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LEGIONNAIRES' DISEASE IN NURSING HOMES AND LONG-TERM CARE FACILITIES: AN EMERGING CATASTROPHE

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Abstract: Outbreaks of Legionnaires' diseases in nursing homes and longterm care facilities have become increasingly cited in newspaper and television reports especially when deaths are involved. News reports can lead to unsubstantiated rumors and widespread disruption of services. A sense of panic can lead to adoption by the facility of expensive, short-term measures that are unscientific and expensive. The worst case scenario is that the measures will also be found to be useless. We present an evidence-based approach that has been successful and cost-effective in longterm care facilities. Environmental cultures of the drinking water for Legionella within the nursing home and longterm care facility is a necessary first step. Infection control personnel should make the key decisions in management of the outbreak. Healthcare facility managers and outside water treatment consultants often make costly and expensive recommendations that will be proven ineffective over time.

Key words: Long-term care facilities, nursing homes, Legionella, Legionnaires' disease.

Introduction

Outbreaks of Legionnaires' diseases have been a popular subject in the news media, especially those in which many individuals have become infected and deaths have occurred. In the past 2 years, outbreaks have been reported the news media for at least 10 longterm care facilities and/or nursing homes in the U.S (Table 1). The most recent nursing home outbreak in Forsyth County, NC involved six cases of Legionnaires' diseases identified at Oak Forest Health and Rehabilitation center (1). In 2012, an outbreak was discovered in a long term care facility in Quebec, Canada where 180 cases were suspected with 13 deaths (2). In 2013, an elderly patient contracted Legionnaires' disease from a Pittsburgh senior high-rise building (3). In 2013, an outbreak of Legionnaires' disease associated with long term care facilities occurred in Reynoldsburg, OH, 39 cases of Legionnaires' disease were diagnosed and deaths occurred in 5 patients. Legionella pneumophila was isolated from both cooling towers and the drinking water system (4).

An outbreak of Legionnaires' disease can lead to media publicity, unsubstantiated rumors, and even panic leading to widespread disruption of services. Other inpatients, family members, employees and hospital staff need to be educated and reassured. So, in this review we elucidate aspects of Legionnaires' disease that allow a reasoned and evidence-based approach to Legionnaires disease in longterm care facilities. Ironically, such an approach is not only more effective but less disruptive and surprisingly less costly.

Microbiology of Legionella

Legionella is the genus (a major class of bacteria) that causes the pneumonia, termed Legionnaires' disease. There are many different types of Legionella and these types are called "species"; several species can infect humans. The most common is Legionella pneumophila (pneumo=lung, phila=love, hence lung-loving in Greek).

In the immune system, antibodies attack or disable foreign invaders (called antigens) entering into the human body. In this case, the Legionella bacteria are antigens. The individual Legionella species have different types of antigens, so Legionella can be subclassified by their reaction to different antibodies; the antigen types are termed serogroups. So, within the different Legionella species, numerous serogroups exist. There are more than 50 species and serogroups of Legionella. The most common species is Legionella pneumophila. Legionella micdadei, L. bozemanii, L. dumoffi, L. feelei and other species can also cause Legionnaires' disease. The most common serogroups of L. pneumophila that cause disease are serogroups 1, 4 and 6.

The amount of Legionella in the water is an indicator of risk. CFU/ml is commonly used to designate the amount of Legionella in water. CFU/ml means colony-forming units in one ml of water. However, we and others have demonstrated that CFU/ml is an inaccurate parameter for predicting risk of disease in a facility (5-6). Several samples taken from the same faucet may have a large range of CFU/ml, and the amount of CFU/ml does not correlate with risk of contracting Legionnaires' disease by a patient.

