Removal of waterborne pathogens from liver transplant unit water taps in prevention of healthcare-associated infections: a proposal for a cost-effective, proactive infection control strategy

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Abstract

Hospital water supplies often contain waterborne pathogens, which can become a reservoir for healthcare-associated infections (HAIs). We surveyed the extent of waterborne pathogen contamination in the water supply of a Liver Transplant Unit. The efficacy of point-of-use (POU) water filters was evaluated by comparative analysis in routine clinical use. Our baseline environmental surveillance showed that *Legionella* spp. (28%, 38/136), *Pseudomonas aeruginosa* (8%, 11/136), *Mycobacterium* spp. (87%, 118/136) and filamentous fungi (50%, 68/136) were isolated from the tap water of the Liver Transplant Unit. 28.9% of *Legionella* spp.-positive water samples ($n = 38$) showed high-level *Legionella* contamination ($\geq 10^3$ CFU/L). After installation of the POU water filter, none of these pathogens were found in the POU filtered water samples. Furthermore, colonizations/infections with Gram-negative bacteria determined from patient specimens were reduced by 47% during this period, even if only 27% (3/11) of the distal sites were installed with POU water filters. In conclusion, the presence of waterborne pathogens was common in the water supply of our Liver Transplant Unit. POU water filters effectively eradicated these pathogens from the water supply. Concomitantly, healthcare-associated colonization/infections declined after the POU filters were installed, indicating their potential benefit in reducing waterborne HAIs.

Keywords: Healthcare-associated infection, hospital water supply, infection control, POU water filter, waterborne pathogens
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Introduction

Hospital water supplies have served as reservoirs for waterborne pathogens such as *Legionella* spp., *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia*, *Acinetobacter* spp., *Mycobacterium* spp. and fungi [1–5]. The degree of the colonization in water supplies has been correlated with the incidence of healthcare-associated infections (HAIs) [6,7]. Forty-two per cent of ICU patients with *Pseudomonas aeruginosa* harbored isolates with identical genotypes to those found in the taps [8]. Water supplies were recognized as one of the most important and controllable, and yet the most overlooked, sources of HAIs [1,2].

Despite water treatment with chlorination, domestic water supplies may still be contaminated by low concentrations of various microorganisms [9]. Although most of the microorganisms are not harmful to the general public, some opportunistic pathogens pose threats to hospitalized patients. In China, the waterborne pathogen contaminations of water supplies have often been overlooked. In fact, the European Working Group for Legionella Infections (EWGLI) reported in 2009 that China was one of the top 15 countries implicated in cases of travel-associated Legionnaires' disease [10]. In a study of eight hospital water supplies in Shanghai [11], 43.0% (83/193) of water samples were positive for *Legionella* spp., and 63 water samples exceeded the concentration of 10^3 CFU/L. So, we sought to determine if waterborne pathogens were present in the water supply of our hospital, especially in the Liver Transplantation Unit (LTU), where the patients are most susceptible to opportunistic infections. Furthermore, could removal of these waterborne pathogens reduce the incidence rate of hospital-acquired infections in the LTU? Thus, we performed an infection control intervention by: (i) investigating the baseline frequency of waterborne pathogens in the water supply of the LTU, and (ii) evaluating the efficacy of point-of-use (POU) water filters in removing waterborne pathogens. To our knowledge, this is the first environmental surveillance of waterborne pathogens in a hospital water supply in China.

Materials and Methods

Study site

This study was performed in an 18-bed LTU of a university-affiliated general hospital with 1600 beds in Shanghai, China. The Unit consists of nine patient rooms (two patient beds and one sink/tap in each room), one nurses' station and one doctor's office. The hospital receives its water from a municipal water treatment plant without additional on-site disinfection.

Study design

Cold tap water samples were collected between 2009 and 2011 (June, September and October in 2009, January, July, August, September, October and November in 2010, and March in 2011) from each tap outlet in sterile containers with 0.01% w/v sodium thiosulphate.

Three taps located in one patient room, the nurses' station and the doctor's office were installed with 0.2 μm POU filters (AQ14F1S, Pall Corp., Port Washington, NY, USA) for removal of the waterborne pathogens (Fig. 1). A pre-filtration fixture (pore size, 1.2 μm) was also installed for capturing particulate debris to extend the life of the POU filter. Filters were changed every 2 weeks according to the manufacturer's instructions from July to November 2010 (18 weeks), and water samples were collected and cultured every 3–4 days. The unfiltered tap water sample served as the control, while the water filtered through the pre-filter alone served as the pre-filtered water control. We picked the doctor's office and nurses' station for installation so that all medical staff had access to filtered (pathogen-free) water before and between patients' care.

FIG. 1. Tap installed with POU water filter and pre-filtration fixture.

The incidence of Gram-negative bacteria colonization/infection in the LTU was also monitored. We analyzed patient-related data for the same 4-month period before the installation of the water filters (from July to November 2009) and a corresponding 4-month period after outlets had been equipped with filters (from July to November 2010). Patient data were retrieved from the hospital surveillance system. Microbiological cultures from patients were performed only when clinically indicated. No additional control measures were carried out during this period.

Microbiological analysis

Total heterotrophic plate count (HPC) bacteria, cultured on R_2A agar (Oxoid, Basingstoke, UK) at 25°C for 14 days, were enumerated by the standard pour plate method [12]. *Legionella* spp. was monitored using GVPC selected agar (Oxoid) according to ISO 11 731 [13]. Colonies morphologically consistent with *Legionella* spp. were identified by the latex agglutination test (Oxoid). For *Pseudomonas aeruginosa*, filamentous fungi and *Mycobacterium* spp. detection, water samples were filtered (pore size of 0.45 μm, Millipore, USA) and the filter membrane was placed on Cetrimide agar plates, Sabouraud dextrose agar plates containing 25 mg/L penicillin and 400 mg/L chloramphenicol (Oxoid) and Middlebrook 7H10 plates (BD, Franklin Lakes, NJ, USA), and incubated at 35°C for 48 h, 30°C for 28 days and 35°C for up to 8 weeks, respectively.

Statistical analyses

An ANOVA (SPSS ver. 15.0) was used to analyze the bacterial counts in POU-filtered, pre-filtered and unfiltered control samples. Comparison of the incidence of Gram-negative bacterium infection/colonization in the post-filtration period with that in the pre-filtration period was carried out by use of the chi-squared test (SPSS ver. 15.0). The correlation coefficient of temperature and the number of positive water samples were calculated by use of two-tailed Spearman's analysis.