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Microbiological risk of anaesthetic breathing circuits after extended use

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Introduction: Daily change of breathing circuits in the operating theatre requires a lot of resources and is time and labour consuming. The extended use of breathing circuits could reduce the workload of the staff and health care costs. The aim of the present study was to evaluate the contamination rate of anaesthesia breathing circuits changed after 24, 48 or 72 h of use.
Materials: The study was performed as an experimental observational study. Microbiological samples were taken from 112 breathing systems including both parts of the ventilator circuit (inspiration and expiration) and analysed using microbiological standard techniques. Breathing circuits were changed according to three different schedules. In the 24-h group, breathing circuits were changed every day, whereas in the 48-h group changing of the circuits took place on Mondays, Wednesdays and Fridays. A period of 72 h operating use was tested on weekends.
Results: A total of 112 breathing systems comprised of 224 samples from the ventilator circuit were tested for bacteria and yeast contamination. A non-significant increase in the contamination rate was observed with the extended use for breathing circuits (24 h: 3.33%, 48 h: 4.35% and 72 h: 5.56%; P for trend = 0.66). Similarly, no significant increase in contamination rate could be observed at the sample level (24 h: 1.67%, 48 h: 3.26% and 72 h: 2.78%; P for trend = 0.71).
Conclusion: The extended use of breathing circuits for 48 and 72 h does not increase significantly the risk of contamination, provided that HME filters are changed separately for every patient.

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Key words: Breathing circuits; bacterial contamination; bacterial filters.

CONSIDERABLE attention has been paid to the relationship between humidification devices and ventilatory support circuit change frequencies. The optimised use of equipment may reduce labour costs as well as material costs, providing safe conditions for the patient. In this sense, reusing the same anaesthesia breathing circuit for multiple patients has been proposed (1). However, this practice is not recommended by the United States Centers for Disease Control (CDC), which suggests the use of a new or at least a purified tube for each narcotised patient (2). German hygiene guidelines allow a 24-h use of the breathing circuit associated with a new filter for each patient (3).

With the development of new viral and bacterial filters, the possibility of reusing breathing circuits has been reconsidered. Heat–moisture exchangers (HMEs) that are used to replace upper airway functions during mechanical ventilation have shown good bacterial filtration properties (4–6), with filtration efficacy exceeding 99.99%, and could prevent bacterial cross-contamination when reusing breathing systems. The aim of this study was to evaluate the presence of microorganisms after a 24-h use of the anaesthesia breathing circuits in a routine situation and possible changes when the operating life is extended to 48 and 72 h.

Materials and methods

The study was performed at the Department of Anaesthesiology and Intensive Care of the University Clinical Center Giessen and Marburg, Marburg, Philipps University Marburg, Germany. Draeger Medical devices (Luebeck, Germany; model Cicero EM and Primus) were used in the department and after every anaesthesiological

procedure, the disposable HME filter (Humid-Vent® Filter Compact S, Hudson RCI, Lohmar, Germany) was replaced. At the Department of Neurosurgery, disposable tubes were used because of the length of surgery procedures and the improved handling (InEx 2.0 m; Dahlhausen GmbH; Cologne, Germany and Uniflow 2.4 m, Intersurgical, Wokingham, UK), while in all other operating theatres tested in this study, patients were ventilated with reusable flexible tubes (Draeger Medical). The reusable tubes were thermodisinfected following an automatic programme including washing–drying cycles at 94 °C, according to the Robert Koch Institute guidelines (7).

The study was performed as an experimental observational study including a control period (24 h) in which a daily changing of breathing circuits was performed from Monday to Friday and an intervention period (48 h) where the breathing circuits were changed every 48 h (Monday, Wednesday and Friday). On weekends, a period of 72 h operating life was tested. Breathing circuits used for 48 and 72 h were not disinfected during this period.

Microbiological procedures

Under aseptic conditions, the tubes were disconnected and 50 ml of Ringer Lactate solution was injected from the ventilator side separately into each branch, first in the inspiration branch. The tube was oscillated and shaken for 30 s each time to strip microbiological biofilm-producing strains. Using the Y-piece as a drain, the solution was collected in a sterile dish and 5 ml was transferred to the laboratory in a sterile test tube. All the samples were collected before thermal disinfection.

