An evaluation of one and two airflow filters in preventing the movement of bacteria through the anesthesia circle system

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A review of the literature demonstrated that controversy exists as to whether anesthesia circle systems can be a source of transmission of bacteria to patients.

The purpose of this study was to evaluate the use of one airflow filter (on the expiratory limb) versus two airflow filters (one on the inspiratory limb and one on the expiratory limb) in the prevention of bacterial migration in the anesthesia circle system, during general anesthesia, using semiquantitative analysis of the number of bacterial colony forming units (CFUs).

This study consisted of two randomized groups receiving one or two airflow filters. Thirty-five volunteers participated in the study. At the conclusion of the surgical cases, a culture was taken of the anesthesia circle system. The cultures were read at 24 and 48 hours for the presence of CFUs. No CFUs were reported in either group.

The results of the study were inconclusive. Therefore, the use of one airflow filter on the expiratory limb should remain the standard of care, pending additional research. Some practitioners may use a second airflow filter when there is a greater risk of infection, such as in the case of an immunocompromised patient. However, this study can neither support nor question the effectiveness of this practice.

Key words: Anesthesia equipment, circle system, general anesthesia.

Introduction
The American Association of Nurse Anesthetists Infection Control Guide (1992) contains a recommendation that one airflow filter should be used (no specific site). Nosocomial infections remain potential sources of morbidity and mortality among hospitalized patients. A nosocomial infection is an infection that a patient acquires in the hospital that is unrelated to the patient's primary diagnosis. As a result of nosocomial infections, patients remain hospitalized for longer periods and are thereby placed at a higher risk for death. Their hospital costs are also increased. Nosocomial infections extended hospitalization an average of 4 days per infection, and nearly 4% of all nosocomial infections resulted in death.

The possible introduction of bacteria from the anesthesia circle system may increase the patient's risk for developing a lower respiratory tract infection. A relationship between contamination of anesthesia equipment and infection of the patient must be considered because as many as 40 out of 10,000 patients receiving general anesthesia may suffer postoperatively from hospital-acquired pneumonia.

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filters (one on the inspiratory and one on the expiratory limb) in preventing the movement of bacteria through the anesthesia circle system when used on patients undergoing general endotracheal anesthesia in an operating room setting.

Methods

A consecutive sample of 35 surgical patients undergoing general endotracheal anesthesia was recruited for this study after obtaining approval from our institutional review board. Upon obtaining informed consent, subjects were randomly assigned (using a random number generating computer) to one of two groups. Because smoking and advanced age are possible risk factors for increased bacteria in the respiratory system, patients were stratified within groups by smoking status and age (younger than 60 years or 60 years and older) and randomly assigned. Group 1 consisted of 15 anesthetized subjects using one airflow filter (Virobac II, King Systems Corporation, Noblesville, Indiana) on the expiratory limb of the anesthesia circle system. Group 2 consisted of 20 anesthetized subjects using two airflow filters: one airflow filter on the expiratory limb and one airflow filter (Virobac II, King Systems Corporation, Noblesville, Indiana) on the inspiratory limb of the anesthesia circle system.

Subjects were selected from a consecutive sample of males and females by using the following criteria: 18 years old or older, no apparent respiratory infection at the time of preanesthetic assessment, and scheduled for surgical cases requiring general endotracheal anesthesia. Patients receiving antibiotic therapy for greater than 24 hours were excluded from the study, as were immunocompromised patients because they could not be randomized into the one airflow filter group. Commonly a second airflow filter is placed in the anesthesia circle system to minimize the risk for the immunocompromised patient.

The following procedure was used for data collections: single-use disposable patient breathing circuits with one airflow or two airflow filters and Humid-Vent® were used. Figures 1 and 2 depict the location of the airflow filters.

The function check for high pressure leaks, which involved handling the anesthesia circle system, was done by occluding the elbow connector with the inner surface of the disposable anesthesia circle system packaging, thereby avoiding contamination of the anesthesia circle system. Gas flow rates were held constant at 2 L/min for nitrous oxide or air and 1 L/min for oxygen.

At the end of the surgical case, cultures for aerobic bacteria were obtained using a sterile culturette bacterial swab. The culture site was on the inspiratory limb of the anesthesia circle system proximal to the point where the corrugation begins. This point is approximately 4.7 cm from the proximal end of the tubing. Culture sites are depicted in Figures 1 and 2. The bacterial culturette was transported to the microbiological section of the laboratory within 2 hours of collection and...
plated onto sheep blood agar plates by a laboratory technician.

The sheep blood agar plates were incubated for 24 hours in 5-10% carbon dioxide and 90-95% oxygen at 35-37°C. After 24 hours, a count of the number of bacterial colony forming units (CFUs) was completed by a laboratory technician and recorded on the laboratory request slip. A CFU in this study is equal to 100 colonies of bacteria.

