Resolution of a *Pseudomonas aeruginosa* outbreak in a hematology unit with the use of disposable sterile water filters

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We observed a significant increase of *Pseudomonas aeruginosa* bacteremias during 2002. Eighty-five microbiological samples were taken from different potential sources of infection. Twenty-nine out of 46 specimens obtained from water taps, shower heads and siphons tested positive for *Pseudomonas aeruginosa*. Weekly pharyngeal and rectal swabs in high risk patients, use of tap water after running the tap for at least 5 minutes and use of weekly disposable sterile filters in all taps and showers resulted in a significant decrease in *Pseudomonas aeruginosa* bacteremias. Moreover, we observed a significant reduction in *Pseudomonas aeruginosa*-positive surveillance cultures after implementation of these measures.

Key words: *Pseudomonas aeruginosa*, sterile water filters, nosocomial pathogens, infections in neutropenic patients.

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Pseudomonas aeruginosa is one of the most common nosocomial pathogens in intensive care and oncol-hematology units and represents an important cause of mortality and morbidity.[1] Several *P. aeruginosa* outbreaks have been linked to contaminated tap water,[2,3] medical devices[4-7] and surface cleaning equipment.[8] Over a short period of time we observed an unusually high number of *Pseudomonas aeruginosa* positive bacteriemias in one of our care units. We report our experience and the procedures employed to resolve the problem.

Design and Methods

Since 1993 we have monitored blood cultures performed in our units. The criterion for performing blood cultures is a temperature >38.5°C or 38°C twice within 12 hours in patients with severe neutropenia (neutrophil count < 500/μL). Environmental samples were taken from various surfaces, devices, water taps, shower heads and siphons using sterile swabs and were analyzed by culture assays. The assays were performed using media selective for *P. aeruginosa* (Pseudomonas selective agar Biolife, Italy) and the inoculated plates were incubated at 37°C for 48 hours. All bacteria grown under these conditions were counted as presumptive *P. aeruginosa*, and confirmed to be such by API 20 NE (Biomèieux Industry, France). Air samples (500 μL) were collected by an RCS High Flow Air Sampler (Biotest), using an agar strip selective for *P. aeruginosa*. Surveillance cultures of samples taken with pharyngeal and rectal swabs were performed on all patients at admission and subsequently once weekly during their hospital stay, in the period from 4 months before to 9 months after the introduction of the corrective measures. The corrective measures were:

i) surveillance cultures including pharyngeal and rectal swabs, performed weekly in high-risk patients;

ii) flushing taps for at least 5 minutes before using the water in them;

iii) use of sterile filters validated for *P. aeruginosa* retention (Pall Medical, UK) in shower heads and water taps and weekly replacement of these filters.

Pall-Aquasafe disposable water filters retain *Brevundimonas diminuta* in laboratory liquid microbial challenge tests for 0.2 μm sterilizing grade filters (challenge level $\geq 10^7$ colony-forming units/cm^2). The use of sterile filters on shower heads and water taps was implemented in the Care Unit from November 2002.

Comparisons were made between data accrued in 2001 vs 2002 and 2002 vs 2003. Proportions were compared by using χ^2 tests with a continuity correction or Fisher's exact test when appropriate. Two-sided significance was used for all the statistical analyses.

Results and Discussion

In 2002, a high incidence of *P. aeruginosa* bacteremia was observed in one of our Care Units. In June 2002, infection control personnel took environmental samples from eight different water taps in two bath-

Table 1. Blood cultures performed from 2001 to 2004.

	2001	2002	2003	2004
Number of patients	387	486	514	546
Total number of blood cultures	824	1478	1445	1479
Number of positive blood cultures	236	330	258	402
Number of blood cultures positive for *P. aeruginosa*	19	61	7	11
p: 2001 *vs* 2002	0.001	*p*: 2002 vs 2003	0.0001	

Table 2. Results of sampling performed to determine possible sources of *Pseudomonas aeruginosa* infection.

Sample Site	*Total samples*	*Positive samples*
Detergent solution	4	0
Air	11	0
Bathroom door handle	6	0
Water siphon tank	6	0
Toilet seat	6	0
Toilet flush handle	6	0
Water tap, shower, trap*	*46	*29
Total	85	29
*Total**	**46 samples*	**29 positive*
Sink tap	11	4
Ink trap	11	9
Bidet tap	6	4
Bidet trap	6	5
Shower head	6	3
Shower trap	6	42

Table 3. *In vitro Pseudomonas aeruginosa* sensitivity.