Portions of 0.5 ml were inoculated on chocolate, blood and MacConkey agar plates (Becton Dickinson GmbH, Heidelberg, Germany) and incubated at 36 °C for 2 days under aerobic and microaerophilic conditions. Bacterial identification was conducted using standard microbiological procedures (BD-CRYSTAL–Kit, BENEX Limited, Shannon, UK). Quantitative determination was performed by counting the colony-forming units on the agar plates. Yeasts were incubated on Sabouraud agar plates for a further 24 h and later identified by a commercial test system (Dade Behring GmbH, Marburg, Germany).

Data analysis

A non-parametric test for trend across ordered groups, an extension of the Wilcoxon rank-sum test, was used to compare the occurrence of contamination in the breathing circuits evaluated (8). Fisher's exact test and simple logistic regression were used to compare the occurrence of contamination between different departments. The level of significance was set at 5%.

Results

Over a period of 42 days, 550 patients underwent surgery with artificial ventilation in 10 different operating theatres of six different departments. A total of 112 breathing systems comprised of 224 samples were evaluated for possible contamination. Overall microbiological contamination was observed in 4.46% of the breathing systems and 2.68% of the samples. Most of the time, only one sample (expiration sample) was contaminated in each breathing system.

The contamination rate was 3.33% for breathing circuits that were changed daily (standard procedure). The contamination rate increased to 4.35% and 5.56% when breathing systems were changed every 48 and 72 h, respectively (Table 1). No statistically significant trend was observed across the three different changing intervals. Compared with

Table 1

Bacterial contamination at breathing systems following 24-, 48- and 72-h intervals ($n = 112$).

Operating theatre	24-h interval ($n = 30$)		48-h interval ($n = 46$)		72-h interval ($n = 36$)		*P*-value for trend
	contaminated/ sterile	% contaminated	contaminated/ sterile	% contaminated	contaminated/ sterile	% contaminated	
Urology	0/6	0	0/7	0	0/6	0	
Abdominal, thoracic	0/3	0	1/19	5.00	0/13	0	
Accident surgery	0/5	0	1/5	16.67	0/5	0	
Orthopaedics	0/12	0	0/7	0	0/7	0	
Neurosurgery	1/3	25.00	0/6	0	2/3	40.00	
Total	1/29	3.33	2/44	4.35	2/34	5.56	0.66*

*Non-parametric test for trend across ordered groups.

the 24-h change interval, the odds ratios for contamination of the breathing circuits were 1.32 ($P = 0.83$) and 1.71 ($P = 0.67$) for the 48 and 72-h intervals, respectively.

Contamination rates at the sample level (inspiration/expiration from ventilator circuits) were somewhat lower than at the breathing system level. It increased from 1.67% for the 24-h change schedule to 3.26% and 2.78% for the 48 and 72-h schedules, respectively (Table 2). No significant trend in contamination rate was observed with increasing change schedule. Single samples evaluated after 48 and 72 h were, respectively, 1.99 ($P = 0.56$) and 1.69 ($P = 0.67$) times more likely to be contaminated than those changed after 24 h.

The contamination rate of the breathing systems and samples (inspiration/expiration from ventilator circuits) was higher at the neurosurgery department than at the other departments (breathing systems: 20.00% vs. 2.06%, $P = 0.02$; single samples: 10.00% vs. 1.55%, $P = 0.03$). Breathing systems or samples alone from the neurosurgery department were, respectively, 11.88 ($P = 0.01$) and 7.07 ($P = 0.02$) times more likely to be contaminated than samples from other departments. The overall occurrence of contamination would decline significantly if samples from the neurosurgery department were removed from the analysis. In addition, no association could be established by the mode or the duration of the surgery on the contamination rate of the anaesthetic breathing systems.

Discussion

It could be demonstrated that bacterial contamination was not associated with the changing interval of breathing circuits and that the reuse of an anaesthetic breathing circuit with a new filter for each patient does not increase the incidence of cross-infection between patients. In addition, the reuse of a breathing circuit with filters may reduce the operating cost and medical waste.

The detected microorganisms in this study are facultative pathogenic bacteria (Table 3). In recent years, *Acinetobacter baumanii* has been recognised as an important species causing nosocomial infections and hospital outbreaks. *A. baumanii* is involved in a wide range of infections including bacteraemia, urinary tract infections, pulmonary infections and meningitis (9–11). *Enterobacter* species have been considered important nosocomial pathogens colonising frequently hospitalised patients (12). They are regularly recovered from the human gastrointestinal, urinary and respiratory tracts and are considered as members of the normal faecal flora (13). Here, *Enterobacter gergoviae* and *Enterobacter*

Table 2

Bacterial contamination at breathing filters (inspiration/expiration) following 24, 48 and 72 h intervals ($n = 224$).

