INFEKTOL GLASN 2021;41(1):3-7
https://doi.org/10.37797/ig.41.1.1

Izvorni znanstveni rad | Original scientific paper

Preventing Healthcare-Associated Legionellosis with Rapid Reduction of High Concentrations of Legionella Using Mechanical Removal of Blind Ends and Intensive Hot Water Flushing

Sprječavanje legioneloza povezanih sa zdravstvenim sustavom brzim smanjenjem visoke koncentracije legionela uz pomoć mehaničkog uklanjanja slijepih završetaka i ispiranjem vrućom vodom

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Keywords:
prevention
Legionella pneumophila
hospital
water flow

Ključne riječi:
prevencija
Legionella pneumophila
bolnica
protok vode

Abstract

Background: The aim of this paper was to present the effectiveness of the mechanical removal of blind ends and flushing of hot water systems at outlets as the only possible emergency measures to reduce the concentration of *Legionella* spp in hot water.

Methods: Two measures have been undertaken: mechanical removal of blind ends and intensive hot water flushing when the water has not been used for more than 7 days.

Results: We detected *Legionella pneumophila* serogroup 1 in concentration of 1.000- 55.000 CFU/L at all samples sites. In the control sampling, after three weeks, we found seven sampling sites negative for Legionella and only two sampling sites positive. All nine sampling sites were negative after ten weeks.

Conclusion: Establishing good water flow throughout the hospital seems to be the most important measure, in order to make the multiplication of Legionella in the hot water distribution systems unlikely.

Primljeno: 08-09-2020
Received: 08-09-2020

Prihvaćeno: 09-10-2020
Accepted: 09-10-2020

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Sažetak

Cilj: Cilj rada je prikazati učinkovitost mehaničkog uklanjanja slijepih završetaka te ispiranja izljevnih mjesta u sustavu vrućom vodom kao jedinih mogućih hitnih mjera za smanjenje koncentracije *Legionella* spp u vrućoj vodi.

Metode: Poduzete su dvije mjere: mehaničko uklanjanje slijepih završetaka u sustavu te intenzivno ispiranje vrućom vodom u slučajevima kada se voda nije koristila duže od 7 dana.

Rezultati: *Legionella pneumophila* serogrupe 1 u koncentraciji od 1.000- 55.000 CFU/L izolirana je u svim uzorcima. Kontrolno uzorkovanje nakon tri tjedna pokazalo je sedam mjesta uzorkovanja negativna na bakteriju Legionella, a samo dva mjesta su bila pozitivna. Svih devet mjesta uzorkovanja bila su negativna nakon deset tjedana.

Zaključak: Uspostavljanje dobrog protoka vode predstavlja najvažniju mjeru za sprječavanje umnožavanja legionele u bolničkom sustavima za distribucije tople vode.

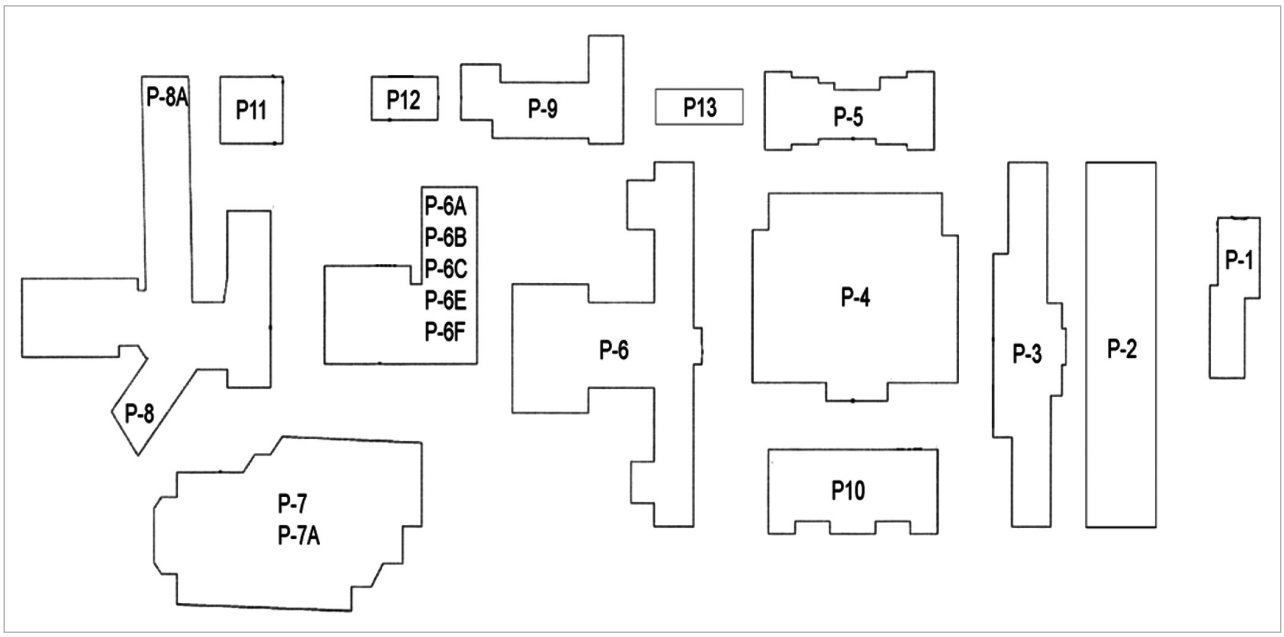
Introduction

This paper describes the contamination of the hot water system by Legionella bacteria at the Zadar General Hospital (Zadar GH) and the success of emergency measures to reduce their concentration in hospital hot water. The aim of this paper is to present the effectiveness of the mechanical removal of blind ends and flushing of hot water systems at outlets as the only possible emergency measures to reduce the concentration of *Legionella* spp in hot water.

