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REVIEW ARTICLE

Infectious Diseases after the 2011 Great East Japan Earthquake

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A catastrophic earthquake occurred off the Pacific coast of Japan on 11 March 2011, striking the northeastern part of the country. The earthquake was followed by huge tsunamis, which destroyed many coastal cities and towns. Many displaced people moved into shelters or temporary homes supplied by the government, not only because of disruptions to community utility services but also because of health risks associated with nuclear power plant malfunctions in Fukushima. In this review, we summarize the characteristics of illnesses that occurred in the aftermath of this earthquake, including respiratory tract infection (tsunami-related aspiration pneumonia, legionellosis and influenza), wound infection (tetanus) and other infections (food poisoning, tsutsugamushi disease and measles). Our review also outlines several activities concerning the management of illnesses and infection control.

1. Introduction

On 11 March 2011, at 2:46 PM (Japan Standard Time), a catastrophic earthquake occurred off the Pacific coast of Japan, striking the northeastern part of the country. The earthquake was followed by devastating tsunamis, which destroyed many coastal cities and towns (Figure 1).[1] According to the Japan Meteorological Agency, the magnitude of this earthquake was Mj9.0. A huge number of aftershocks have continued to occur since the earthquake, even up to the time of writing this article (21 October 2011). The tsunamis, which reached heights of 10–38 m, completely destroyed more than 90% of the dwellings in the towns that they struck. According to the report by the National Police Agency of Japan, as of 21 October 2011, 15,828 people had died in this disaster, and 3760 individuals are still missing.[2] In addition, 302,066 homes were completely or partially destroyed, and 3559 roads were destroyed.[2] Many displaced people (peak number approximately 470,000 on 14 March 2011) were living in shelters or temporary homes supplied by the government, not only because of disruptions to community utility services but also because of health risks associated with nuclear power plant malfunctions in Fukushima.[3,4] In particular, 37,482, 35,923 and 25,501 people were residing in the 357, 403 and 157 evacuation centers located in Iwate, Miyagi, and Fukushima prefectures, respectively, as of 6 May 2011.

Patient information regarding hospital admissions for respiratory diseases in the aftermath of the Great Hanshin-Awaji Earthquake in 1995 was obtained using questionnaires.[5] The queries concerned individuals who were admitted from the day of the earthquake until 10 weeks later, and the total number of patients admitted with respiratory diseases was 148. Patients with lobar pneumonia or focal pneumonia, or both, accounted for 58.8% of the total, and those with upper respiratory tract infection made up 19.6%. These observations suggest that infectious diseases are among the main illnesses requiring hospital treatment in the aftermath of an earthquake, and that they may lead to disaster-related deaths among evacuees.

In this review, we summarize the characteristics of illnesses including respiratory tract infection (tsunami-related aspiration pneumonia, legionellosis and influenza), wound infection (tetanus) and other infection (food poisoning, tsutsugamushi disease, and measles) that occurred in the aftermath of the 2011 Great East Japan Earthquake. Our review also outlines several activities concerning the management and prevention of these illnesses.

2. Respiratory tract infection

After the tsunamis that occurred off the coast of Banda Aceh, Sumatra, Indonesia, in 2004, tsunami-related aspiration pneumonia with lung and brain abscesses probably caused by polymicrobial pathogens was documented in a 17-year-old girl with

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Figure 1 Sendai city destroyed by tsunamis.

respiratory distress and hemiparesis.[6] Likewise, Okinaga[7] has reported clinical aspects of tsunami-related pneumonia in the aftermath of the 2011 tsunamis at the annual meeting of the Japan Geriatrics Society (JGS). Fifty-six subjects having tsunami-related pneumonia were admitted in the period 11–31 March to Kesennuma City Hospital in Miyagi. This was a significantly greater number of patients than the 12 pneumonia cases admitted during the same period in 2010. Six subjects with pneumonia as a result of tsunami drowning were transferred to the hospital during 11–14 March, and the remaining patients having pneumonia not associated with the drowning, some of whom revealed a bilaterally diffuse bud-in-trees appearance on chest computed tomography (CT) scans, were admitted later. Forty- six (82.1%) of the tsunami-related pneumonia patients were aged 70 years or older. They had been living in evacuation centers ($n = 25$), nursing homes ($n = 11$), and their own houses ($n = 10$) before admission, and seven (63.6%) of the 11 nursing-home residents died after admission, suggesting that this population might be at risk of poor prognosis. Seventeen individuals with shelter-acquired pneumonia (SAP), who were transferred to Tohoku University Hospital, have been described by Suzuki and her colleagues.[8] The mean age of the subjects in that study was 81.6 years (male:female ratio, 14:3), and all had a history of cerebrovascular accident or neurodegenerative disorder. The mean duration between arrival at the shelter and SAP onset was 15.2 days. Laboratory tests on admission showed low levels of serum albumin (2.6 g/dL), cholesterol (110 mg/dL), and peripheral blood lymphocyte count (1032/μL), with high serum C-reactive protein concentrations (21.1 mg/dL). Urine pneumococcal antigen test showed positive in three subjects. The chest CT scans indicated that consolidation was located in the lower part or the back of the lungs. In addition, the patients had both prolonged swallowing reflexes (4.1 seconds, normal <2.0 seconds) and low sensitivities of cough reflex (2.1 log mg/mL, normal <0.5 log mg/mL). These data suggest that silent aspiration might have triggered the development of SAP. Under the unfavorable circumstances found in shelters, the evacuees were forced to sleep on narrow spaces on the floor in a supine position, hesitated to cough in order to avoid making noise, and did not pay attention to their oral care (i.e., tooth brushing or cleaning false teeth). Guidelines for preventive interventions for SAP need to be established immediately.

