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Should electronic faucets be used in intensive care and hematology units?

Received: 12 April 2005
Accepted: 15 September 2005
Published online: 15 October 2005
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Abstract *Objective:* To compare bacterial contamination associated with electronic faucets and manual faucets in wards admitting patients highly susceptible to infection. *Design:* Water samples from electronic faucets and manual faucets were taken according to the French recommendations on water surveillance in healthcare settings. *Setting:* Hematology and intensive care units (ICUs) of a 900-bed university hospital and a 500-bed general hospital. *Measurements and results:* Overall 227 water samples were collected, 92 from electronic faucets and 135 from manual faucets. Thirty-six (39%) of the water samples from electronic faucets and 2 (1%) from manual faucets yielded pathogenic bacteria. In hematology wards 17 (30%) samples from electronic faucets and 2 (2%) from manual faucets were contaminated. In ICUs 19 (53%) samples from electronic faucets and none of 48 from manual faucets were contaminated. All samples were con-

taminated with various strains of *Pseudomonas aeruginosa* (8 to >100 CFU/100 ml). Despite hyperchlorination the electronic faucets remained contaminated. Replacing the contaminated electronic faucets by manual faucets led to a complete and sustained elimination of bacterial contamination. Contamination was not associated with a particular brand of electronic faucets. *Conclusions:* Our findings demonstrate that electronic faucets are significantly more frequently contaminated than manual faucets and could be a major reservoir for *P. aeruginosa*. Wards admitting patients highly susceptible to infection and using electronic faucets should be aware of this potential threat. Moreover, units already equipped with these devices, should check water quality periodically.

Keywords Faucet · Water contamination · *Pseudomonas aeruginosa* · Intensive care unit · Hematology

Introduction

No-touch faucets are becoming very common in hospitals to lower water consumption and to optimize hand washing technique. The no-touch technique of drawing water prevents recontamination of healthcare workers hands, which seems an obvious advantage in wards admitting patients highly susceptible to infection, such as hematology and intensive care units (ICU). However, there are no

studies to support a decrease in nosocomial infection or colonization rates with the use of these devices. On the other hand, technical characteristics of electronic faucets might lead to heavy contamination of the device, and previously published reports have presented conflicting results on this [1, 2, 3, 4, 5, 6]. Figure 1 demonstrates the technical characteristics of an electronic faucet. It is important to determine whether electronic faucets represent a potential reservoir of pathogenic bacteria, particularly in

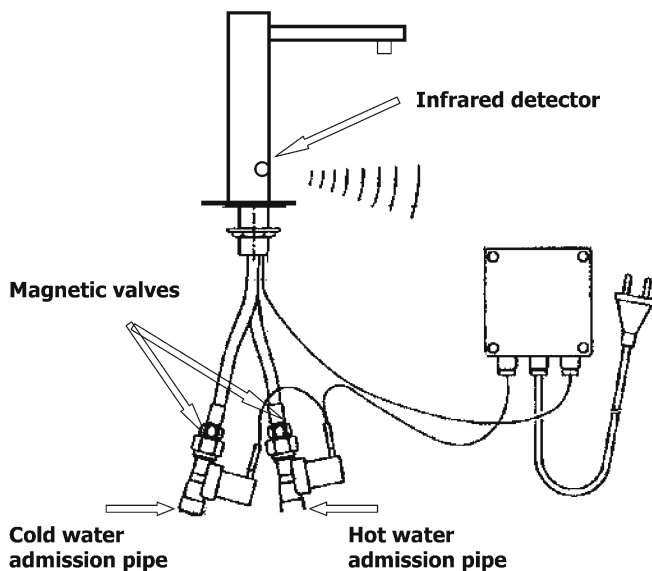


Fig. 1 Diagram of an electronic faucet

areas receiving patients highly susceptible to infection.

This study compared bacterial contamination associated with electronic faucets and manual faucets in hematology and ICUs. The findings have been presented in part at the Société de Réanimation de Langue Française Annual Conference in 2005 [7].

Methods

The study was performed in the hematology ward and ICUs of two French hospitals in the suburbs of Paris, France. Hospital A is a 900-bed university hospital with a 32-bed hematology ward, a 26-bed medical ICU, and a 10-bed surgical ICU; hospital B is a 500-bed general hospital with a 18-bed neonatal ICU and a 16-bed medicosurgical ICU. Two units (18 beds) of the hematology ward were equipped with positive pressure rooms to admit patients undergoing bone marrow transplantation. In hospital A the ICUs and the hematology ward were supplied with water through two different closed loop water circuits. Hot water at 60°C was produced in two different tanks located in the hospital basements. In hospital B the ICUs were located in different wings. For each wing hot water at 60°C was provided by a specific plate heat exchanger to a closed loop water circuit. In both hospitals the temperature of the hot water measured from the manual faucets ranged from 50° to 57°C and the cold water temperature from 12° to 15°C. No thermal or hyperchlorinated shock was performed during the study period. No online water filters were installed. Continuous chlorination was administered in the hot water distribution system of both hospitals throughout the study period. Faucet aerators were scaled every month in

hospital B ICUs and replaced yearly or after renovation in hospital A.

