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SHORT COMMUNICATION

An audit into the efficacy of single use bacterial/viral filters for the prevention of equipment contamination during lung function assessment

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Summary Lung function testing has been suggested to provide a potential risk regarding cross-infection between patients. About 155 patients (86 infectious, 69 non-infectious) used a single use bacterial/viral filter when performing routine lung function tests. Swabs from the patient side of the filter (Proximal) and the equipment side (Distal), and two sections of the filter itself were cultured. About 33/155 samples showed bacterial growth on the Proximal compared with 2/155 on the Distal side ($P<0.01$). Growth was obtained from the filter in 125/155 (80.6%) of cases. Pathogenic micro-organisms such as *Pseudomonas aeruginosa* (4 cases) and *Staphylococcus aureus* (5 cases) were isolated. Appropriate infection control measures should be used when performing lung function tests.

Introduction

Lung function tests that involve both expiratory and inspiratory manoeuvres have been proposed as a potential source of cross-infection between patients.[1–3] In light of hospital infection control policies, increased patient awareness and medico-legal issues there is a need to control for such risk, however small. Although the optimal measures for prevention of cross-infection have not been universally accepted, single use bacterial/viral filters have been proposed as a viable method to reduce possible risk to patients.[4] However, the application of single use patient filters is not widespread, extra cost being the major limiting factor. Recent review articles have called for research into the efficacy of filters in removing micro-organisms.[5]

The purpose of this study was to investigate the transmission of micro-organisms from patient to equipment during pulmonary function testing and

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to assess the removal of micro-organisms by bacterial/viral filters in both infectious and non-infectious patient groups.

Method

About 155 patients performed routine lung function assessment consisting of flow volume loops, gas transfer and body plethysmography (Erich Jaeger GmbH, Wurzburg, Germany). Instructions and encouragement to the subjects were given throughout the tests by trained personnel. Patients were instructed to remain in a seated upright position with nose clips positioned accordingly. The proximal port of the bacterial/viral filter was used as the mouthpiece, this reduced the deadspace of the circuitry and also minimised cost. The circuit consisted of filter/mouthpiece, plastic connector and pneumotachograph, fixed upright in a bracket and adjusted so patients were positioned correctly in relation to the equipment/mouthpiece. During the tests, patients were asked to refrain from holding the equipment to reduce any cross-contamination. Patients were split into infectious and non-infectious cohorts. Infectious patients ($n = 86$) were classified as patients with a confirmed diagnosis making the presence of respiratory pathogens likely; in this case cystic fibrosis (CF; $n = 44$) and bronchiectasis (Bx; $n = 42$). The non-infectious group ($n = 69$) consisted of individuals not classed infectious and with conditions routinely tested by the unit: asthma ($n = 8$), interstitial lung disease ($n = 22$), chronic obstructive pulmonary disease and emphysema ($n = 23$) or miscellaneous conditions ($n = 16$). Tests were performed using a single use bacterial/viral filter (Spiroguard 2800, Air Safety Limited, UK: 200 g electrostatic media with 99.96% stated efficiency at a flow of 720 L/min). During the tests a total of 8–10 maximal vital capacity manoeuvres were performed using the same filter. Upon completion of lung function, patient filters were collected and heat-sealed in a plastic-lined foil bag to ensure minimal environmental contamination during transit to the Microbiology laboratory.

Bacteriological analysis using standard techniques[6] was designed to assess transmission onto and from equipment, capture of micro-organisms by the filter itself and any passage of isolates through the filter onto the equipment.

The patient side of the filter was referred to as the Proximal side and the equipment side Distal. Both the Proximal and Distal sides were swabbed using a sterile swab (Transwab®, Medical Wire and Equipment Co., Wilts, UK). Swabs were then inoculated onto culture media (blood, MacConkey and chocolate agar) and then streaked across half plates. If from clinical details, specific organisms were sought, Sabouraud, *Burkholderia cepacia, Pseudomonas* or *Staphylococcal* selective media were also inoculated. All plates were incubated aerobically at 37 °C, except for chocolate plates, which were incubated in 4–6% CO_2. After 24 and 48 h incubation, colony types present were identified and enumerated.

