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# Hospital-Acquired Legionnaires Disease in a University Hospital: Impact of the Copper-Silver Ionization System

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**We evaluated the impact of the copper-silver ionization system in a hospital where hyperendemic nosocomial legionellosis and was present and all previous disinfection measures had failed. After implementation of the copper-silver ionization system, environmental colonization with *Legionella* species decreased significantly, and the incidence of nosocomial legionellosis decreased dramatically, from 2.45 to 0.18 cases per 1000 patient discharges.**

Nosocomial legionellosis has been hyperendemic at the Hospital Universitari Germans Trias i Pujol (Barcelona, Spain) for many years. Previous epidemiological studies that involved chromosomal subtyping demonstrated the presence of a clone of *Legionella* species (*Legionella pneumophila* serogroup 1) in the water system of this hospital that was identical to the clone found in patients with hospital-acquired legionnaires disease (HALD) [1]. Although major efforts were made to eradicate *Legionella* species from the water system, an optimum situation was not achieved. Periodic cultures of water specimens continued to yield *Legionella* species, and cases of HALD persisted.

In September 1999, the Hospital Universitari Germans Trias i Pujol installed a copper-silver ionization system for the disinfection of the hospital's hot-water system. This system has been demonstrated to reduce *Legionella* colonization of hospital water distribution systems in several studies [2, 3]. However, few studies have been published on its effectiveness in reducing cases of HALD [4]. The hyperendemia of HALD in the Hospital

Universitari Germans Trias i Pujol and the failure of the previous disinfection measures provided a challenging opportunity to prove the efficacy of this system. The aim of this study was to investigate the impact of use of the copper-silver ionization system on environmental legionellosis and in the prevention of new cases of HALD.

**Materials and methods.** The Hospital Universitari Germans Trias i Pujol is a 630-bed university hospital with renal and bone marrow transplantation programs. During the first period of the study (January 1998 through September 1999), the disinfection system of the hot water circuit used continuous chlorination and heat-and-flush methods. The first was performed by an automatic chlorination system located between the heat exchangers and the water tanks. The thermic shocks were performed by sectors, with taps and showers turned on for 10–30 min, maintaining an exiting water temperature >60°C; this was performed every 15–30 days. Hot water temperatures were >50°C and >60°C at distal points and in the water tanks, respectively, throughout the whole period. During this period, different structural reforms were made in an attempt to eradicate the most troublesome parts of the circuit.

The second period from the study was from October 1999 through December 2004. A copper-silver ionization system (Time-Water TIL 5297; Desinfecciones Alcora) was installed on 30 September 1999, and it continued to work through the end of the period. Copper levels were measured daily in the return pipes by colorimetric analysis (optimum level, 0.2–0.5 mg/L), and silver levels were determined monthly (optimum level, 0.02–0.05 mg/L) by atomic absorption. When copper levels decreased to 0.2 mg/L, the electrodes were removed and cleaned. During this period, thermic shock was occasionally performed, and the hot water was not hyperchlorinated. Chlorine levels in the cold water were maintained at 0.3–0.8 mg/L during both periods.

*Legionella* testing was periodically performed during both periods in accordance with a method described elsewhere [1]. Four hundred seven water samples from distal points were seeded in selective modified Wadowsky Yee–buffered charcoal yeast extract– $\alpha$  agar.

Active surveillance of hospital-acquired pneumonia was performed during both periods. Patients with pneumonia were clinically evaluated by a physician from the infectious diseases unit. All patients with hospital-acquired pneumonia were tested for *Legionella* infection by urinary antigen testing and sputum culture, or representative respiratory samples were collected (whenever possible) and seeded in selective buffered charcoal

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yeast extract medium. When these tests yielded negative results, paired serum samples were obtained for serologic testing.

The diagnosis of pneumonia due to *L. pneumophila* was based on the presence of the following characteristics: isolation of *L. pneumophila* from respiratory samples, a 4-fold increase in antibody titers to >1:128 in paired serum samples, or positive results of a urinary antigen test. Nosocomial legionnaires pneumonia was defined in accordance with Centers for Disease Control and Prevention criteria [5].

**Results.** During period 1, continuous chlorination was unsuccessful in maintaining minimum free chlorine levels at peripheral and return points. Therefore, chlorine levels in the sections close to the automatic chlorator were very high, with corrosion and deterioration of these sections occurring early, producing a considerable increase in the number of repairs required.

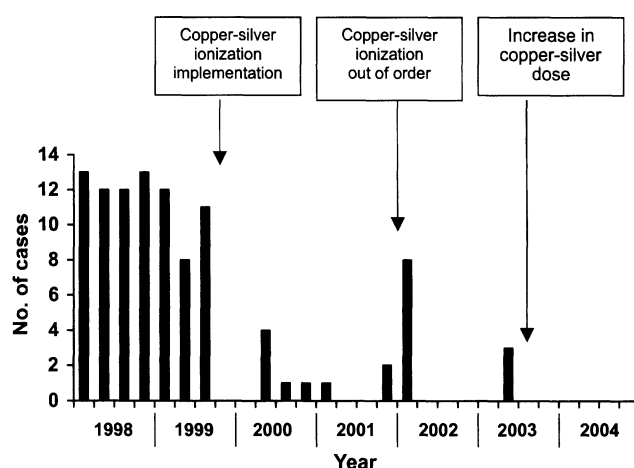
The copper and silver levels were maintained at 0.1–0.3 mg/L and at 0.01–0.03 mg/L, respectively, during the period from September 1999 through May 2003, respectively. However, the system was out of order because of technical problems in February and March 2002. To maintain copper and silver ion levels >0.3 mg/L and >0.03 mg/L, ionization was increased in May 2003.

