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CASE REPORT

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Acquired Legionnaire's Disease Through Aerosolization of Water from Natural Sources

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ABSTRACT

Legionnaire's disease is a potentially fatal pneumonia caused by *Legionella pneumophila* bacteria. Aerosol inhalations by human-generated sources are linked to the breakout of Legionnaire's disease. This epidemiological review highlights the survival of *Legionella* in natural habitats and its possible role in sporadic cases of Legionnaire's diseases. In addition, possible natural sources, which may cause *Legionella* epidemic, are presented in detail.

Keywords: *Legionella, Legionnaire's disease, Fresh water infections*

INTRODUCTION

Legionellosis is a generic name commonly used to describe *Legionella pneumophila* bacterial infections, which could usually cause two types of illnesses, Pontiac Fever (mild, febrile illness) and Legionnaire's disease (rapid and potentially fatal pneumonia). Legionnaire's disease was first recognized during an epidemic of pneumonia at the Pennsylvania State American Legion's convention in Philadelphia in 1976 [1]. Historically

Legionnaires disease has been mostly described in the context of linked cases or epidemics occurring through aerosol inhalation because of man-made sources [2]. These sources comprise but are not limited to cooling towers, water heaters, fountains, even shower heads [3-6] and almost anything, which may cause aerosolization of water droplets including disturbances in soil. Little significance is placed on all the sporadic cases, which by far, outnumber the cases found during outbreaks of *Legionella* [7]. There has been no report to our knowledge in which the aerosolization of water from natural sources causes Legionnaire's disease. Recently, a case of *Legionella* was presented to us suggestive of it being caused by aerosolization of water from natural sources.

A SPORADIC CASE OF LEGIONELLOSIS FROM AEROSOLIZATION OF WATER

A 29 year old man with history of smoking presented to a hospital in June with symptoms of pneumonia including cough, general malaise and high grade fevers ranging from 101 - 104 °F degrees for five to seven days. He had been camping near

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waterfalls in Utah and had explored caves behind those falls with his girlfriend during the week before the onset of these symptoms. He also had spent his time during the day outside painting airplanes. Upon imaging, the man was subsequently found to have positive results for the *Legionella* antigen in his urine along with the left lower lobe infiltrates. His blood and respiratory cultures remained negative along with the urine streptococcal antigen. No recent outbreaks were reported from that area in Utah. During that time he did not stay in any hotel or residential place nor did he have any human contact or report alterations in his health before going camping. Incidentally, his girlfriend also had an acute febrile illness, which subsided on its own without any intervention. She refused any diagnostic testing. Through extensive questioning and surveying, it appeared that the waterfalls in Utah were the only source of aerosols he came in contact with, perhaps when he explored the caves behind it. The patient was put on levofloxacin. As his fever resolved and condition improved, he was subsequently discharged with oral prescription of levofloxacin. We believe that the patient acquired the organism from aerosols generated by the waterfall. No attempts were made to culture the legionella from the waterfall, so the objective evidence is missing. Here, we reason the possibility of Legionellosis through natural sources.

DISCUSSION AND REVIEW

Legionella are gram negative, obligate aerobes, having a median incubation period of four to six days that ranges from two to ten days [8,9]. Although there are several groups and subgroups, *Legionella pneumophila* serogroup 1 causes over 70 to 90 percent of the outbreaks and sporadic cases of *Legionella* [2,10,11]. *Legionella* have been known to be ubiquitous in our environment and is present in low concentrations in wide variety of fresh natural water sources including lakes, rivers and even coastal sea areas [2,5]. *Legionella* have been detected in up to 80 % of freshwater sites by PCR analysis [12-14]. Its concentration is notably higher in warmer waters between temperatures of 25 to 40 °C.

Amoebae and some other organisms play a vital role in the ecology of *Legionella*, serving as a medium of its intracellular growth and multiplication, where it acts as a facultative intracellular parasite. *Legionella* can stay under a viable but non-cultivable (VBNC) state when the amoebae encyst ensuring their survival under temperature extremes and unfriendly environment [15]. Simultaneous presence of amoebae also correlated with the presence of epidemic strains of *L. pneumophila* in man-made plumbing systems [16]. The low metabolic state also protects the bacteria from biocides and enables continuous supply to the environment as well as ensures survival when more favorable conditions return. Also, the infectiousness and virulence of the bacterium is increased

multiple times during this spore like form, making it more pathogenic. Another ecological niche where bacteria attain high concentrations is the presence of biofilms found in both natural and manmade sources. A biofilm is a complex polysaccharide interaction between bacterial colonies and other different microorganisms including amoebae, generally attached to a surface. This also, according to some experts plays a crucial role in survival and concentration of these bacteria.

Legionella are found to be present in concentrations of around 1 bacterium per liter in these natural water sources. This does not take into account the much higher concentrations present in biofilms and in a single amoeba, which are usually present in these water bodies. The inoculum known to cause disease in humans remains unknown. In guinea pigs, 100 -1000 *Legionella*, if delivered through aerosol can cause mild to severe disease including death, at higher concentrations. These naturally occurring amoebae and *Legionella* particularly abundant in biofilms, have concentrations high enough to be capable of causing disease by the engulfment of a single amoeba or biofilm fragment. This has at least been seen in guinea pigs [2]. There is a possibility that encysted amoebae containing bacteria or the parts of biofilm, in addition to ensuring survival of bacteria in aerosolization phase, may itself be capable of causing disease; however, these possibilities needs to be explored.