No. of samples	*17*	*1*	*2*	*8*	*1*
Amikacin	S	S	S	I	S
Aztreonam	S	S	S	S	S
Ceftazidime	S	S	S	S	S
Ciprofloxacin	S	S	R	R	R
Gemtamicin	S	I	R	R	R
Imipenem	S	S	S	S	S
Mezlocillin	S	R	S	S	R
Tica.+ clav acid	S	S	S	S	R
Pipera.+Tazobactam	S	S	S	S	S

S: sensitive; I: intermediate; R: resistant.

rooms used by eight patients. *P. aeruginosa* was isolated from one of the eight samples (300 colony-forming unit/mL). These data did not suggest that water was responsible for the *P. aeruginosa* infections observed. However, after two months the *P. aeruginosa* outbreak worsened and more extensive sampling was performed to determine the possible source of infection. Internal pipe line Biofilm was analyzed from different sites (Table 2). Twenty-nine out of 85 specimens tested positive for *P. aeruginosa*. It should be noted that all 29 positive specimens were collected from 46 peripheral water network outlets (Table 2). In 17 of the 29 positive specimens *P. aeruginosa* was sensitive, *in vitro,* to antibiotics (Table 3).

From November 2002, after sterile water filters were introduced, the incidence of *P. aeruginosa*-positive blood cultures dropped significantly (Table 1). Nine of 169 pharyngeal swabs, 8/166 rectal swabs, 2/570 pharyngeal swabs and 5/563 rectal swabs resulted positive for *P. aeruginosa* before and after implementation of corrective measures (p=0.0001 and 0.0008 for pharyngeal and rectal swabs, respectively).

The potential for serious hospital-associated infection with *P. aeruginosa* in immunocompromised patients is well recognized.[9-11] Several *P. aeruginosa* outbreaks have been linked with contaminated tap water,[2,3] surfaces of medical devices[5-7,12] and surface cleaning equipment.[8] Although colonization by *P. aeruginosa* frequently precedes overt infection,[13] the original source and the precise mode of transmission are often unclear. Some authors have suggested that endogenous colonization occurs rather than exogenous nosocomial acquisition.[14-16]

However, the environment has been clearly shown to be a source of *P. aeruginosa* infections and to be involved in horizontal transmission.[17] Bertrand reported data from intensive care units (ICU) demonstrating that approximately 50% of *P. aeruginosa* carriage or colonization/infection was acquired via cross-transmission. He concluded that cross-colonization seems to play an important role in the general spread of *P. aeruginosa* in ICU.[18] Recently Trautmann and Reuter showed the importance of tap water as source of infection for *P. aeruginosa* in an ICU and a surgical ICU, respectively, because the same *P. aeruginosa* genotype was found both in the colonized patients and in tap water outlets, confirmed by polymorphic DNA-polymerase chain reaction (PCR) analyses.[19,20]

We report a *P. aeruginosa* outbreak observed in one of our Care Units in which severely neutropenic patients with hematologic diseases were admitted. The microbiological surveillance of environmental surfaces was negative while 29 out of 46 specimens from taps and

traps, bidet taps, bidet and shower traps and shower heads resulted positive for *P. aeruginosa*, supporting the significant role of water as a source of contamination.

Unfortunately, we were unable to perform a genotype study by PCR. Among these 29 positive specimens, 12 were resistant to ciprofloxacin and gentamicin and therefore antibiotic prophylaxis or treatment against *P. aeruginosa* infections was likely to have been compromised. Contaminated water could have played a central role in two different ways: by generation of a biofilm containing *P. aeruginosa* in the pipe work and consequently transmission to patients, and/or by *P. aeruginosa* contaminated aerosols generated during washing colonized or infected patients.[16,18]

The use of *Pall-Aquasafe* disposable water filters with a 0.2 μm validated membrane on taps and shower heads of Care Unit bathrooms significantly reduced *P. aeruginosa*-positive bacteremias and contributed to the control of the *P. aeruginosa* outbreak. This improvement was associated with a significant decrease of pharyngeal and rectal swabs found to be positive for *P. aeruginosa*.

Weekly replacement of disposable sterile filters resulted in an increase of annual costs, but contributed to reducing the morbidity from *P. aeruginosa*, antibiotic consumption and time spent in hospital.

NV, MBG, CQ, PR: conception of the study, data analyses and interpretation, manuscript writing; MABS, AN, PG, SG: collected the data and contributed to describe the microbiological methods; MF, AdV: performed statistical analyses; MB: finally revised the manuscript and gave the approval to the submission.

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