However, the percent of distal sites (faucets, showerheads) with Legionella does correlate with risk for Legionella infection in patients exposed to this water. We have used 30% of distal site Legionella positivity as an empiric cutpoint based on our experience and a review of other hospital outbreaks. In a prospective study of 20 hospitals, it was found that when Legionella was found in greater than 30% of distal water sites, patients in these hospitals were notably more likely to contract Legionnaires' disease (7). 30% is not an absolute indicator with complete accuracy, nevertheless, it has proven

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Table 1
Legionnaires' disease outbreaks in nursing homes from 2009 ~ 2013 (Source: News)

Year	Location	Patients (n)	Deaths (n)	Source* Investigated?	Control Measures**	News Source
2014	Winston-Salem, NC	6	0	Water (+)	Cl2, Heat, Restrict water	Camel City Dispatch
2013	Sharpsburg, PA	1	0	Water (+)	Water Filters	KDKA-TV
2013	Wesley Ridge, Reynoldsburg, OH	39	5	CT (+) Water (+)	Cl2, Heat, POU, Restrict water	WBNS-TV
2012	Quebec City, Canada	180	13	CT (+)	Cl2	The Star
2011	Lighthouse Senior Living, Ellicott City, MD	1	1	Water	NA	CBS Baltimore
2011	Hampden nursing home, Baltimore, MD	2	0	NA	Restrict water	Baltimore Sun
2011	LGAR Health and Rehab Center, Turtle Creek, PA	10	0	Water (+)	NA	Tribune Review
2011	Hamilton Hills Personal Care Facility, Turtle Creek, PA	3	0	Water (+)	Restrict water	CBS Pittsburgh
2011	Elizabeth Severance Center, Cleveland, OH	3	0	Water (?)	Restrict Water and Shower	Cleveland.com
2010	Tranquility Assisted Living, Frederick, MD	2	0	Water (?)	Restrict water and showers	Washington Post

*Source: CT: Cooling Tower; **Control measures: Cl2 (Hyperchlorination), Heat (Superheat and Flush), POU (Point of Use filter)

Table 2
Legionnaires' disease outbreaks in nursing homes from 2009 ~ 2013

Location	Patients (n)	Deaths (n)	Source* Investigated?	Source identified?	Ref
Baltimore, MD	8	1	Water (74%+)	Water	(7)
Celje, Slovenian	10	0	Water (80%+)	Water (?)	(8)
Ontario, Canada	135	23	CT (+) Water (-)	CT	[29]
Cherokee County, NC	7	3	CT (+) Water (-)	CT (?)	[30]
Pittsburgh, PA	6	3	Water (>50%+)	Water	(31)

*Source: CT: Cooling Tower; **Control measures: Cl2 (Hyperchlorination), Heat (Superheat and Flush), POU (Point of Use filter)

to be a useful estimate of risk. Thus, we recommend culturing a minimum of 10 sites in addition to all hot water tanks. We add one additional site for every 100 nursing home residents. The sites chosen should be in locations where the most disabled residents are housed. Thus, we recommend that nursing homes and long-term care facilities should perform routine cultures for Legionella in the water distribution of their nursing homes at least once a year. If the distal site positivity exceeds 30%, preventive measures are indicated.

Nursing homes and Long Term Care Facility Outbreaks in Scientific Publications

Compared to outbreaks reported in the lay news media, outbreaks in long term care facilities are relatively few in scientific publications (Table 2). An outbreak in one Baltimore retirement home resulted in 8 cases including one death. L. pneumophila, serogroup 1 was responsible for this outbreak (8). The distal site positivity of Legionella in the water distribution system was 74%. In a well-documented Slovenia outbreak, 10 patients in a nursing home contracted Legionnaires' disease due to L. pneumophila, serogroup 1; the distal site positivity was 80% (9).

Facilities experiencing outbreaks showed Legionella distal site positivity (i.e. faucets and showerheads) for Legionella ranging from 50 ~ 80% at the time of outbreaks suggesting that the empiric threshold of >30% might be a reasonable indicator for prevention using routine environmental cultures as a cutpoint (10).

Diagnosis

The symptoms of Legionnaires' disease are those of pneumonia: fever, cough, productive sputum. However, a few clues might raise the index of suspicion for the healthcare professional: high fever greater than 39oC and gastrointestinal symptoms are often distinctive. Abdominal discomfort, nausea, vomiting and diarrhea may occur. Diarrhea in a patient with pneumonia should immediately raise suspicion for Legionnaires' disease.

Although fever and cough are classical symptoms of pneumonia, recognition may be difficult in nursing home residents since elderly patients often present without fever or cough despite their pneumonia (11-13). The diagnosis of Legionnaires' disease requires application of specific microbiology tests for Legionnaires' disease which are rarely available in long-term care facilities.