Water samples from manual and electronic faucets were collected routinely in hospital A between January 2003 and June 2004 and in hospital B between May and July 2004. At each sampling we recorded faucet type and brand and the specific location of the faucet in the ward. Three different brands of electronic faucets were installed (one in hospital A and two in hospital B), all equipped with temperature selection system. Water samples were collected following removal of the faucet aerator, disinfection of the faucet nose with 70° alcohol, and flushing by running the water for 1 min. Samples were collected aseptically in sterile 500-ml bottles containing sodium thiosulfate to neutralize chlorine disinfectants.

Microbiological examinations were performed according to French regulations on quality of water for human consumption [8, 9]. Each water sample (100 ml) was processed by membrane filtration. Trypticase-soja agar was used to screen for aerobic flora, TTC-Tergitol 7 agar to screen for fecal coliform, and cetrimide agar to detect *Pseudomonas aeruginosa*. Water samples were not cultured for *Legionella* detection. Bacterial contamination was established if at least one of the following criteria was met: water sample with more than 100 colony-forming units (CFU) per milliliter of aerobic flora at 22°C and 36°C and detection of fecal coliform bacteria or *P. aeruginosa* in 100 ml water. Bacterial contamination proportions were compared by the χ^2 test or Fisher's exact test as appropriate. Differences with a *p* value less than 0.05 were considered significant.

When bacterial contamination was established, decontamination was performed using a 100 mg/l sodium hypochlorite solution injected through a recirculation pump plugged to water distribution system of the faucet. The decontamination lasted 1–2 h and then the faucet was abundantly rinsed. After each decontamination procedure a control sample was collected.

Results

A total of 227 water samples were collected: 92 from electronic faucets and 135 from manual faucets. Electronic faucets were found significantly more frequently to harbor bacterial contamination than manual faucets, regardless of the ward and the hospital (Table 1). In the hematology ward 17 (30%) samples from electronic faucets and 2 (2%) from manual faucets were contaminated ($p < 0.0001$). In ICUs 19 (53%) samples from electronic faucets and none of 48 from manual faucets were contaminated ($p < 0.0001$). In one ICU four sinks were equipped with both types of faucets (to allow nurses to wash the patients with hot water) and with the same incoming water. Three of four electronic faucets were contaminated and none of the manual faucets. The con-

Table 1 Bacterial water contamination of electronic and manual faucets according to hospitals and wards. Results are presented as number of contaminated samples/number of samples tested unless otherwise indicated

	Electronic faucets	Manual faucets	<i>p</i>
Hospital A	19 (29%)	2 (2%)	<0.0001
Medical-surgical ICUs	2/9	0/27	
Hematology ward	17/56	2/87	
Hospital B	17 (63%)	0	<0.0001
Neonatal ICU	10/14	0/13	
Medicosurgical ICU	7/13	0/8	
Total	36 (39%)	2 (1%)	<0.0001

tamination was not associated with a particular brand of electronic faucets. *P. aeruginosa* was found in all contaminated faucets, ranging from 8 to more than 100 CFU/100 ml; 29% were heavily contaminated (>100 CFU/100 ml). Serotype O10 was preponderant but others (O1, O4, O6, O11) were also isolated in both hospitals. Two or three different serotypes were usually found in the same ward. No other nonfermentative bacteria or fecal coliform bacteria was detected.

One or two successive hyperchlorination procedures were necessary to temporarily achieve faucets decontamination in both hospitals. Once in hospital A (hematology ward) an electronic faucet remained heavily contaminated with *P. aeruginosa* despite two successive decontaminations. In the neonatal ICU of hospital B three electronic faucets still harbored *P. aeruginosa* 4–12 days after hyperchlorination. Of note, the incoming water of these three faucets was sampled and showed no contamination. Contamination was recurrent in electronic faucets as found in samples collected monthly in the hematology ward of hospital A. Complete and sustained disappearance of the bacterial contamination in both hospitals was observed only after the replacement of contaminated electronic faucets by manual faucets.

