workstation was tested after connecting a 1-L test lung to the patient side and volume-controlled ventilation was performed with 300 mL tidal volume, a respiratory rate of 10/min, and O2 flow of 1.5 L/min. When the end-tidal concentration of desflurane reached 6%, the flow of desflurane was stopped and the time until desflurane had completely disappeared from the circuit under continuous gas flow was measured.

Results: The mean washout times were 175 ± 5.5 s for the Aisys™ system, 216 ± 13 s for the Fabius GS™ system, and 254 ± 31 s for the Pro-next™ system. The calculated washout times per circuit capacity were 175 ± 5.5 s/L for the Aisys™ system, 216 ± 13 s/L for the Fabius GS™ system and 254 ± 31 s/L for the Pro-next™ system. The Aisys™ system provided significantly shorter times compared with the other systems.

Conclusion: The Aisys™ system provided the shortest washout time for desflurane. These findings may help prevent malignant hyperthermia among patients who are preparing to undergo anesthesia.

Introduction

Inhaled halogenated anesthetic agents are commonly used for general anesthesia. However, the time required for halogenated anesthetic agents to wash out of the anesthesia workstation, including the ventilator circuit, is an important safety consideration. Furthermore, the washout profiles of anesthesia workstations are useful for predicting patient recovery from general anesthesia. Moreover, halogenated anesthetics must be removed from the anesthesia workstation to prevent malignant hyperthermia. Several studies have investigated the kinetic profiles of various volatile anesthetics, such as sevoflurane or isoflurane [1]. However, Kim et al. [2] recently demonstrated that the Aisys™ system (GE Healthcare, Madison, WI, USA), which uses an electronic vaporizer system, may retain saturated vapor in the breathing system. Few studies have evaluated the washout kinetics of desflurane, a new volatile anesthetic used in Japan, and no studies have evaluated the washout profiles of desflurane in different anesthetic machines. Although arousal from general anesthesia depends on the blood-gas partition coefficient values, patient factors, and anesthetic-specific factors, it is also possible that arousal depends on the respiratory and circulatory circuit volumes of the anesthesia machine. Therefore, the present study compared the washout profiles for desflurane in various anesthesia workstations that included different types of breathing systems and components.

Materials and methods

The present study evaluated non-patient-derived data; therefore, ethical approval was not required for this study. We evaluated the Aisys™ (GE Healthcare), Fabius GS™ (Dräger, Inc., Lubick, Germany), and Pro-next™ (Acoma, Inc., Tokyo, Japan) anesthesia workstations, which are used in our operating theater and throughout Japan. The ventilators were tested using closed breathing circuits with a vaporizer of desflurane. Each circuit consisted of a 1-L test lung, a S5 Compact Gas Monitor™ (GE Healthcare), and a portable gas analyzer module (E-CaIOVX™; GE Healthcare). The workstations were tested after connecting the 1-L test lung to the patient side of the anesthesia circuit, and without a disposable humidifier. Volume-controlled ventilation was performed using 500 mL of tidal volume, a respiratory rate of 10/min, and an O2 flow rate of 1.5 L/min. When the end-tidal concentration of desflurane reached 6% for 1 min, the flow of desflurane was stopped and the time until desflurane had completely disappeared from the anesthetic circuit using continuous gas flow was measured. The total washout time for desflurane was measured using the S5™ Compact Gas Monitor, which captures data every 5s. The mean and standard deviation values were calculated based on the results from 20 repetitions. Because each workstation has different breathing systems and components, we also calculated the total washout time divided by the total circuit volume. The total circuit volume was defined as the sum of the internal anesthesia breathing circuit, the volume of the soda lime canister, and the ventilator capacity including the respiratory bellows. The volumes for each workstation were obtained from the

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leakage provided by the manufacturer.

Results were expressed as the mean ± standard error, and were compared using repeated measures analysis of variance with post hoc Bonferroni correction. All statistical analyses were performed using GraphPad Prism software (version 6.01; Graph Pad Software Inc., San Diego, CA, USA). All results were considered statistically significant at a p-value <0.05.

Results

The specifications of each anesthesia workstation are shown in Table 1. The measured total washout times for sevoflurane were 902 ± 28 s in the Aisys™ system, 1,060 ± 64 s in the Fabius GS™ system, and 1,363 ± 168 s in the Pro-next™ system. The measured total washout time for desflurane in the Aisys™ was significantly shorter compared with the other two anesthesia workstations (both p < 0.01) (Figure 1). The calculated washout times per circuit capacity for desflurane were 175 ± 5.5 s/L in the Aisys™ system, 216 ± 13 s/L in the Fabius GS™ system, and 254 ± 31 s/L in the Pro-next™ system (Figure 2). The calculated washout time per circuit capacity in the Fabius GS™ system was significantly shorter than that in the Pro-next™ system, and the calculated washout time per circuit capacity in the Aisys™ system was significantly shorter than that in the Pro-next™ system (both p < 0.01).

Discussion

The present study revealed that the Aisys™ system provided a shorter desflurane washout time compared with the Fabius GS™ and Pro-next™ systems. Moreover, the washout time of the Fabius GS™ system was significantly shorter than that in the Pro-next™ system (p < 0.01).

Figure 1. Comparison of the measured total washout times for desflurane
The measured total washout times for desflurane were 902 ± 28 s in the Aisys™ system, 1,060 ± 64 s in the Fabius GS™ system, and 1,363 ± 168 s in the Pro-next™ system. The total washout time for desflurane in the Aisys™ system was significantly lower than for the two other systems (*p < 0.01). Values are the mean ± standard error.

Figure 2. Comparison of the calculated washout times for desflurane
The calculated washout times for desflurane were 175 ± 5.5 s/L in the Aisys™ system, 216 ± 13 s/L in the Fabius GS™ system, and 254 ± 31 s/L in the Pro-next™ system. The calculated washout time per circuit capacity in the Aisys™ system was significantly shorter than in the Fabius GS™ (p < 0.01) and Pro-next™ systems (both p < 0.01). The calculated washout time per circuit capacity in the Fabius GS™ system was significantly lower than that in the Pro-next™ system (p < 0.01). Values are the mean ± standard error.

The measured total washout times for desflurane in various anesthesia workstations.
This study had several limitations. First, we did not evaluate how components in each anesthesia workstation affected the washout time. Second, we did not use a fresh-gas flush to remove desflurane. Usually, many anesthesiologists use the fresh-gas flush for wash out the volatile agents but rather select continuous gas flow to wash out the halogenated volatile agent to prepare the workstation for patients who cannot be exposed to desflurane.

Conclusions

In conclusion, we evaluated the washout times for desflurane in various anesthesia workstations. Our results indicate that the Aisys™ system washes out desflurane quicker than the Fabius GS™ and Pronext™ systems, based on continuous gas flow. However, other studies and washout conditions are required to validate our findings.

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