The diagnostic test that is most used is the Legionella urinary antigen (Alere, Waltham, MA). It has a sensitivity of 80%. The main limitation is that it only detects Legionella pneumonia, serogroup 1; however, this species and serogroup account for 80% of Legionella infection in the community. Serogroup 1 is the predominant serogroup, but serogroups 6 and 4 are common in institutions. Other Legionella species, especially L. micdadeii, L. bozemanii, L. dumoffii, L. longbeachae may also be causative pathogens but are not detectable by the urinary antigen test.

Legionella is not easily visualized on microscopic stains and will not grow on standard microbiology media typically used

for sputum specimens. Special Legionella media must be used. When an expert laboratory processes sputum specimens, the culture may yield a diagnosis when the urinary antigen test is false-negative. However, sputum culture for Legionella is not widely available except in specialized laboratories. Moreover, an adequate sputum specimen is often difficult to obtain in patients with Legionnaires' disease.

Mode of Transmission

Pneumonia is the leading cause of death and an important cause of transfer to acute care facilities and long-term care facilities (11). Conventional wisdom is that Legionella is aerosolized and it spreads through the air into the patient. We have found that while aerosolization can occur, it is uncommon. So, air conditioners and hot tubs have been over-rated as sources. Most patients contract Legionella through aspiration and drinking water is the actual source.

Aspiration is the mechanism by which microbes in the mouth bypass the host defense of the lung and enter the lung to cause pneumonia. Cigarette smoking inactivates and damages these host defenses. Microaspiration of water contaminated with Legionella is the primary mode of Legionella transmission. Long-term care residents also have swallowing difficulties and nasogastric tube feedings are inserted. Legionnaires' disease has resulted from aspiration in patients with nasogastric tube feedings diluted with tap water (14).

Prevention – Surveillance

Based on the mode of transmission, environmental cultures for Legionella in the drinking water is a necessary first step in prevention. At the current time, US Centers for Disease Control do not recommend routine environmental cultures for hospitals and nursing homes. In contrast, the World Health Organization and many public health agencies in Europe and Asia do recommend routine environmental surveillance for Legionella. If the facility has a predominance of bedridden patients and immunosuppressed patients, such a plan is necessary for maximal protection against a potentially-fatal disease.

Prevention – Disinfection

If Legionella is found in the water supply, and the distal site positivity rate exceeds 30% or patients have contracted Legionnaires' disease, disinfection of the drinking water warrants primary consideration. We recommend proactive culturing for Legionella in the water of the nursing home or longterm care facility ie culture the drinking water in the absence of evidence that patients have contracted Legionnaires' disease. We make this recommendation because Legionnaires' disease may be occurring in a nursing home, but go unrecognized. Other causes including influenza or aspiration pneumonia may be incorrectly assumed and the actual cause of Legionnaires' disease overlooked. Outbreaks involving many patients may occur for some time before it is recognized that these patients had contracted Legionnaires' disease. The 30% cutpoint that we advocate is an empiric value based on prior experience in hospitals.

We are introducing a new innovative approach using intermittent disinfection with intensive environmental monitoring of Legionella colonization (15-17). This approach may be inexpensive and long-term evaluation suggests greater efficacy due to a delay of Legionella recolonization in the water plumbing systems (18). Disinfection modalities can be categorized as either focal or systemic. "Focal" disinfection refers to disinfection directed at only a portion of a water system, usually the point of entry (incoming water) and point of use (the outlets). "Systemic" disinfection refers to disinfection directed at the entire water system by providing a disinfectant residual throughout the water system, especially the distal sites. Point-of-use disposable filters are a focal method to control Legionella in restricted areas in which bedridden patients are congregated. Point of use water filters (0.2 μm) can be applied quickly in an urgent situation and can supplement other long-term disinfection options. A focal approach might be applied if the distal site positivity is low and cases have not occurred (19-20).

A disinfection system installed onto the water supply might be applied in facilities experiencing many cases and the distal site positivity for Legionella is high. Two systemic disinfection methods have proven efficacious against Legionella in hospital water supplies: copper-silver ionization and chlorine dioxide (21).

Copper-Silver Ionization: The efficacy of copper-silver ionization in eradicating Legionella from hospital water distribution systems has been documented by numerous investigators worldwide. The first 3 hospitals to apply hyperchlorination for Legionella disinfection (Wadsworth VA Medical Center, CA; University of Burlington Medical Center, VT; University of Pittsburgh Medical Center, PA) discontinued hyperchlorination because of failure to control Legionella and extensive corrosion caused by the chlorine. Copper-silver was adopted as their final solution. Ten published studies have demonstrated that copper-silver ionization is an effective method to control Legionella when both ion levels and Legionella cultures were monitored (21, 22).

