Hospital-acquired Legionnaires' disease: new developments

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Purpose of review

Hospital-acquired Legionnaires' disease is being increasingly discovered with the advent of rapid diagnostic techniques. This review examines both the clinical and political aspects of this important problem.

Recent findings

New sources are being recognized, including the water supply of pediatric hospitals, long-term care facilities, and rehabilitation centers. Concern by the public, unfavorable publicity and litigation are now emerging as hospital-acquired Legionnaires' disease is coming under scrutiny by the lay media.

Summary

Pro-active approaches to environmental detection and disinfection of hospital water systems are being demanded by public officials in place of the passive approach favored by many public health agencies.

Keywords

Legionella, pneumonia, nosocomial

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Introduction

Legionnaires' disease made its debut in 1976 as an explosive outbreak of community-acquired pneumonia. Shortly thereafter, cases of hospital-acquired Legionnaires' disease were reported. This disease can be easily overlooked if *Legionella*-specific diagnostic testing is not performed, and if that testing is not available on-site. With increasing recognition of this preventable disease by the public, the problem of hospital-acquired Legionnaires' disease is gaining increasing prominence.

Hospital-acquired Legionnaires' disease: a diagnosis worth making

The prompt diagnosis of Legionnaires' disease in the hospital setting can save lives. Not only has early initiation of appropriate therapy been associated with improved outcome, but the diagnosis of a single case of hospital-acquired Legionnaires' disease can prompt the recognition of endemic Legionnaires' disease at the facility [1–3].

The most common method for making the diagnosis of Legionnaires' disease no longer involves culture or serology. Among the Legionnaires' disease case-reports submitted to the US Centers for Disease Control and Prevention in Atlanta, GA, there has been a significant increase in the proportion of patients with a positive urine antigen test result [4•]. The urinary antigen enzyme immunoassay test also accounts for the majority (81%) of laboratory notifications in Australia [5]. For patients with severe pneumonia, the Infectious Diseases Society of America recommends diagnostic tests for *Legionella* [6]. When Legionnaires' disease is suspected, both *Legionella* culture of a respiratory specimen and a urinary antigen test should be ordered. The availability of the clinical isolate from culture can be critical for subsequent epidemiological investigations [7]. Another reason for not relying exclusively on the urine antigen test is that it may give a negative result if the infecting strain is not of serogroup 1 or when the infecting strain is of serogroup 1 but is monoclonal antibody subgroup 2-negative (Dresden Panel monoclonal antibody subgroup 3/1-negative). Of 317 culture-proven cases of Legionnaires' disease studied by Helbig *et al.* [8•], 67 (21%) were nosocomial cases. Only 45% of these cases were urine antigen-positive because 22% of the cases were caused by the monoclonal antibody subgroup-2 negative serotype.

Increased use of the rapid urinary antigen test and the increasing empirical use of quinolones for hospital-acquired pneumonia may explain the decline in Legion-

naires' disease-related mortality in the US. The case-fatality rate for hospital-acquired Legionnaires' disease decreased from 46% in 1982 to 14% in 1998 [4•].

Prevention of Legionnaires' disease in health-care facilities

Acknowledging the relationship between colonization of hospital water systems with *Legionella pneumophila* and the occurrence of hospital-acquired Legionnaires' disease is the first step towards prevention. *Legionella* spp. have been shown to colonize 12–85% of hospital water systems [9,10]. Prospective studies have demonstrated cases of hospital-acquired Legionnaires' disease in colonized hospitals after environmental and clinical surveillance was initiated [9]. The majority of cases of hospital-acquired Legionnaires' disease, like community-acquired cases, are caused by *L. pneumophila* [5,11•,12,13]. Serogroup 1 of *L. pneumophila* is most often implicated in hospital-acquired outbreaks.

Risk assessment should not be based on the concentration of *Legionella* recovered from a given water outlet: quantification has no relevance to occurrence of the disease [14–16]. Increased risk is, however, associated with the extent of the colonization with *L. pneumophila* (e.g. a high percentage of water outlets are positive); this relationship was first demonstrated in 1983 [16], and later confirmed in 1999 [14,15]. Complete elimination of *Legionella* from a hospital water system is not necessary to minimize the risk of hospital-acquired legionellosis [17].

Recognizing this fact, guidelines for *Legionella* prevention from the Allegheny County Health Department in Pittsburgh, PA, and the State of Maryland recommend routine environmental monitoring of the hospital water system as an important first step in assessing the risk for hospital-acquired Legionnaires' disease [18,19] (Table 1 [18–20]). If any outlets yield *L. pneumophila*, diagnostic tests for *Legionella* are made available in-house. If more than 30% of outlets yield positive results for *L. pneumophila*, the Allegheny County guidelines recommend that the facility consider disinfection of the water system [18]. Guidelines from the Texas Department of Health [20] recommend environmental surveillance for *Legionella* only if a risk assessment indicates that the facility has a significant risk of legionellosis transmission. For example, a high-risk facility could be a multi-storey facility with multiple water distribution systems, supplied with water treated with chlorine, with water stored at 51°C (124°F) and delivered at 43°C (110°F), and housing bone-marrow or solid-organ transplant recipients or cancer patients undergoing chemotherapy.

