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ARTIGO ORIGINAL

Bacterial Contamination of the Anaesthesia Breathing Machine: Effectiveness of Current Infection Control Measures

Contaminação Bacteriana do Ventilador de Anestesia: Eficácia das Medidas Atuais de Controlo de Infecção

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ABSTRACT

Introduction: Bacterial contamination of anaesthesia breathing machines and its potential hazard for patients have been a concern for many decades. Bacterial filters effectively prevent breathing circuit contamination, but clear recommendations about their use are lacking. This study aims to verify whether our institution's current infection control standards effectively prevent contamination of the anaesthesia breathing machine.

Methods: For five consecutive days, samples were collected with sterile swabs moistened with sterile 0.9% NaCl solution by rubbing, for 5 seconds, the entire inner circumference of the inspiratory and expiratory ports of two anaesthesia breathing machines, in routine use for 12 hours every day. Cultures were incubated and followed up for the identification of aerobic bacteria.

Results: A total of 20 samples were collected and processed for aerobic bacterial culture. No bacterial growth was observed at 24 and 48 hours.

Conclusion: No aerobic bacterial growth was observed in the cultures of the samples collected when using a bacterial filter in the expiratory port of the breathing circuit, together with a disposable HME filter for each patient. The current infection control protocol prevents aerobic bacterial contamination of the anaesthesia breathing machine ports for five days, despite only a 24 hours filter efficacy guarantee. This increased interval allows the hospital an estimated annual saving of 4442€. Clear national and international guidelines about breathing circuit management are lacking, and regulatory policies would be most welcome.

RESUMO

Introdução: A contaminação bacteriana dos ventiladores de anestesia e o potencial risco para doentes anestesiados tem sido uma preocupação há muitas décadas. Os filtros bacterianos são eficazes na prevenção da contaminação do circuito respiratório, mas faltam claras recomendações sobre a sua utilização. O objetivo deste estudo é verificar se as normas de controlo de infeção para o bloco operatório da nossa instituição são eficazes na prevenção da contaminação do ventilador anestésico.

Métodos: Durante 5 dias consecutivos, foram colhidas amostras com recurso a zaragatoas esterilizadas embebidas em solução de NaCl a 0,9% esterilizada, esfregando durante 5 segundos a circunferência interna das portas inspiratória e expiratória de dois ventiladores de anestesia, em utilização 12 horas por dia. As culturas foram incubadas e observadas para identificação de bactérias aeróbicas.

Resultados: Um total de 20 amostras foram colhidas e processadas para cultura de bactérias aeróbicas. Não foi observado qualquer crescimento bacteriano às 24 e 48 horas.

Conclusão: Não foi observado crescimento bacteriano aeróbico nas culturas das amostras colhidas, usando um filtro bacteriano na porta expiratória juntamente com um filtro HME descartável para cada doente. O atual protocolo de controlo de infeção parece eficaz na prevenção da contaminação das portas do ventilador de anestesia por bactérias aeróbicas durante 5 dias, apesar da eficácia referida do filtro ser de apenas 24 horas. Este intervalo alargado permite ao hospital uma poupança anual estimada de 4442€. Não existem normas nacionais nem internacionais claras sobre a gestão de circuitos respiratórios e são, portanto, necessárias diretrizes.

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INTRODUCTION

Bacterial contamination of anaesthesia breathing machines (ABM) and its potential hazard for pulmonary cross-infection among anaesthetised patients has been an infection control concern for years.[1-10] Organisms have been observed to lodge in the components of the breathing system.[1,9,11,12] While evidence regarding cross-infection between successive patients is refuted by some authors,[1,5,13] others argue that contaminated anaesthesia circuits have been implied in severe and even fatal respiratory infections.[3,14]

Before the breathing circuit can be a vector for respiratory infections, the patient must aerosolise enough pathogens to contaminate the anaesthesia machine. The pathogen must remain viable and be eluted from the device in sufficient amounts and virulence to infect other patients.[3] Bacterial filters and disposable breathing circuits have been instituted to reduce this risk[4,5,7,8,12,15] and are now routine practice. Despite the effectiveness of bacterial filters in preventing breathing circuit contamination,[6-10,12,15-17] recommendations about their use are conflicting.[18] The healthcare environmental impact is also a growing concern, and operating suites produce around a quarter of all hospital waste.[19] Bacterial filters can be beneficial in reducing waste by allowing for breathing circuits to be reused,10 which could also reduce hospital costs.[20] This study aims to verify whether the current infection control standards for the operating theatre at our institution are effective in preventing contamination of the ABM.