Discussion

This study demonstrates that electronic faucets are contaminated significantly more frequently with *P. aeruginosa* than manual faucets in wards admitting patients with high susceptibility to infection. This is the largest study performed in high-risk areas in the literature. In addition, despite hyperchlorination the electronic faucets remained contaminated, and only the replacement of contaminated electronic faucets by manual faucets led to sustained disappearance of the contamination. The main limitation is that our study was the result of routine controls rather than randomized. However, there is no evidence of selection bias among the faucet groups. Samples came from selected units admitting the same types of patients and the maintenance procedures were the same for electronic

faucets and manual faucets. In addition, the results were identical and statistically highly significant in ICU and hematology wards separately.

Electronic faucets are being marketed as a means to improve hand hygiene. However, no study has yet been published to support this. Previous reports have noted that the technical characteristics of these devices can lead to contamination of the faucets. Our results are in agreement with most of these previous studies. Halabi et al. [3] demonstrated that ten electronic faucets without temperature selection were heavily contaminated with *P. aeruginosa* and *Legionella* spp., whereas none of ten manual faucets adjacent to the no-touch faucets were contaminated by *P. aeruginosa* and only three with *Legionella* spp. In a study performed in the intensive care setting [4] Hargreaves et al. found 11 (32%) of 34 electronic faucets of a particular brand contaminated and 12 (11%) of 110 manual faucets contaminated ($p < 0.006$) whereas there was no difference between another brand of faucets and conventional ones. Another study observed no difference between 18 electronic faucets and 18 manual faucets tested randomly throughout a 200-bed teaching hospital [1]. Finally, in the most recent study [2] microbiological examination of 27 electronic faucets recently installed in a hospital kitchen revealed persistent *P. aeruginosa* and high bacteria count during the 6-month period of observation. Electronic faucets were removed and replaced by conventional elbow-operated faucets. No further contamination of the conventional faucets was observed.

Although both types of faucets may have become colonized initially by healthcare workers' hands or by upward splashes from contaminated sinks [10], the major reasons mentioned in the previous studies [2, 3, 4] to explain the persistent contamination of electronic faucets are: (a) due to the water-saving function of electronic faucets the low amount of water that flows through the outlet is unable to clean it, (b) the remaining column of water in the faucet has a temperature of about 35°, providing nearly ideal growth conditions for *P. aeruginosa*; and (c) the magnetic valve is made of rubber, plastic, and polyvinylchloride membranes, materials very likely to favor *P. aeruginosa* biofilms, which are very difficult to remove with disinfectants (see Fig. 1). Another possible reason is that flushing out electronic faucets is more difficult in practice than manual faucets when necessary, for example, after a long period of nonuse.

Although not demonstrated specifically for electronic faucets, the link between contamination of sinks or faucets with *P. aeruginosa* and outbreaks is well documented [10, 11, 12, 13], and the contribution of water to nosocomial transmission of antibiotic-resistant *P. aeruginosa* has recently been reviewed [14]. In our study the occurrence of *P. aeruginosa* infections was not specifically surveyed in the participating units. However, the relationship between faucet contamination and endemic *P. aeruginosa* colonization or infection in the critically ill patients has been

demonstrated in two recent studies. Trautmann et al. [15] reported that over a 7-month study period 29% of patients infected with *P. aeruginosa* harbored the same genotype detectable in the faucet of the patient's room. In a study performed in five different ICUs Blanc et al. [16] found that 42% of the colonized/infected patients with *P. aeruginosa* harbored strains which were genotypically identical to those recovered from the faucets of the ICUs. These studies suggest that the water system of the ICUs was the primary reservoir of patient's colonization with *P. aeruginosa* in a substantial proportion of cases. Although terminal tap water filtration could be used in outbreaks related to water contamination [15] or to prevent nosocomial legionellosis in high-risk units, routine use of these devices is expensive and needs a rigorous maintenance [17]. Therefore whenever possible it seems better to avoid contamination of faucets by *P. aeruginosa* which is an

important nosocomial pathogen causing serious infections and high mortality rates in patients who are mechanically ventilated or severely immunocompromised [18, 19].

Our findings thus suggest that electronic faucets are a major reservoir for *P. aeruginosa*. Wards admitting patients highly susceptible to infection and using electronic faucets should be aware of this potential threat. Moreover, units already equipped with these devices should check water quality periodically. Persistent contamination of electronic faucets despite hyperchlorination and change of faucet aerator should lead to prompt replacement of electronic faucets by conventional faucets. In addition, considering the unknown actual benefit of electronic faucets use on nosocomial infection rates with the risk of bacterial contamination, recommending their installation should be made cautiously. In our hospitals we have withdrawn electronic faucets from ICUs and hematology units.