After obtaining a count of CFUs, the culture plates were given to a microbiologist for identification of organisms that may have been pathogenic. The number of bacterial CFUs were recorded for each culture plate. The Mann-Whitney U test was applied to determine if a statistically significant difference (P<.05) existed between the number of CFUs obtained from the one airflow filter circle anesthesia systems and those obtained from the two airflow filter circle anesthesia systems.

A sample of 15 subjects per group provided a 95% confidence interval for a contamination rate of 0-8.5% (defined as 0 CFUs). If CFUs were detected in the one airflow filter group (controlling for the probability of a Type I error at alpha = .05) a sample of 30 subjects per group would have provided an 80% power to detect a difference of 25%.

Results
The absence of bacterial growth in group 1 and group 2 precluded statistical comparisons between the groups. To conduct a statistical analysis, positive growth at the culture site was needed to demonstrate a difference between the groups. The findings of the study do not allow us to make a statistically based conclusion. There was no growth in group 1 nor group 2, therefore the research hypothesis can neither be accepted nor rejected.

Discussion
Shiotani et al evaluated machine contamination and effectiveness of various components to act as bacterial filters. In an initially sterile circle system that was artificially inoculated with Staphylococcus aureus, bacterial contamination was found throughout the system. The expiratory tubing was extensively contaminated. The inspiratory tubing was also contaminated, despite the belief that bacteria do not usually pass through the soda lime absorber.

Albrecht and Dryden performed a retrospective study of 220 charts of patients who underwent anesthesia using anesthesia circle systems. One hundred of these patients received anesthesia through anesthesia circle systems that were not cleaned between patients. Of these 100 patients, 23 developed postoperative pulmonary infections. Of 50 patients who had received anesthesia through a totally clean circuit, except for the soda lime absorber, three (6%) developed a postoperative pulmonary infection.

A recent study investigated the usefulness of airflow filters in protecting the circle system and isolating the ventilator from contamination. This study was done using low-flow anesthesia circle systems. Low-flow anesthesia circle systems are semiclosed systems that permit the rebreathing of expired gases. Gas flow settings are governed by minute ventilation, oxygen consumption, and anesthetic gas uptake.

In yet another study, bacterial filters were put on both the inspiratory and expiratory ports of the CO2 absorber. Here no differences were found in the incidence of postoperative pneumonia between patients who received their anesthesia through filtered and nonfiltered anesthesia circuit systems. Patients considered to be at a higher risk for infection, such as smokers and those with a history of chronic obstructive pulmonary disease, asthma, bronchitis, or pneumonia, did not demonstrate a higher incidence of postoperative pneumonia.

Because no CFUs were found in any cultures submitted, it appears that the use of a second airflow filter on the inspiratory limb of the anesthesia circle system may not be necessary to prevent bacterial transfer. The results of the study are inconclusive. Therefore, the use of one airflow filter on the expiratory limb should remain the standard of care, pending additional research. Some practitioners use a second filter when there is a greater than routine risk of infection, such as for an immunocompromised patient. However, this study can neither support nor question the effectiveness of this practice.

REFERENCES

AUTHORS

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**PRECAUTIONS**

**Labor and Delivery:** The use of ZEMURONTM (rocuronium bromide) Injection in cesarean section has been studied in a limited number of patients. ZEMURON1 is not recommended for rapid sequence intubation in cesarean section patients unless the usual dosing guidelines should be adequate.

**Hepatic Disease:** Since ZEMURON1 (rocuronium bromide) Injection is primarily excreted by the liver it should be used with caution in patients with clinically significant hepatic disease. ZEMURON1 0.6 mg/kg has been shown to increase the onset of neuromuscular block in patients with hepatic disease under- stead-state isoflurane anesthesia. After ZEMURON1 0.6 mg/kg, the median (range) clinical duration of 65 (35-166) minutes was moderately prolonged compared to 42 minutes in patients with normal hepatic function. The median recovery time of 53 minutes was also prolonged in patients with cirrhosis compared to 20 minutes in patients with normal hepatic function. Four of eight patients with cirrhosis, who received ZEMURON1 0.6 mg/kg on hepatic/intermediate oxygen/anesthesia, did not achieve complete block. These findings are consistent with the increase in volume of distribution at steady state observed in patients with significant hepatic disease (see Pharmacokinetics subsection of CLINICAL PHARMACOLOGY). If used for rapid sequence intubation in patients with normal hepatic function it may be necessary to administer a test dose to determine if the drug may be necessary to achieve complete block. Duration will be prolonged in these cases. The use of doses higher than 0.6 mg/kg has not been studied.