METHODS

The study was conducted at a secondary care Portuguese hospital with 371 beds. The hospital's infection control standards for the operating theatre dictate the use of a disposable heat and moisture exchange (HME) filter (DAR™ Adult – Pediatric Electrostatic Filter HME – Fig. 1) for each anaesthetised patient (a new filter for each patient). The filter is on the patient's side and inserted between the airway device and the breathing circuit's Y-piece. Reusable facemasks are cleaned and disinfected between patients, and anaesthesia gases are applied using a disposable breathing circuit, which is changed daily. The breathing circuit will be changed earlier if visibly soiled or after use on a patient with a particular infectious disease status (e.g., HIV, tuberculosis, methicillin-resistant staphylococcus aureus, COVID-19). One additional filter (Air-Guard Clear, Intersurgical® - Fig. 1), which is changed every Monday, is routinely positioned on the machine side and placed on the outlet of the expiratory port of the breathing circuit. Intersurgical® claims the Air-Guard Clear to have a 99.999% viral and bacterial filtration efficiency, protecting from contamination for up to 24 hours.[21]

Once daily for five days (8th to 12th July 2019), samples were collected and microbiologically examined for aerobic bacteria. These samples were collected from 2 ABM (Primus, Dräger Medical, Germany) around 2 p.m. The ABM tested

Figure 1. HME filter and Air-Guard Clear (black arrows)

Figure 2. Inspiratory and expiratory ports (black arrows)

in this study were in routine use (around 12 hours a day) in two operating rooms (orthopaedic surgery and emergency surgery) and received no special treatment other than having their expiratory port filters marked with a pen when they were changed at the beginning of the week, to ensure they were not changed again without notice. Samples were taken from 2 defined locations inside the ABM's internal breathing circuits: the inspiratory port and the expiratory port (Fig. 2). They were collected by the same person with sterile swabs moistened with sterile 0.9% NaCl solution by rubbing the entire inner circumference of the ports for 5 seconds. The swabs were then immediately transported to the microbiological laboratory in Amies medium, where they were plated on chocolate agar PolyViteX (bioMérieux®) by smearing and then incubated at 37°C at 5% CO_2 for 48 hours. The plates were observed for colony forming units (CFU) and followed up for identification of any microorganism at 24 and 48 hours. An on-site process observation by the infection control team was performed during sample collection from the ABM.

RESULTS

Over a period of five days, a total of 20 samples were collected. Cultures were incubated, observed for CFU and followed up with identifying any microorganisms (aerobic bacteria). During this process, no CFU was observed in any collected samples at 24 and 48 hours (Fig. 3).

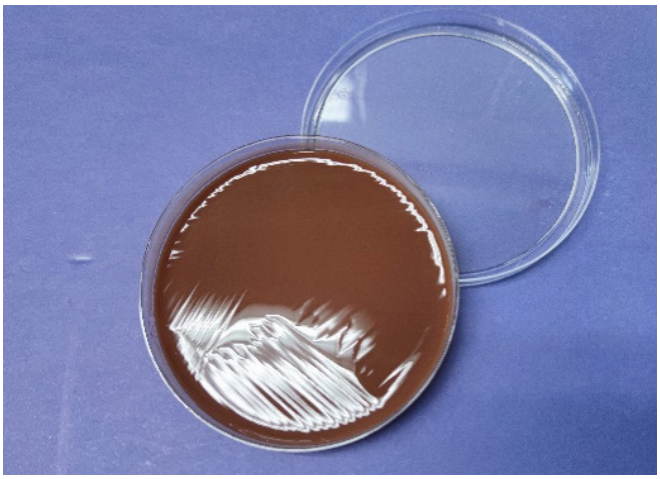

Figure 3. Collected samples in chocolate agar.