Material and Methods

This paper describes the contamination of the hot water system by the *Legionella* spp at the Zadar GH and the success of emergency measures to reduce their concentration in hospital hot water. Only two measures have been undertaken: mechanical removal of blind ends and intensive hot water flushing when the water has not been used for more than seven days. The mechanical removal of the blind ends was carried out in all places where flushing could not be performed due to the inability to access the outlet pipe or the installation of faucets. In places where water had not been used for more than seven days, but were easily accessible or where faucets could be installed, tap water was discharged at least once a week for 1 to 2 minutes. The Zadar GH Drawing according to the department sampling sites is shown in Figure 1.

Figure 1. Zadar General Hospital Drawing according to the departments and sampling sites
Slika 1. Skica Opće bolnice Zadar s označenim odjelima i mjestima uzorkovanja



Legend/Legenda: P1- Pathology and Forensic Medicine/Patologija i forenzička medicina, **P2**- Hospital Kitchen/Bolnička kuhinja, **P3**- Outpatient Clinics/Poliklinika, **P4**- Internal Medicine, Emergency Hospital Admission/Interna medicina, Hitni bolnički prijem, **P5**- Infectology/Infektologija**, P6 (A,B, C, E, F**) - Surgery, Anesthesiology, Central Sterilization, Hemodialysis, Neurology, Psychiatry/Kirurgija, Anesteziologija, Centralna sterilizacija, Hemodijaliza, Neurologija, Psihijatrija, **P7 A**-Ophthalmology, Cytology/Oftalmologija, Citologija, **P7**- Pediatrics, Pulmonology/Pedijatrija, Pulmologija**, P8**- Neonatology/Neonatologija, **P8 A**- Gynecology and Obstetrics, Transfusion Medicine/Ginekologija i opstetricija, Transfuzijska medicina, **P9**- Urology, Otolaryngology/Urologija, Otolaringologija, **P10**- Administrative building/Upravna zgrada, **P11**- Pharmacy/Ljekarna, **P12**- Electric station/Električna stanica, **P13**- Boiler room/Kotlovnica

Sampling was carried out using sample collection standard procedures, transport and storage according to ISO standards. Cultivation and identification were performed by the cultural method according to ISO standards. The concentration of the bacteria was determined with membrane filtration using paper filter of 0.20 μm pore size (a polyamide filter, Millipore, Bedford, USA).

Colonies grown on BCYE agar with cysteine were further tested for *Legionella pneumophila* serogroup 1, serogroup 2–14 and *Legionella non–pneumophila* by the use of the agglutination test (Legionella Latex Test, Oxoid)[6-7].

Results

During a routine epidemiological survey, the Hospital Infections Control Team at the Zadar GH noticed that the hot water temperature was not satisfactory (it was from 30 to 35°C). Hot water sampling was taken at nine locations and resulted with the detection of *Lp. serogroup 1* in concentrations of 3.000-55.000 cfu/l (colony-forming unit). (Table 1)

Table 1. Legionella pneumophila serogroup 1. concentration in Zadar General Hospital hot water before and after emergency measures

Tablica 1. Koncentracija Legionella pneumophila serogroupe 1 u vrućoj vodi Opće bolnice Zadar prije i nakon primjene hitnih mjera

Site code	Sampling site	Measures taken			
		a) Routine surveillance-low hot water temperature detected (October 10th)	c) Removal of blind ends and intensive flushing (November 15th)	e) Additional removal of blind ends and intensive flushing (December 20th)	g) Additional removal of blind ends and intensive flushing (February 2nd)
		Sampling results: *Legionella pneumophila serogroup 1 (cfu/l)**			
		b) The first sampling	d) The second sampling	f) The third sampling	h) The fourth sampling
P2	Kitchen	13.000	0	0	0
P4	Endocrinology Unit – Department of Internal Medicine	21.000	0	0	0
P5	Department of Infectology	4.000	0	0	0
P6	Abdominal Surgery Unit-Surgery Department	3.000	0	0	0
P6A	Intensive Care Unit-Department of Anesthesiology, Reanimatology and Intensive Medicine	21.000	3.000	0	0
P6B	Department of Neurology	50.000	0	0	0
P7	Department of Pediatrics	26.000	1.000	0	0
P8	Neonatology Unit-Departments of Gynecology and Obstetrics	55.000	0	10.000	0
P13	Boiler room	1.000	0	0	0

*Legend. *cfu/l (colony-forming unit)*

Measures taken after sampling:

A. Immediate measures taken

- Cleaning of shower rosette and taps
- Daily drainage of water for 1-2 minutes at locations that have not been used for at least seven days during the first week,
- The hospital infection control team with its technical service staff located, marked and mechanically removed the blind spots. A total of 54 blind ends (valves in the wall that cannot be drained) and 47 locations where water had not been used for more than seven days were detected

B. Measures not taken due to the age/construction issues of the hospital water distribution system:

- Thermal disinfection of hot water due to the deterioration of the heating system, i.e. the technical inability to raise the temperature in boilers above 65°C.
- Chemical disinfection (use of chlorine preparations) and the installation of chlorinators in the hot water system due to the no scheme of the water supply network and no possibility to control distribution of chlorine in the hot water system

Control sampling after one month resulted with two positive samples out of a total of nine samples (locations) at places where the prescribed anti-epidemic measures were not regularly implemented (water discharge at sites not used for more than a week). Following corrective measures, these deficiencies were corrected and negative results were obtained in all samples three months later. Microbiological findings of water were within normal limits, free residual chlorine was 0.35 mg/L.

Discussion

The present article outlines our experience of *Legionella* control in heavily contaminated hospital water in circumstances where usual disinfection methods (pasteurization or hyperclorination) were not possible due to the old and large water network.

Proctor et al. found that the temperature was more important than both pipe composition and the concentration of assimilable organic carbon for con-

trolling *L pneumophilla* growth, and that high temperatures decreased the effect of copper pipes[8].

Cervero-Aragó et al. found that amoebae-associated *Legionella* decreased *Legionella* inactivation by chlorine and high temperature. They concluded that water close to the tap posed an increased health risk given the lower chlorine levels and temperatures[9].

The hot water heater outlet temperature should be at or above 60°C; the hot water temperature at the coldest point in the hot water heater, storage tank, or distribution system should be at or above 51°C; and the cold water temperature in any part of the system should be at or below 25°C. If the hazard analysis and critical control point team determine that these temperatures cannot be achieved, it may then be concluded that additional hazard control measures are required[10]. In the Zadar GH, hot water temperature ranged from 25-44°C. Due to the technical issues related to the old construction and complex water distribution system with undocumented reconstruction during hospital history, it was not possible to perform thermal shock disinfection (> 65°C), nor even maintain the daily temperature at the outlet above 50°C.

In Europe, thermal treatment is recommended. Alternative treatments are only permitted when thermal treatment is insufficient. Alternative treatments are recommended in the following order: (1) physical disinfection (pasteurization, ultraviolet radiation, micro and ultrafiltration); (2) electrochemical disinfection (copper-silver ionization, anodic oxidation); and (3) chemical disinfection (free chlorine, chlorine dioxide, etc.)[11].

Permanent installation of a chlorinator and hyperchlorination in the water distribution system of the Zadar GH was not possible. The concentrations of chlorine in the water could not be controlled since there were no technical drawings of a water supply network. Most of the facilities at Zadar GH were built between 1887 and 1978 (9 out of 14), while the rest were renovated from 2000 to 2006. Over the years, the hospital has undergone numerous repairs in terms of the reconstruction and upgrading of many rooms, as well as the extension of water pipes to the existing ones. In addition, chlorination has many disadvantages, including the fact that 4-6 mg/L of chlorine kills only 90% of *Lp. species*[12].

Pasteurization and flushing are methods of first choice as preventive and antiepidemic measures because they do not require special equipment and can be implemented immediately. Therefore, we established a good flow of hot water and reduced water stagnation.

In the management of these anti-epidemic measures, very little knowledge of hospital staff (medical and technical) about *Legionella* was shown, which significantly reduced the speed of implementation of measures and their effectiveness. Danila et al. surveyed Minnesota hospitals and found that only 51% of the respondents knew about the ASHRAE standard, 27% had water management plans, and 21% regularly tested water for *Legionella*[13]. Acquiring knowledge in this area is necessary for a better implementation of anti-epidemic measures.

Our experience may be of value for facilities that have a large plumbing network and inability to raise the hot water temperature sufficiently and do not allow other measures to control LD such as hyperchlorination. As suggested by the WHO, all healthcare facilities should have a specific water safety plan (WSP) as part of their infection control program. Therefore, we improved WSP in Zadar GH, which provides a systematic assessment and prioritization of hazards, as well as operational monitoring of barriers and control measures. This plan has addressed issues such as training of medical and nonmedical staff in an active participation to the WSP implementation task.

The limitation of the study is in fewer samples and a lower monitoring frequency (once a month) than recommended due to financial reasons. More frequent sampling could give a better insight into the dynamics of legionella concentrations in the water supply system.

Conclusion

In this hospital, the mechanical removal of the blind ends and regular flushing of hot water were the only possible measures to reduce the concentration of legionella in the plumbing hospital system. Establishing good water flow throughout the hospital water supply system seems to be the most important measure, in order to make the multiplication of the bacterium in hot water distribution systems unlikely.

Funding

The authors did not receive support from any organization for the submitted work.

Conflict of Interest

The authors have no relevant financial or non-financial interests to disclose.

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