Three environmental studies were performed during period 1, and 51 (57.3%) of 89 samples tested positive for *L. pneumophila* serogroup 1. The mean colony count was 11,972 CFU/L (range, <50 to 24,900 CFU/L). Thermic shock was performed every 15 days because of rapid recolonization after this procedure.

Twenty-one environmental studies were performed during period 2 up to April 2003, and 48 (20.9%) of 230 samples tested positive for *L. pneumophila*, and most isolates belonged to serogroup 1. The mean colony count was 758 CFU/L (range, <50 to 21,000 CFU/L). Of the samples obtained during February and March 2002, when the system was out of order, 67% tested positive for *Legionella* species. Three more environmental studies were performed after May 2003, after ion levels had been increased, and 14 (15.9%) of 88 samples tested positive for *L. pneumophila*. In this period, *L. pneumophila* serogroups 2–14 were more prevalent than in the previous test period. The mean colony count was 42,982 CFU/L (range, <50 to 235,000 CFU/L).

Eighty-two cases of HALD (2.45 cases per 1000 patient discharges) were diagnosed during period 1. Twenty cases of HALD (0.18 cases per 1000 patient discharges) were detected in period 2 (9 were sporadic cases, and 11 were associated with 2 small outbreaks). The small outbreaks of HALD happened when the copper-silver system was out of order. All cases occurred before May 2003 (figure 1). The overall mortality rate was 15.7% (16 of 102 patients).

**Discussion.** Hot water distribution systems constitute the



**Figure 1.** Number of cases of hospital-acquired legionnaires disease

main reservoir for *Legionella* species in hospitals and also represent a challenge for traditional disinfection methods. When *Legionella* colonization is demonstrated in a hospital water distribution system and when cases of HALD have been documented, strategies to minimize the problem are needed. It is essential to revise the maintenance practices and to strictly control the temperature and chlorine levels in hot and cold water, respectively. In some cases, however, the lack of control makes the application of complementary measures of disinfection necessary, with the most commonly used methods including heat-and-flush, hyperchlorination, and copper-silver ionization methods.

Heavy metals, such as copper and silver ions, are good bactericidal agents with demonstrated efficacy in reducing *Legionella* water contamination. Moreover, anecdotal experiences and controlled studies from individual or multiple hospitals have shown that they are effective for the prevention of HALD [4].

However, the endemic situation seen in our hospital, in which there were 20–50 cases of HALD per year, and the dramatic reduction in the number of cases after the implementation of copper and silver ionization has never been reported. After the detection of the first cases of HALD in our hospital at the end of the 1990s, awareness about legionnaires disease increased enormously among the medical staff, and active surveillance for nosocomial pneumonia in intensive care unit areas and hospitalization wards was implemented. This undoubtedly contributed to the high incidence of HALD in our hospital and explains the low mortality rate observed in our series, compared with other studies of HALD [6]. Strict maintenance, structural changes in the water distribution lines, and heat-and-flush and continuous chlorination methods were not effective in reducing the incidence of HALD. Although the distal outlets that yielded positive culture results would yield negative results after the heat-and-flush procedure, water recolonization was constant over time. Furthermore, the frequency of the heat-and-flush

procedure led to personnel fatigue, bad compliance, and accelerated pipe deterioration. Continuous chlorination was also ineffective in controlling *Legionella* contamination in the hot water system, because it was very difficult to achieve adequate levels throughout the whole pipe system. Moreover, water instability was further aggravated by the need to maintain hot water temperatures of >50°C. Chlorine dioxide or monochloramines, which have demonstrated some efficacy in controlling water contamination with *Legionella* species [7, 8] and are more stable in hot water temperatures, were not considered at this time.

As other authors have pointed out [2], the copper-silver ionization system has a dose-dependent effect on environmental *Legionella* colonization. The percentage of distal sites that tested positive for *Legionella* species decreased significantly with the use of this disinfection system. However, periodic sampling showed significant oscillation in positivity rates when copper and silver levels were maintained at <0.3 and <0.03 ppm, respectively. The highest percentage of positive results was observed when the system was out of order. During this short period of time, cases of HALD reappeared. When the copper and silver concentrations were increased to 0.4 and 0.004 ppm, respectively, a significant decrease was observed in *Legionella* positivity at distal points, and no cases of HALD have been documented in the past 2 years.

Our study clearly demonstrates the efficacy of the copper-silver ionization system, not only in reducing water contamination with *Legionella* species, but also in stopping a dramatic situation of endemic HALD. Moreover, this study reinforces

the need to maintain adequate bactericidal ion levels and the usefulness of the percentage of positive distal point results as a marker for the appearance of cases of HALD [9].

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**Potential conflicts of interest.** All authors: no conflicts.

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