

Case Study

Legionnaires' disease as an occupational risk related to decontamination work after the Fukushima nuclear disaster: A case report

Toyoaki Sawano¹, Masaharu Tsubokura², Akihiko Ozaki¹, Claire Leppold³, Shigeaki Kato⁴ and Toshiyuki Kambe⁵

¹Department of Surgery, Minamisoma Municipal General Hospital, Japan, ²Department of Radiation Protection, Minamisoma Municipal General Hospital, Japan, ³Global Public Health Unit, School of Social and Political Science, University of Edinburgh, UK, ⁴Research Institute of Innovative Medicine, Jyoban Hospital, Japan and ⁵Department of Pulmonary Medicine, Minamisoma Municipal General Hospital, Japan

Abstract: Objectives: Legionnaires' disease (LD), which is atypical pneumonia with a broad variety of clinical symptoms, can lead to death despite its low incidence. There are multiple risk factors for LD, yet little information is available concerning what kind of environmental factors are linked to higher risk of LD development. We have experienced a fatal case of LD, which occurred in a decontamination worker after the Fukushima nuclear disaster. **Case:** A 53-year-old Japanese male visited our hospital with symptoms of fever, vomiting, diarrhea, and altered mental status, but not with respiratory manifestations. He was engaged in decontamination work, which generally includes operations such as the removal of topsoil in mountainous areas and cleaning roads and roofs of residential buildings with high-pressure water. He was required to wear specific equipment to prevent radiation exposure, and lived in a workers' dormitory or shared house, thereby sharing spaces with other workers. Normal antibiotic therapy did not improve his symptoms following his diagnosis with pneumonia. A urinary antigen detection test was then conducted, leading to a diagnosis of LD. Despite the change of antibiotic to levofloxacin, multiple organ failure led to his death. **Conclusion:** Decontamination workers may be at a high risk for developing LD and living and working conditions among them are possible contributors.

(J Occup Health 2018; 60: 271-274)

Received February 7, 2017; Accepted December 2, 2017

Published online in J-STAGE December 28, 2017

Correspondence to: T. Sawano, Department of Surgery, Minamisoma Municipal General Hospital, 54-6 Takamicho 2 chome Haramachi, Minamisoma, Fukushima 975-0033, Japan (e-mail: toyoakisawano@gmail.com)

doi: 10.1539/joh.17-0041-CS

Journal of Occupational Health is an Open Access article distributed under the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 International License. To view the details of this license, please visit (<https://creativecommons.org/licenses/by-nc-sa/4.0/>).

Key words: Clean-up worker, Decontamination worker, Fukushima Daiichi Nuclear Power Plant accident, *Legionella* bacteria

Introduction

Legionnaires' disease (LD) is an atypical pneumonia with a broad variety of clinical symptoms such as altered mental status, neurological abnormalities, diarrhea, and others, although respiratory symptoms are not prominent^{1,2}. Caused by *Legionella* bacteria, its occurrence is comparatively rare, comprising only 2%-9% of cases of community-acquired pneumonia³. However, severe LD can lead to death^{4,5}. The causal *Legionella* bacteria has spread globally in soils, natural, and artificial aquatic environments, and its epidemic form has been well described⁶⁻⁸. It is therefore imperative for clinicians to consider LD, despite its low incidence, in patients under conditions of high LD risks.

There are multiple risk factors for LD. First, from the patients' side, underlying health conditions such as a weakened immune system, diabetes mellitus, binge drinking, smoking, and being aged older than 50 years have been shown to facilitate the disease development^{7,9}. In addition, LD incidence is related to patient exposure to aero-

Table 1. Result of the laboratory test on admission day

Variable (Unit)	Value on admission	Reference range, adults
White-cell count (per mm ³)	15590	4500-11,000
Hematocrit (%)	42.2	41.0-53.5
Hemoglobin (g/dl)	14.9	13.5-17.5
Platelet count (per mm ³)	135000	150,000-400,000
Sodium (mmol/liter)	133	135-145
Potassium (mmol/liter)	2.6	3.4-4.8
Chloride (mmol/liter)	97	100-108
Glucose (mg/dl)	174	70-110
Aspartate aminotransferase (U/liter)	76	7-33
Alanine aminotransferase (U/liter)	32	9-32
Urea nitrogen (mg/dl)	14.2	8-25
Creatinine (mg/dl)	0.78	0.60-1.50
Creatin kinase (U/liter)	3903	52-336
C-reactive protein (mg/dl)	31.35	Negative

sols containing *Legionella* bacteria from soil and water, suggesting the importance of environmental factors¹⁰. *Legionella* bacteria can explosively proliferate under optimal temperatures in the presence of sufficient nutrients, such as in closed water circulation system and soils with composted leaves⁸. Thus, a higher risk of LD is suggested to exist in occupational environments with exposure to water and soils such as plants equipped with cooling towers or coolant systems, circulation baths, water and sewage plants, and farm land¹¹. However, there is limited information available concerning the kind of environmental factors linked to a higher risk of developing LD as *Legionella* bacteria is commonly seen in any natural aquatic environment, despite in low concentrations.