References

- Assadian O, El-Madani N, Seper E, Mustafa S, Aspöck C, Köller W, Rotter ML (2002) Sensor-operated faucets: a possible source of nosocomial infection? *Infect Control Hosp Epidemiol* 23:44–46
- Chaberny IF, Gastmeier P (2004) Should electronic faucets be recommended in hospitals? *Infect Control Hosp Epidemiol* 25:997–1000
- Halabi M, Wiesholzer-Pittl M, Schoberl J, Mittermayer H (2001) Non-touch fittings in hospitals: a possible source of *Pseudomonas aeruginosa* and *Legionella* spp. *J Hosp Infect* 49:117–121
- Hargreaves J, Shireley L, Hansen S, Bren V, Fillipi G, Lacher C, Esslinger V, Watne T (2001) Bacterial contamination associated with electronic faucets: a new risk for healthcare facilities. *Infect Control Hosp Epidemiol* 22:202–205
- Leprat R, Denizot V, Bertrand X, Talon D (2003) Non-touch fittings in hospitals: a possible source of *Pseudomonas aeruginosa* and *Legionella* spp. *J Hosp Infect* 53:77
- Mee-Marquet N van der, Bloc D, Briand L, Besnier JM, Quentin R (2005) Non-touch fittings in hospitals: a procedure to eradicate *Pseudomonas aeruginosa* contamination. *J Hosp Infect* 60:235–239
- Merrer J, Girou E, Ducellier D, Clavreul N, Cizeau F (2005) Faut-il utiliser des robinets à cellule photoélectrique dans les services de réanimation? Presented at the 23rd Congress of the Société de Réanimation de Langue Française, Paris, S192
- Ministère de la Santé (2001) Décret n°2001–1220 du 20 décembre 2001 relatif aux eaux destinées à la consommation humaine, à l'exclusion des eaux minérales naturelles. *J Off République Française* 20381–20399
- Ministère de la Santé (2003) Arrêté du 17 septembre 2003 relatif aux méthodes d'analyse des échantillons d'eau et à leurs caractéristiques de performance. *J Off République Française* 19027–19033
- Reuter S, Sigge A, Wiedeck H, Trautmann M (2002) Analysis of transmission pathways of *Pseudomonas aeruginosa* between patients and tap water outlets. *Crit Care Med* 30:2222–2228
- Bert F, Maubec E, Bruneau B, Berry P, Lambert-Zechovsky N (1998) Multi-resistant *Pseudomonas aeruginosa* outbreak associated with contaminated tap water in a neurosurgery intensive care unit. *J Hosp Infect* 39:53–62
- Bukholm G, Tannaes T, Kjelsberg AB, Smith-Erichsen N (2002) An outbreak of multidrug-resistant *Pseudomonas aeruginosa* associated with increased risk of patient death in an intensive care unit. *Infect Control Hosp Epidemiol* 23:441–446
- Ferroni A, Nguyen L, Pron B, Quesne G, Brusset MC, Berche P (1998) Outbreak of nosocomial urinary tract infections due to *Pseudomonas aeruginosa* in a paediatric surgical unit associated with tap-water contamination. *J Hosp Infect* 39:301–307
- Muscarella LF (2004) Contribution of tap water and environmental surfaces to nosocomial transmission of antibiotic-resistant *Pseudomonas aeruginosa*. *Infect Control Hosp Epidemiol* 25:342–345
- Trautmann M, Michalsky T, Wiedeck H, Radosavljevic V, Ruhnke M (2001) Tap water colonization with *Pseudomonas aeruginosa* in a surgical intensive care unit (ICU) and relation to *Pseudomonas* infections of ICU patients. *Infect Control Hosp Epidemiol* 22:49–52
- Blanc DS, Nahimana I, Petignat C, Wenger A, Bille J, Francioli P (2004) Faucets as a reservoir of endemic *Pseudomonas aeruginosa* colonization/infections in intensive care units. *Intensive Care Med* 30:1964–1968
- Vonberg RP, Eckmanns T, Bruderek J, Ruden H, Gastmeier P (2005) Use of terminal tap water filter systems for prevention of nosocomial legionellosis. *J Hosp Infect* 60:159–162
- Valles J, Mesalles E, Mariscal D et al (2003). A 7-year study of severe hospital-acquired pneumonia requiring ICU admission. *Intensive Care Med* 29:1981–1988
- Chastre J, Fagon JY (2002) Ventilator-associated pneumonia. *Am J Respir Crit Care Med* 165:867–903