Operating theatre	24-h interval ($n = 60$)		48-h interval ($n = 92$)		72-h interval ($n = 72$)		*P*-value for trend
	contaminated/ sterile	% contaminated	contaminated/ sterile	% contaminated	contaminated/ sterile	% contaminated	
Urology	0/12	0	0/14	0	0/12	0	
Abdominal, thoracic	0/6	0	1/39	5.00	0/26	0	
Accident surgery	0/10	0	2/10	16.67	0/10	0	
Orthopaedics	0/12	0	0/14	0	0/14	0	
Neurosurgery	0/24	0	0/12	0	2/8	40.00	
Total	1/59	1.67	3/89	3.26	2/70	2.78	0.71*

*Non-parametric test for trend across ordered groups.

Table 3

Distribution of microorganisms according to operating theatre and period of breathing circuits change.

Period tested	Operating theatre	Contimated systems	Bacterial species
24 h interval	Neurosurgery	1	*Enterobacter gergoviae*, *Bacillus circulans*, *Corynebacterium aquaticum*
48 h interval	Abdominal, Thoracic	1	*Staphylococcus schleiferi*
	Accident surgery	1	*Staphylococcus simulans*, *Acinetobacter baumanii*
72 h interval	Neurosurgery	1	*Enterobacter sakazakii*
		1	*Candida inconspicula*

sakazakii were isolated at 24 and 72 h breathing circuit change, respectively, at the neurosurgery operating theatre. A nosocomial outbreak of bacteraemia caused by *E. gergoviae* has been shown in a neonatal intensive care unit, which was suggested to be due to a cross-contamination of a healthcare worker and parenteral dextrose saline (14). This emphasises the importance of controlling cross-contamination and the implementation of infection control policies, which should be practiced by all healthcare workers without exception.

Staphylococcus schleiferi is known as a commensal of carnivores and may be transferred from pets to their owners or handlers (15). The species is also supposed to be a member of the human preaxillary skin flora (16) while *Staphylococcus simulans* is occasionally found on human skin (17). As both bacteria are considered mostly as colonisers of the skin flora, this could be an explanation for the findings that bacterial contamination was seen on the breathing circuits examined. *Corynebacterium aquaticum* has its natural habitat in fresh water and is increasingly isolated from different clinical specimens, but is seldom the proven cause of infection, unless the patients present some form of immunosuppression. This would highlight the hypothesis that the risk of developing a respiratory tract infection from an anaesthesia breathing circuit will be determined by the host defence mechanisms but also by the bacterial load.

Hand hygiene has been proposed as being a very important issue for preventing nosocomial spread of pathogens in the hospital setting and community (18, 19). In addition to contamination of hands, environmental contamination is considered to be an important factor in hospital-acquired infections with several bacteria being able to survive for months on inanimate surfaces (20). In this context, inanimate surroundings as well as patients and health care workers play an important role in the bacterial transmission and could even be, in part, related to the contamination on the breathing circuits seen in this study. This, on the other hand, would leave one to speculate that the longer the breathing circuit is reused, the less it would be contaminated.

The findings of this investigation are consistent with other studies, suggesting that the same breathing circuit can be used at least twice in association with the use of bacterial filters for every patient (21). The filter will then prevent contamination of the circuit from the patient and contamination of the patient from the circuit. The demand for proven benefit of using breathing filters must be a reduction by the factor 10^5–10^6 of the prevailing bacteria. Filters have already been shown to have a good efficiency (6, 22) and high contamination rates were observed when no filter was installed in the system (9).

Bengtson et al. (23) observed no differences between the number of anaesthetised patients and contaminations of the system as well as no correlation between detected microorganisms in the system and postoperative diagnostic findings. Despite the absence of a preoperative screening in our study protocol, no correlation was found between detected microorganisms in the breathing circuits system and postoperative diagnostic findings. However, one limitation of the study was that microorganisms were recovered from the swab sample sites within the circuit without using devices to recover microorganisms presented as an aerosol in the inspired gas.

With regard to the processes in long-term ventilation, durations of 168 h should be evaluated. Use of disposables and a reduced amount of work would lead to greater economic efficiency and further cost savings. As the breathing circuit is vulnerable to colonisation and a possible vector of cross-contamination, a structural alteration, like water traps, should also be considered. Every modification in the working process must be evaluated consistently to eliminate any accumulation of pathogens and higher rates of colonisation of the breathing circuit.

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