Decontamination work was launched in the radio-contaminated areas of Fukushima Prefecture with the goal of minimizing the level of external radiation to the general public after the Fukushima Daiichi Nuclear Power Plant disaster, which followed the mega-earthquake and tsunami on March 11, 2011^{12,13}. The number of decontamination workers in Fukushima Prefecture was approximately 30,000 to 40,000 in 2015¹⁴. Although it is of importance to deal with the health of the workers on public health because such many workers are engaged, to date there has been limited research concerning the occupational risks of decontamination work.

We have experienced 3 cases of LD, which occurred in individuals employed in decontamination and decontamination-related work in Fukushima Prefecture. Among them, we present here one fatal case of LD, as we were not able to contact the other two patients to obtain informed consent. Development of LD may be associated with the decontamination working environment and we, therefore, find important to publish detailed information about LD cases in order to work toward developing better

support for the workers' health.

Case Presentation

A 53-year-old Japanese man who had no past medical history moved to Fukushima Prefecture in April 2015 and lived in a workers' dormitory, taking up employment in decontamination work. Decontamination work is generally conducted under the following conditions: 8 hours of work per day, 5 days a week, with a 1-hour break per day. Decontamination work includes operations such as the removal of topsoil in mountainous areas and cleaning roads and roofs of residential buildings with high-pressure water, indicating frequent exposure to water and soil among the workers¹⁵. During decontamination work, workers such as the current case are required to wear long-sleeved shirts, long pants, and paper masks to avoid external or internal radiation exposure¹⁶. A considerable proportion of the decontamination workers are hired from other parts of Japan due to a severe shortage of workers in Fukushima, and almost all of these migrant workers live in workers' dormitories or shared houses, thereby sharing spaces with each other; our case experienced these same circumstances. Poor living conditions are reported to be a possible cause for the high burden of non-communicable diseases (NCDs) among the decontamination workers¹⁷.

The patient visited our hospital with symptoms of fever, vomiting, diarrhea, and altered mental status, although with no respiratory manifestations, in October 2015. Laboratory tests revealed a hepatic dysfunction, elevated creatine kinase, and hyponatremia (Table 1). Chest radiograph showed disseminated pulmonary infiltrates (Fig. 1). He was diagnosed with bacterial pneumonia and admitted to our hospital. Despite initiation of administration of ampicillin-sulbactam, his symptoms did



Fig. 1. Chest radiograph showed disseminated pulmonary infiltrates, particularly on left lung.

not improve.

Atypical pneumonia was suspected from the following factors: pneumonia without respiratory manifestations, altered mental status and inefficacy of antibiotic. A urinary antigen detection test was then conducted and he was finally diagnosed with LD. Although his antibiotic treatment was changed to levofloxacin, multiple organ failure led to his death at 5 days after admission.

Discussion

This study showed a case of LD diagnosed among decontamination workers in Fukushima Prefecture. The present study suggests that decontamination work, which includes removal of topsoil and cleaning roads and roofs of houses with high-pressure water, could be an environmental risk factor for the development of LD.

In Japan, clinicians are obligated to report the occurrence of a LD case to a local healthcare authority; however, we found that there had been no cases of LD reported since 2004 in the north coastal area of Fukushima Prefecture, where our hospital and the Fukushima Daiichi Nuclear Power Plant are located, before our cases were reported in 2015. A sudden occurrence of LD patients appears to be possibly associated with the increase of decontamination workers since 2014 in the areas affected by the Fukushima nuclear disaster. It is known that *Legionella* bacteria can spread under optimal temperatures in the presence of sufficient nutrients, and individuals likely to be exposed to these water and soil conditions have a higher risk of developing LD⁸⁾. Decontamination work includes eliminating topsoil in mountainous areas and using high-pressure water washing in the workplace, and the workers may therefore be in a highly susceptible

environment to *Legionella* infection. In order to prevent decontamination workers from developing LD, specific provisions such as personal protective equipment, including paper mask, disinfection of water supplies, improving working environment and educating employees, may be necessary.

The living environments of the decontamination workers may additionally contribute to LD risk. This report highlights one LD patient who lived in a dormitory. According to an investigation by the local healthcare center, *Legionella* bacteria was not detected in the bathes of the dormitories where each of the 3 patients lived. Furthermore, there were no epidemic cases in the dormitories. However, the local healthcare center did not investigate other potential high risk areas such as cooling systems in meeting places and other aquatic environments in the dormitories, and it is therefore possible that *Legionella* bacteria could remain at significant levels in the living environment where the patients had resided. It would clearly be helpful to carefully re-investigate the living environments where the decontamination workers are living in order to prevent further LD development, although in this report we could not investigate in detail the role of the living environments due to lack of available information.

A high incidence of NCDs among decontamination workers may also be a risk for developing LD. Although the current case did not have any past medical history of NCDs, possible poor control of NCDs, which was previously reported among decontamination workers¹⁵⁾, could lead to a greater susceptibility to bacterial infections. Indeed, another reported case in which poor control of an underlying disease led to the eventual death of a decontamination worker from sepsis following infection with *Klebsiella pneumoniae*¹⁶⁾ supports this hypothesis. It is important not only to improve the living and working environment of the decontamination workers, but also to improve the management of any underlying conditions.