In order to determine the total qualitative bacterial content, two sections of filter material were cut out from each patient filter using a sterile scalpel after they were swabbed. For mycobacterial investigation, one section was placed in Dubos broth supplemented with OADC and PANTA and incubated for 14 days at 37 °C. The broth was then sub-cultured onto Lowenstein–Jensen slopes and incubated for a further 14 days. The second section was placed in brain–heart infusion broth, incubated for 24 h at 37 °C, sub-cultured and incubated using the same methods as for the Proximal and Distal swabs.

Statistical analysis was performed using McNemar χ^2-tests with continuity correction.

Results

Bacteriological results obtained from all samples are displayed in Table 1. Significantly greater bacterial growth was found on the Proximal side (33/155) compared with the Distal (2/155) side ($P < 0.01$). Some growth was obtained from the filter in 80.6% (125/155) of cases.

No significant differences were found between infectious and non-infectious groups in transmission of normal respiratory flora. Of the identifiable pathogenic organisms found, all were transmitted by the Infectious group. *P. aeruginosa*, *P. stutzeri* and *S. aureus* were isolated on the Proximal or Filter cultures in 9 (10.5%) subjects in this group. Most of the pathogenic organisms were isolated from the Filter culture, although *S. aureus* and *P. aeruginosa* were each isolated from the Proximal site on one occasion. In these cases the same bacterium was isolated from the Filter culture. No pathogenic bacteria were isolated from the Distal site; only two isolates of Coagulase-Negative Staphylococci (CNS) were obtained from the Distal site. No pathogenic bacteria were isolated from any culture taken from the non-infectious cohort.

All samples were processed within 2 h of collection. Additional samples ($n = 10$) were inoculated

Table 1 Micro-organisms isolated from proximal, distal and filter sample sites.

Isolate	Sample site								
	Infectious group ($n = 86$)			Non-Infectious group ($n = 69$)			All subjects ($n = 155$)		
	Proximal	Distal	Filter	Proximal	Distal	Filter	Proximal	Distal	Filter
Any growth	17 (19.8%)	2 (2.3%)	72 (83.7%)	16 (23.2%)	0	53 (76.8%)	33 (21.3%)	2 (1.3%)	125 (80.6%)
No growth	69 (80.2%)	84 (97.7%)	14 (16.3%)	53 (76.8%)	69	16 (23.2%)	122 (78.7%)	153 (98.7%)	30 (19.4%)
AHS	9 (10.5%)	0	12 (24.4%)	13. (18.8%)	0	5 (7.2%)	22 (14.2%)	0	17 (11.0%)
Aeromonas salmonicida	0	0	1 (1.2%)	0	0	0	0	0	1 (0.6%)
Bacillus sp.	0	0	35 (40.7%)	0	0	27 (39.1%)	0	0	62 (40%)
CNS	6 (7.0%)	2 (2.3%)	17 (19.8%)	9 (13.0)	0	26 (39.9%)	15 (9.7%)	2 (1.3%)	40 (25.8%)
Diptheroids	4 (4.7%)	0	3 (3.5%)	2 (2.9%)	0	0	6 (3.9%)	0	3 (1.9%)
Micrococcus sp.	0	0	1 (1.2%)	0	0	0	0	0	1 (0.6%)
Neisseria sp.	1 (1.2%)	0	0	2 (2.9%)	0	0	3 (1.9%)	0	0
NHS	4 (4.7%)	0	5 (5.8%)	6 (8.7%)	0	5 (7.2%)	10 (6.5%)	0	10 (6.5%)
Ochrobactrum anthropi	0	0	0	0	0	1 (1.4%)	0	0	1 (0.6%)
Pseudomonas aeruginosa	1 (1.2%)	0	3 (3.5%)	0	0	0	1 (0.6%)	0	3 (1.9%)
Pseudomonas stutzeri	0	0	1 (1.2%)	0	0	0	0	0	1 (0.6%)
Ralstonia picketii	0	0	1 (1.2%)	0	0	1 (1.4%)	0	0	2 (1.3%)
Sphing. paucimobilis	0	0	0	0	0	1 (1.4%)	0	0	1 (0.6%)
Staphylococcus aureus	1 (1.2%)	0	4 (4.7%)	0	0	0	1 (0.6%)	0	4 (2.6%)