Chlorine Dioxide: Chlorine dioxide as an option for Legionella control was first initiated in Europe, and most systems failed. The Special Pathogens Laboratory (Pittsburgh, PA) published the first successful controlled evaluation for Legionella pneumophila in the U.S. at Geisinger Medical Clinic (Pennsylvania) where it was successfully applied (23). Maintaining a sufficient residual concentration of chlorine dioxide (ClO2) in the hot water system is challenging. Elevated temperature hastens the conversion of chlorine dioxide to chlorite. An effective residual (0.3 – 0.5 mg/L as ClO2) must be maintained throughout an extensive water distribution

system. The decay of chlorine dioxide is dependent on the water temperature and the distance from generation site to the distribution system. Given its rapid decay in hot water, a higher concentration of chlorine dioxide must be injected at the source to reach an effective concentration (0.3 – 0.5 mg/L) at the distal site. Thus, the efficacy of chlorine dioxide may be limited to only cold water supplies, not hot water recirculating lines. The advantage of chlorine dioxide is its lower cost compared to copper-silver ionization for the same capacity.

Control measures that are proven ineffective

Several control measures are often recommended by some consultants without proven efficacy (24). If a consultant suggests any of the following expensive control measures, management should challenge the recommendation because the recommendations are not only ineffective, but logistically tedious to implement and expensive. Ineffective measures include:

Cleaning of distal outlets: Faucets and showerheads are disinfected by immersion in chlorine of high concentration or boiling water. Or these outlets are replaced with new ones. This method only eradicates the Legionella at the outlets, a small proportion of the total Legionella in an existing plumbing system. Legionella can be isolated from water flowing through these fixtures within days to weeks later because Legionella is still present in biofilms throughout the plumbing system (25).

Removal of deadlegs: The concept of a "stagnant" aquatic environment in which Legionella readily propagates is an appealing one. However, scientific evidence supporting this concept is lacking. In contrast, two studies actually showed that the lowest counts were in the deadlegs (26, 27). One medical center conducted a field study which, among the 12 persistently positive sites at deadlegs, plumbing modifications were implemented in 7 sites and the 5 other sites were left unchanged as controls. The follow up environmental cultures showed 71% (5/7) of sites with deadlegs removal became negative; however, all 100% (5/5) of the control sites also became negative (23). In a 16-hospital study, none of the study hospitals had a protocol for removal of dead legs; despite this, Legionella was eradicated and well-controlled after copper-silver ionization was implemented (22). Thus, the efficacy of removal of dead legs remains unestablished and such removal is costly, labor-intensive and tedious.

Superheat-and-flush: This is a common initial approach at disinfection. However, consultants experienced in implementing this method should oversee the process since this method almost invariably fails if healthcare facilities personnel oversee the process. Adequate temperature (>60°C or 140°F) at the tap and time of duration of the flush needs to be documented by the infection control practitioners (28). We have found that strict documentation is routine for healthcare givers involved in public health; this critically important task is oftentimes ignored by healthcare facilities personnel (21).

Restriction of water use is the most economical and easiest method to implement. Sterile water should be provided for the residents in drinking, brushing teeth, and other activities. Point-of-use water filters also are effective, and can be implemented quickly in selected areas.

If a systemic disinfection system is installed because of occurrence of patient cases, copper-silver ionization may be the preferred approach given its established track record especially if the outbreak has been reported in the news media. Chlorine dioxide may be an excellent alternative if cases of Legionnaires' disease have not occurred, but Legionella has been found in the water. Its disadvantage is that several weeks to months of trial-and-error may be required before eradication becomes complete.

Summary

Legionnaires' disease is underdiagnosed in nursing homes. When it is discovered, it may be in the context of an outbreak with many cases. If deaths occur, panic during the outbreak and exorbitant costs from litigation can occur.

A major benefit of infection control participation is the avoidance of poor decision-making during the chaos of an outbreak. Inexperienced consultants and healthcare facilities managers often make costly and useless recommendations to management. Prevention can be low-cost and effective.

Conflict of Interest: None

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