An alternative approach advocated by the US Centers for Disease Control and Prevention is to implement intensive laboratory surveillance for the disease without knowledge of the colonization status of the facility. Environmental cultures are recommended only when one to two cases of hospital-acquired Legionnaires' disease are discovered. The major problem with this approach is that it is not a preventive one. First, an outbreak with numerous patients contracting the disease (and possibly dying) may be necessary for such low-level endemicity to be detected. This approach places patients at undue risk, since *Legionella* tests, especially culture methods, are not widely available. Second, hospital-acquired Legionnaires' disease does not occur in a facility with a water system that is not extensively colonized with *L. pneumophila* [9,14]; thus, scarce laboratory resources may be wasted on such diagnostic testing.

In 2003, the Centers for Disease Control and Prevention Healthcare Infection Control Practices Advisory Committee will issue a revision to the 'Guideline for Prevention of Healthcare-Associated Pneumonia' [21]. A number of important issues remain unresolved in this guideline, including the role of routine culturing of water systems for *Legionella* spp. in health-care facilities. As part of a comprehensive strategy to prevent Legionnaires' disease in transplant units, the Centers for Disease Control and Prevention Healthcare Infection Control Practices Advisory Committee recommends that facilities with solid-organ transplant programs and/or with hematopoietic stem-cell transplant recipients perform periodic culturing for legionellae in the potable water supply of the transplant unit. If *Legionella* spp. are detected in the unit's water system, corrective measures (disinfection) should be performed until no *Legionella* is cultured. No such recommendation is made for health-care facilities treating non-transplant patients, or for disinfection of areas serving these patients.

The obvious shortcoming of this approach is that many cases of hospital-acquired Legionnaires' disease occur in non-transplant patients. In fact, not a single patient in our original report of endemic hospital-acquired Legionnaires' disease was a transplant recipient, and Legionnaires' disease constituted 22.5% (32/142) of the cases of hospital-acquired pneumonia [22]. In a Swedish hospital [23], 31 persons with hospital-acquired Legionnaires' disease were diagnosed over a 14-month period: eight were from surgical wards, 16 were from internal medicine or geriatric wards, and three each were from psychiatric and physiotherapy units.

Disinfection modalities

Methods for water-system disinfection also remain an unresolved issue. According to the Centers for Disease Control and Prevention Healthcare Infection Control Practices Advisory Committee guideline, there is insufficient evidence, or no consensus, regarding the

Table 1. United States Guidelines for Prevention of Legionnaires' Disease (health-care facilities in Pennsylvania and Maryland recommend routine environmental culture for *Legionella*)

State/Organization	Routine environmental cultures?	Culture on site?	Urine antigen on site?	Disinfection?
Allegheny County Health Department 1993/1997 [18]	Yes Frequency: annually, but more often in transplant hospitals	Yes, if environmental cultures positive	Yes, if environmental cultures positive for *Legionella pneumophila* serogroup 1	Consider disinfection if more than 30% sites positive
Maryland Health Department [19]	Yes Frequency: to be determined by institution	Yes, if transplant hospital	Yes for all acute-care hospitals (or contract laboratory with 24–48 h turn-around time)	If cases identified
Texas Department of Health [20]	No, unless high-risk facility Frequency: unspecified	Yes, if transplant hospital	Yes for acute-care and long-term-care hospitals	If cases identified
Centers for Disease Control [21]	No, unless bone-marrow transplant unit Frequency: unspecified	Yes, if more than 400 beds	Yes, if more than 400 beds	If cases identified

efficacy of the following disinfection methods: treatment with ozone, ultraviolet light, copper–silver ions or monochloramine. It is somewhat surprising that treatment with copper–silver ionization is not included among the recommended disinfection approaches at this point in time. This disinfection option has been in use for more than 10 years; copper–silver ionization systems are now operational in more than 100 US hospitals, and 32% (12/38) of surveyed hospitals in the National Nosocomial Infection Surveillance program [24] used ionization for *Legionella* disinfection. The first 16 installations in the US have experienced sustained success at 5–11 years follow-up [25].

Unfortunately, the recommended disinfection modalities include superheating and flushing of the potable hot water (thermal eradication) or hyperchlorination. Neither of these methods can be sustained for long periods. The practice of superheating is logistically tedious, labor-intensive, and only effective for weeks to months. It is important to note that the 5-min flush duration given in the Centers for Disease Control and Prevention Healthcare Infection Control Practices Advisory Committee guidelines is an error: this short duration is usually insufficient to yield a significant reduction in the level of *Legionella* colonization. A flush time of 30 min at each outlet has been shown to be effective [26]. Hyperchlorination over long periods (years) has resulted in significant corrosion such that this modality has been abandoned by many hospitals in favor of ionization [25]. Continuous hyperchlorination has fallen out of favor because of high expense, marginal efficacy, and release of carcinogenic by-products into the drinking water [27,28••]. Both shock chlorination and thermal eradication have resulted in only short-term control of *Legionella* [29,30].