DISCUSSION

Surgery is associated with alterations in cell-mediated humoral immunity, accentuated by clinical status and the patient's concurrent medications, thereby increasing susceptibility to infection.[1,11] In the U.S. "Guidelines for Preventing Health-Care Associated Pneumonia, 2003" from the Centers for Disease Control and Prevention (CDC), there is no recommendation for "placing a bacterial filter in the breathing system or patient circuit of anaesthesia equipment", and regard this as an "unresolved issue".[22] In European countries, regulations concerning anaesthesia breathing systems are less specific.[20]

The Association of Anaesthetists of Great Britain and Ireland recommends placing a filter between the patient and the breathing circuit and daily exchange of anaesthetic circuits.[23] Despite no clear recommendations about placing a filter on the expiratory port of the ABM, the infection control standards at our institution dictate its use. The benefit of using filters to prevent contamination of the breathing circuits was demonstrated in previous studies.[6,8,10,12,15-17] However, absolute protection cannot be achieved by any hygienic measure alone since there are many possible sources of contamination.

The occurrence of sporadically detected microorganisms which do not correlate with tracheal secretion species, i.e. airborne or cutaneous, has shown this.[12,24] Spertini *et al*[7] demonstrated the presence of bacterial contamination of the ABM despite bacterial filters, stating the most likely cause for bacterial contamination of the internal circuits is a lack of adherence to protective measures during breathing circuits re-processing and assembly of parts. In the work of Hartmann *et al*,[16] hands and environmental contamination were proposed as explanations for the microorganisms isolated from the breathing circuit. Bengston *et al*[4] also conclude that it is likely that most circuit contamination took place when connecting the circle system. Nonetheless, using filters will prevent contamination of the circuit from the patient and contamination of the patient from the circuit.[10,12,16] When microorganisms have been isolated from the ABM or deliberately introduced in the expiratory port, their ability to survive or be transmitted to the patient has been questioned.[3-5,13] The environment within the circle system appears detrimental to bacterial growth and survival due to the desiccating flow of anaesthetic gases, the shifts in humidity and temperature and the lack of nourishment.

The properties of the circuit components and the highly alkaline environment created by the exothermic reactions in the soda lime canister also seem unfavourable for bacteria transmission.[4,5] Murphy *et al*[1] demonstrated soda lime to be bactericidal to most species tested. Nonetheless, the impaction of organisms in the granules is required, and 5%-40% of the microorganisms were not retained by the soda lime in the canister and remained viable.

Contradictorily, other studies have argued that soda lime itself was not bactericidal for any of the organisms tested and that viable bacteria entering the circuit escaped the soda lime canister gaining access to the inspiratory gas flow.[3,8] These authors recommended using bacterial filters to protect the ABM, patients, healthcare workers and the environment from contamination. In this study, no aerobic bacterial growth was observed in the cultures of the collected samples from the inspiratory and expiratory ports of the ABM when using the Air-Guard Clear (Intersurgical®) in the expiratory port of the breathing circuit alongside a disposable HME filter for each patient. Although the current infection control protocol seems to prevent bacterial contamination of the anaesthesia breathing machine ports, we cannot conclude that the entire circuit of the ABM is not contaminated since we only tested a small portion of the circuit components. It must also be stated that our results cannot be extrapolated to viruses, fungi or mycobacteria.

Also, even though Intersurgical® only warranties filter efficacy over 24 hours, the combined measures in current use at our institution appear to prevent aerobic bacterial growth on the anaesthesia machine ports over five days. This increased interval in filter change allows the hospital an annual saving of around 4442€ (1.95€ (filter cost) x 260 days (five days per week) x 11 (number of operating rooms in our institution) - 1.95 x 52 (weeks in a year) x 11 = 5557 - 1115.4 = 4441.6€), while also decreasing the environmental waste.

Regular microbiological studies, monitored by the hospital's infection control team, should be implemented on the 5th day of use to check the filter effectiveness over time. Finally, it is essential to state the experimental character of this study, the limited time frame and the low number of samples collected and that only a small portion of the breathing circuit was tested, which could explain the absence of bacterial growth

from any of the collected samples. Should the number of samples and the duration of the study be increased and the inclusion of other forms of sample collection, namely by direct sample collection or by breathing system washing with sterile 0,9% NaCl solution, followed by sample culture, results may differ. Including cultures for other microorganisms (viruses, fungi, or mycobacteria) could similarly yield different results. The lack of clear national and international guidelines about ABM management creates a huge disparity in practice, and regulatory policies would be most welcome.

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