There are some limitations to this case study. First, we cannot rule out the possibility that this decontamination worker may have incidentally developed LD in a work-unrelated manner. Second, a new full-time respiratory specialist who began working at our hospital after the disaster may have contributed to an accurate diagnosis of LD that could have been missed in the past. Third, although we described the lack of LD reported in the area since 2004, LD patients with mild symptoms may have been treated unintentionally because clinicians tend to liberally prescribe antibiotics, especially newquinolone, to outpatients in Japan. In addition, as to the diagnosis of LD, we cannot directly prove the existence of *Legionella* bacteria in this case as the patient's LD was diagnosed by a urinary antigen test. Moreover, we were unable to identify the species of *Legionella* bacteria, although the *Legionella longbeachae* suspected to have infected the patient is commonly found in the soil, supporting our view

that exposure to soils in decontamination work may contribute to LD occurrence. Further investigation, including the living and working environments of decontamination workers, is warranted to clarify what factor(s) truly underlies LD development among this population.

Conclusion

Decontamination workers may be at a high risk of developing LD and living and working conditions among them are possible contributors.

Acknowledgments: We would like to thank Shun Ishikawa at Ishikawa Construction for teaching us how the workers decontaminate radio-contaminated materials.

Conflicts of interest: None declared.

References

- 1) Cunha BA. Clinical features of legionnaires' disease. *Seminars in Respiratory Infections* 1998; 13(2): 116-127.
- 2) Cunha BA. Legionnaires' disease: clinical differentiation from typical and other atypical pneumonias. *Infectious Disease Clinics of North America* 2010; 24(1): 73-105.
- 3) Stout JE, Yu VL. Legionellosis. *The New England Journal of Medicine* 1997; 337(10): 682-687.
- 4) Fernandez JA, Lopez P, Orozco D, et al. Clinical study of an outbreak of Legionnaire's disease in Alcoy, Southeastern Spain. *European Journal of Clinical Microbiology & Infectious Diseases* 2002; 21(10): 729-735.
- 5) Mykietiak A, Carratala J, Fernandez-Sabe N, et al. Clinical outcomes for hospitalized patients with Legionella pneumonia in the antigenuria era: the influence of levofloxacin therapy. *Clinical Infectious Diseases* 2005; 40(6): 794-799.
- 6) Diederer BM. Legionella spp. and Legionnaires' disease. *Journal of Infection* 2008; 56(1): 1-12.
- 7) Farnham A, Alleyne L, Cimini D, et al. Legionnaires' disease incidence and risk factors, New York, New York, USA, 2002-2011. *Emerging Infectious Diseases* 2014; 20(11): 1795-1802.
- 8) Fields BS, Benson RF, Besser RE. Legionella and Legionnaires' disease: 25 years of investigation. *Clinical Microbiology Reviews* 2002; 15(3): 506-526.
- 9) Ginevra C, Duclos A, Vanhems P, et al. Host-related risk factors and clinical features of community-acquired legionnaires disease due to the Paris and Lorraine endemic strains, 1998-2007, France. *Clinical Infectious Diseases* 2009; 49(2): 184-191.
- 10) Fraser DW. Legionellosis: evidence of airborne transmission. *Annals of the New York Academy of Sciences* 1980; 353: 61-66.
- 11) Principe L, Tomao P, Visca P. Legionellosis in the occupational setting. *Environmental Research* 2017; 152: 485-495.
- 12) Hiraoka K, Tateishi S, Mori K. Review of health issues of workers engaged in operations related to the accident at the Fukushima Daiichi Nuclear Power Plant. *Journal of Occupational Health* 2015; 57(6): 497-512.
- 13) Ohtsuru A, Tanigawa K, Kumagai A, et al. Nuclear disasters and health: lessons learned, challenges, and proposals. *The Lancet* 2015; 386(9992): 489-497.
- 14) Center RDR. Dose distribution among workers engaged in decontamination and related works. [Online]. 2016; Available from: URL: http://www.rea.or.jp/chutou/koukai_jyosen/H27nen/English/honbun_jyosen-h27-English.html
- 15) Yasui S. Establishment of new regulations for radiological protection for decontamination work involving radioactive fallout emitted by the Fukushima Daiichi APP accident. *Journal of Occupational and Environmental Hygiene* 2013; 10(9): D119-124.
- 16) Sawano T, Tsubokura M, Leppold C, et al. Klebsiella Pneumoniae sepsis deteriorated by uncontrolled underlying disease in a decontamination worker in Fukushima, Japan. *Journal of Occupational Health* 2016; 58(3): 320-322.
- 17) Sawano T, Tsubokura M, Ozaki A, et al. Non-communicable diseases in decontamination workers in areas affected by the Fukushima nuclear disaster: a retrospective observational study. *BMJ Open* 2016; 6(12): e013885.