The environmental changes, water currents, shear forces, and other phenomena resulting in disruption of these biofilms may cause the bacteria to continually escape in high enough concentrations capable of causing disease. These bacteria may then gain entrance into human body either through aerosolization or other less common modes like micro-aspiration.

Legionella, also as expected, colonize artificial reservoirs. Almost 80 % of cooling towers and up to 30 % of home water heaters are contaminated with the bacterium without causing any disease, which only signifies their metropolitan presence in both natural and artificial environment. Thus, it seems probable that only mode of dissemination may be needed for them to cause disease regardless of its source being artificial or natural. One other important finding which supports this hypothesis is that outbreaks of *Legionella* cease even when the sources remain contaminated [17]. Inhalation and possible micro-aspiration are some of the modes described in pathogenesis of Legionnaire's disease [2]. There are also rare reports of extra pulmonary forms of *Legionella* caused by direct inoculation of surgical wounds by tap water [18]. There are a variety of host factors, which increase susceptibility to *Legionella* including immunosuppression, smoking, recent surgery and lung conditions [19,20]. This also explains why they do not cause disease in everybody.

Aerosolization of bacteria through various mechanisms, hot water spas, contaminated shower heads, recent plumbing work, proximity to a cooling tower [21,22] and even some reports of near drowning have all been implicated in causing Legionnaires disease. All of the above sources reported till now have been man

made with most of them coming into light because of an epidemic. The explanation being that man-made sources serve to amplify the bacteria resulting in their higher concentration in aerosols [23]. Even aspiration of contaminated water, contamination of nebulizers, nasogastric feeding, ventilators, humidifiers have all been associated with Legionella. Rarely oral ingestion has also been implicated in cases of peritonitis and other extra pulmonary infections.

We still have not been able to pinpoint the source of infection in numerous sporadic cases of Legionella. It has been proposed that man-made reservoirs [24] including heaters, water storage tanks and plumbing systems serve as regions of amplification of these natural bacteria which when disseminated cause the disease. Over 70 % of Legionella cases are sporadic and have not been associated with epidemics described [7,20,25]. Also cases reported to CDC put the incidence of Legionella around 0.4 /100,000. There are multiple reports describing the actual incidence to be up to 50 times higher, and majority of cases, as expected being sporadic. Sporadic cases are estimated to be 3 to 4 times more common than those caused in an epidemic. It has been estimated that at least 2% of pneumonia cases are due to Legionella. One study in Ohio described the correct diagnosis of Legionella pneumonia to be less than 3% [15]. Also some geographical regions have shown to have higher concentration of cases that may point towards natural forces playing a role in the pathogenesis of the disease. There are also some cases diagnosed where people visited a town center without having been inside the contaminated building which caused the outbreak. Also, there has been a direct relationship demonstrated between non-outbreak associated Legionella cases and proximity of residence to cooling towers demonstrating that the cooling towers may have merely served as a means of aerosolization of bacteria.

In spite of Legionella being present in wide variety of natural sources the rarity of infection and their inability to cause an outbreak may be explained by herd immunity. One particular example is of the original outbreak of Legionella in Philadelphia where the hotel employees were immune to Legionella and did not show any signs of infection in spite of having high antibody titers just short of that needed to diagnose infection [8]. Cases also were shown to occur in people in 1976 in Philadelphia who had never been inside the hotel suggesting that factors other than just aerosolization of bacteria inside the hotel may have played a role in the outbreak [8]. In addition, the same group also mentioned about one of the outbreaks where the hotel did not have an air conditioning system in place [8]. A nearby excavation site was suspected in that case, again suggesting that only means of dissemination may be needed for the bacteria to cause disease. Other evidence suggesting that Legionella may also be possibly associated with natural sources is that increase in number of sporadic cases of legionnaires disease in England corresponded to increased amount of rainfall [26].

In our case though there is high probability of Legionnaires disease being acquired from natural waterfall, some other possibilities may need to be explored, such as a) the incubation

period though ranging from 2 to 10 days, has rarely reported to be as long as 28 days. b) Out of the other means of dissemination, micro-aspiration also has been recognized as a way to acquire Legionella pneumonia. c) Aerosolization of contaminated water may have taken place from a nearby cooling tower or other unknown source. d) There is even possibility of air conditioning system of the planes being contaminated by Legionella. Though, all the above possibilities exist in our case, the evidence of infection with Legionella, self-limited acute febrile illness in his companion along with the onset after 3 to 4 days of exposure to aerosol, indicates the waterfall as a source of infection. This compounded with the widespread presence of Legionella in natural sources is compelling and requires further ecological investigation and research.

CONCLUSION

It seems plausible that when environmental conditions are favorable along with simultaneous presence of many other factors including the presence of bacteria in proper concentration, way of dissemination, and susceptibility of host, Legionnaires disease may occur. This could also explain why naturally occurring Legionella, though present widely do not cause disease on a regular basis [27], but may very well be responsible for some sporadic cases of Legionella under appropriate conditions.

There are still only a minor fraction of cases of pneumonia being caused by Legionella, and whether fresh waterfalls should be considered a potential source of Legionnaires disease needs to be tested before concluding. There has to be a consortium of many factors happening at the same time [19], at least theoretically, for a person to acquire Legionnaire's disease from natural sources and the risk may still be very low. This article seeks to bring into light the need of further work in epidemiology and ecology of Legionnaire's disease for determining fresh water aerosols as means of disseminating Legionella.

CONFLICT OF INTEREST

Authors declare no potential conflict of interest.

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