Note: AHS: α-haemolytic streptococci, CNS: coagulase-negative staphylococci, NHS: non-haemolytic streptococci. Methicillin-resistant *Staphylococcus aureus*, *Burkholderia cepacia* and Mycobacteria were not isolated from any test.

within the lung function unit immediately after collection to assess if a delay of 2 h caused any potential growth to go undetected. No significant differences were found between the samples inoculated in the lung function unit and in the bacteriology laboratory.

Discussion

The results of the study demonstrate significant removal of micro-organisms carried in exhaled breath by bacterial/viral filters during routine lung function assessment. All pathogenic isolates passed onto the filter were from CF and Bx patients. As part of clinical visit, 35 subjects provided sputum samples 24 h pre- or post-lung function testing. All subjects who grew pathogens on the filter itself were also positive in their sputum sample and therefore if a filter had not been used transmission onto equipment would have occurred. Recent recommendations for infection control in CF outline care should be taken regardless of microbiology results.[7] In accordance with such guidelines findings from the present study suggest that around 10% of the CF/Bx group transmitted pathogens onto the filter. This supports previous data from Leeming et al.[8] and reflects the large numbers of bacteria that frequently colonise the respiratory tract of these patients.

Pathogens such as *Haemophillus influenzae*, *Streptococcus pneumoniae* and *Moraxella catarrhalis* were not isolated from filters of the Infectious group. This may be due to the excessive growth of *Bacillus* species on the filter material. Filter samples (40%) grew a background level of *Bacillus* spores. Ten filters packaged as sterile (Spiroguard 2800/01S, Air Safety Limited, UK) were sampled and grew no *Bacillus* spp. Due to the rapid growth characteristics of *Bacillus* spp., it seems reasonable to suggest that overgrowth of this organism in broth culture may have obscured that of more fastidious respiratory pathogens.

The Infectious group, due to their significant lung function impairment with predominantly low expiratory flow rates, may have reduced the number of pathogens isolated, which was lower than expected. The environment of the filter itself, which involves hydrostatically charged polymers is not conducive to bacterial growth, potentially underestimating bacterial load onto the equipment. However, the rapid transfer to the microbiology laboratory that we performed makes it likely that this was a less important factor. It is possible that bacteria may have been held on the filter and not transmitted to the broth media.

CNS colonies (1.3%) were identified on the Distal side. This was most probably artefactual. CNS growth was not found on the Proximal side of the affected filters suggesting origins in collection or analysis. This could possibly be due to inadvertent mishandling of the samples by laboratory staff or by patients. Unpublished data collected from this unit over 7 years has only shown environmental growth such as *Staphlycoccus epidermidis* (a CNS species) from equipment on the distal side of filters. No pathogens have ever been grown on the distal port.

Future investigations may wish to isolate infectious groups and directly compare sputum growth with bacterial load onto equipment. A study into the filter environment may also be useful, perhaps introducing a known bacterial load and observing growth patterns. An additional study group that performs lung function without a filter may show differences in growth patterns between filters and equipment itself.

It is widely recognised that respiratory testing equipment is not sterile[9] and that exposure to normal levels of environmental organisms during testing poses no greater risk than being in other public areas.[5] However, we use bacterial/viral filters on all subjects performing tests within the department, because we presuppose that anyone may be 'potentially' infectious irrespective of clinical information provided. In addition, we disinfect relevant equipment on a regular basis and always when a patient is known to be infectious in order to provide ultra clean conditions. This study demonstrates that pathogenic bacteria such as *P. aeruginosa* and *S. aureus* could pass onto equipment if filters are not used.

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