One disinfection option not mentioned in the guideline is the use of chlorine dioxide. Chlorine dioxide has been used in Europe and has received increasing consideration by US hospitals. Results from two controlled studies on the use of chlorine dioxide for control of *Legionella* in hospital water systems showed significant reductions in the recovery of *Legionella* species from the water-distribution system [Sidari FP, Stout JE, VanBriesen JM, *et al.*, unpublished observations; 31]. As with chlorine, there are concerns over disinfection by-products produced by the breakdown of chlorine dioxide (chlorite), but more data are needed to ascertain whether this is a valid or simply theoretical concern. Chlorine dioxide and monochloramine represent promising new technologies, but interpretable results may not be available for several years.

Susceptibility of children and long-term care facility residents

Given the increasing use of diagnostic tests for *Legionella*, new risk groups of patients are being discovered to be susceptible to Legionnaires' disease. They include immunocompromized children in pediatric hospitals colonized with *Legionella*, and elderly patients residing in long-term care facilities and rehabilitation centers colonized by *Legionella*.

In the past year, at least two more cases of hospital-acquired legionellosis in children have been reported, adding to the growing literature on pediatric legionellosis. In each case, molecular subtyping showed that the source of the organism was the hospital water supply. One case was a 5-year-old boy who was malnourished and also receiving corticosteroid therapy [32]. He developed post-operative pneumonia, and urine antigen and cultures yielded *L. pneumophila* serogroup 1. The second case occurred in a 7-day-old neonate who contracted Legionnaires' disease as diagnosed by *Legionella* serology and a positive urinary antigen test [33]. The interesting feature of the neonate case was that the child apparently acquired the organism from the pool water used for water-birthing (an alternative method used in the delivery of babies). The mode of transmis-

sion for both patients was considered by the investigators to be aspiration.

At least three outbreaks of Legionnaires' disease have occurred in long-term care facilities, and in two of them *Legionella* was isolated from the potable water [34–36]. In a third outbreak, only limited environmental sampling was performed. Aspiration was presumed to be the mode of transmission for most of these outbreaks. In one outbreak, the eating of puréed food was a significant risk factor for *Legionella*, consistent with aspiration originating from a swallowing disorder [34]. In two prospective studies of long-term-care residents admitted to hospitals with community-acquired pneumonia, 6.5% of patients in a US study [37], and 1.4% of patients in a Canadian study [38], were found to have contracted Legionnaires' disease.

Prospective studies of both *Legionella* colonization of the water supply and subsequent infection in a long-term care facility were performed in Pittsburgh: 7% of the cases of pneumonia were diagnosed as Legionnaires' disease by serology in one study [39], and, in another prospective study [40], *L. pneumophila* serogroup 1 was isolated from a newly constructed long-term care facility. Six cases of Legionnaires' disease were diagnosed over two years. DNA subtyping established that the isolates from the patients were identical to the environmental isolates from the water supply.

A rehabilitation facility has also been implicated: 11 patients contracted Legionnaires' disease caused by *L. pneumophila*, serogroup 1. *Legionella* serogroup 1 was subsequently isolated from the water-distribution system of that facility [35].

Conclusion

In our opinion, a rational approach to the prevention of Legionnaires' disease requires not only the development of effective disinfection modalities but also education of the public and the lay media. Whenever cases of Legionnaires' disease are linked to *Legionella* in the hospital water supply, the media search for scapegoats. The public is not aware that *Legionella* is a common commensal inhabitant of man-made water-distribution systems. We have observed the implementation of emergency disinfection measures that are expensive, logistically tedious, and often have little impact on the actual risk of acquiring *Legionella*. Given the fact that isolation of *Legionella* from a water supply can lead to irrational action and fear of litigation, many hospital administrators have decided to avoid culturing of the hospital water distribution system, thereby omitting the most effective and rational approach to prevention. Avoidance of environmental culturing in hospitals is the current standard in the UK and Australia. Ironically, in both of these countries, outbreaks attributed to cooling towers are commonly reported in the lay press, although epidemiological investigation of hospital-acquired legionellosis almost always pinpoints the water-distribution systems [41].

The 'avoidance policy' not only places patients at undue risk, but will not protect the institution from litigation. A hospital in Los Angeles, CA, has recently been named in a lawsuit seeking damages in the deaths of two patients from hospital-acquired Legionnaires' disease [42]. This hospital had not pro-actively cultured its water supply for *Legionella* (cost, approximately $1500) and had not pro-actively disinfected its hot-water system (cost, approximately $20 000). The damages being sought amount to approximately $20 million, and brings to mind the aphorism 'penny wise and pound foolish'.

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