**Adjunctive Use:** The use of ZEMURONTM (rocuronium bromide) Injection before surgery and anesthesia. The initial dosage of ZEMURONTM (rocuronium bromide) Injection should be no less than 10 mg (0.1 mg/kg), and in patients with hepatic disease approximating the dose in humans (0.3 mg/kg). No teratogenic effects were observed in this study. There are no adequate and well-controlled studies in pregnant women. Therefore, ZEMURON1 should be used during pregnancy only if the potential benefits justify the risk to the fetus.

**Pediatric Use:** The use of ZEMURONTM (rocuronium bromide) Injection in children less than 3 months of age has not been studied. See Clinical Pharmacology subsection of CLINICAL PHARMACOLOGY. Pediatrics subsection of DOSAGE AND ADMINISTRATION for clinical experience and recommendations for use in infants and children 3 months to 14 years of age.

**ADVERSE REACTIONS**

**Reactions:** In the U.S. (n=1,137) and Europe (n=1,398) total 2,531 patients. Prolonged neuromuscular block is associated with respiratory failure (see Antagonism of Neuromuscular Blockade). ZEMURON1-induced neuromuscular blockage was modified by acidosis and acid-base imbalance and also may be associated with signs or symptoms of local irritation, the injection or infusion should be terminated immediately and restarted in another vein (see DOSAGE AND ADMINISTRATION).

**Carcinogenesis, Mutagenesis, Impairment of Fertility:** In studies in animals have not been performed to evaluate carcinogenic potential or impairment of fertility. Mutagenicity studies (Ames test, analysis of chromosomal aberrations and analysis of sperm post test) conducted in ZEMURON1 (rocuronium bromide) Injection did not suggest mutagenic potential. Pregnancy Category B:** A leader in the Research and Development of Neuromuscular Blocking Agents.

**Laboratory Tests:** The use of ZEMURON1 (rocuronium bromide) Injection is in obese 67 year-old female with hepatic dysfunction who had received gentamicin before surgery. The patients exposed in the U.S. clinical studies were not a basis for the following adverse experience. In the U.S. clinical studies, 12% of patients were exposed in the U.S. clinical studies. The incidence of hypertension, may enhance neuromuscular blockade. Therefore, electrolyte imbalance and acid-base imbalance are usually mixed, either enhancement or inhibition may occur. Magnesium salts, administration of calcium in patients with normal renal function.

**SPONTANEOUS RECOVERY OR ANTAGONISM. Therefore, its administration must be accompanied by adequate anesthesia or sedation. Therapeutic effects of muscle relaxants.**

**THERAPY FOR OVERDOSE**

**Antagonism of Neuromuscular Blockade**

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**Clinical Pharmacology**

**DOSAGE AND ADMINISTRATION**

**Malignant Hyperthermia (MH):** In an animal study in MH-susceptible swine, the administration of ZEMURON1 (rocuronium bromide) Injection has not been studied in MH-susceptible patients. Because ZEMURON1 is always used with other agents, and the occurrence of malignant hyperthermia during anesthesia is possible even in the absence of known triggering agents, clinicians should be familiar with early signs, corrobatory diagnostic test and treatment of malignant hyperthermia prior to the start of any anesthetic.

**Alternate Circulation Time:** Conditions associated with slower circulation time e.g. cardiovascular disease or advanced age, may be associated with a delay in onset time. Because higher doses of ZEMURON1 (rocuronium bromide) Injection produce a longer duration of action, the initial dosage should usually not be increased in these patients. In this time, if needed, more time may be allowed for the drug to achieve onset of effect.

**Drug Interactions:** The use of ZEMURON1 (rocuronium bromide) Injection before succinylcholine, for the purpose of attaining surgical relaxation and maintaining is observed. If ZEMURON1 is administered following administration of succinylcholine, it should not be given until recovery from succinylcholine has been observed. The median duration of action of ZEMURON1 0.6 mg/kg administration of ZEMURON1 0.6 mg/kg at the onset of neuromuscular block was 25% of controls (range 14-57, n=12) 25 minutes (17-51, n=12) without succinylcholine.

**Precautions:** In the setting of the use of ZEMURON1 before or after other nondepolarizing muscle relaxants. Interactions have been observed when other nondepolarizing muscle relaxants have been administered in succession.

**Injection Anesthesia:** Use of injection anaesthetics has been shown to enhance the activity of other neuromuscular blocking agents, enflurane from isoflurane. Isoflurane and enflurane may also prolong the duration of action of initial and maintenance doses of ZEMURON1 (rocuronium bromide) Injection has not been required for the maintenance of a patent airway. The primary treatment is maintenance of a patent airway and administration of adequate anesthesia or sedation. ZEMURON1 (rocuronium bromide) Injection are to be stored under refrigeration, 2 to 8°C (36 to 46°F). Do not freeze. Upon removal from refrigeration to room temperature storage conditions (25±2°C) within 30 days.

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