According to a report from the Infectious Disease Surveillance Center of the National Institute of Infectious Diseases,[9] data regarding legionellosis which occurred in stricken areas, are shown in Table 1. Four patients, including three adults and an infant, who were living in either Iwate or Miyagi, had been caught in the tsunami disaster on 11 March, and one of them died as a result of this illness. Since tsunami waters may contain soil microbes such as *Legionella* species, clinical doctors need to consider the possibility of legionellosis (incubation period 2–10 days) when examining and treating people suffering from pneumonia after a tsunami disaster.[10] Elderly evacuees under unfavorable circumstances have an increased risk for developing pneumonia, and those who aspirate a small amount of the organism may develop legionellosis. Ebisawa et al[11] have reported pulmonary co-infection of *Legionella* and multiple antibiotic-resistant *Escherichia coli* in a previously healthy 75-year-old woman, as a result of immersion in tsunami waters 1 km inland from the Pacific coastline following the 2011 Great East Japan Earthquake. This patient required drainage several times and long-term use of multiple antibiotics according to the bacteria observed and an antibiotic susceptibility test. Clinicians should be aware of infectious diseases caused by multiple pathogens, including *Legionella* species, in the environment following a tsunami.

After the Great East Japan Earthquake, survivors were exposed to cold conditions. Data on influenza virus detected during 12–21 March in and around Sendai city have been documented.[12] Of 1180 visits to Sendai City Emergency Center, 335 subjects received a rapid detection test for the influenza virus. The A type virus was found in 107 (31.9%) patients, while the B type virus was found in only five (1.5%) individuals. The Sendai Institute of Hygiene has reported dominant identification of subtype H3N2, suggesting that the subtype might be circulating in the area. Fortunately, influenza occurred sporadically among evacuees ($n = 3$) and in support staff at the different shelters. Preseason vaccination against the influenza virus is recommended for elderly individuals and support staff.

3. Wound infection

An outbreak of tetanus was observed from December 2004 to January 2005 after tsunamis struck Aceh province, Indonesia.[13] A total of 106 patients with clinically diagnosed tetanus were reported in the first month after the disaster, and most cases occurred among adults. The mortality ratio was 18.9%, and was higher among older individuals and among those with short incubation periods. According to a report from the Infectious Disease Surveillance Center,[9] data regarding tetanus that occurred in the stricken areas in the 2011 disaster in Japan, are shown in Table 2. Nine patients, who were living in either Iwate or Miyagi, had already been injured in the disaster on 11 March. The median age of these subjects was 65 years (range, 56–82 years), and none died. Clinicians always need to consider the possibility of this infection when examining and treating individuals with injuries from tsunamis, especially those who have lockjaw and/or muscular contraction. In addition, preventive measures against tetanus, including both wound cleaning and immunization, should be performed in the context of the disaster.

Table 1 Data regarding legionellosis after the 2011 Great East Japan Earthquake

Case no.	Area (prefecture)	Age (years)	Onset date	Diagnosis date
1	Iwate	2	3/11/2011	3/31/2011
2	Miyagi	70s	3/17/2011	3/17/2011
3	Miyagi	60s	3/18/2011	3/20/2011
4	Iwate	30s	NA	3/27/2011

NA = not available.

Table 2 Data regarding tetanus after the 2011 Great East Japan Earthquake

Case no.	Area (prefecture)	Age (years)	Onset date	Diagnosis date
1	Miyagi	50s	NA	3/20/2011
2	Iwate	60s	3/19/2011	3/25/2011
3	Iwate	50s	3/21/2011	3/21/2011
4	Miyagi	60s	3/21/2011	3/25/2011
5	Miyagi	80s	3/22/2011	3/25/2011
6	Miyagi	60s	3/25/2011	3/27/2011
7	Miyagi	70s	3/25/2011	3/28/2011
8	Miyagi	60s	3/29/2011	4/1/2011
9	Miyagi	70s	NA	4/6/2011

NA = not available.

4. Other infections

An outbreak of norovirus gastroenteritis among elderly evacuees following the 2007 Noto Peninsula Earthquake was documented.[14] There were 74 evacuees, including 61 elderly people, in the shelter where this outbreak occurred. Thirty-one evacuees with acute gastroenteritis, 29 of whom were aged 65 years or older, were examined and treated. Two patients developed aspiration pneumonia and were admitted to the hospital. A medical aid team instructed all the evacuees on personal hand-washing, gargling and the use of disinfectants on environmental surfaces. Few subjects with gastroenteritis were reported in the center 1 week later. After the 2011 earthquake, medical care providers (MCPs) should pay attention to the possible spread of gastroenteritis, diarrhea, and other illnesses caused by contaminated drinking water and food.[15] Fortunately, the gastroenteritis occurred sporadically, not epidemically, at the stricken areas during acute and subacute stages after the disaster.[16] In June 2011, food poisoning caused by *Clostridium perfringens* occurred through the food provisions of support staff living outside the stricken areas.[17] Volunteers should take maximum precautions against food contamination.

Before the 2011 disaster, Tsutsugamushi disease in people infected with *Orientia tsutsugamushi* was endemic in Fukushima in spring and autumn. Therefore, the disease occurrence through a landslide caused by the earthquake is considered a serious problem.[18] However, epidemiological reports regarding this infection have not been performed.

Measles transmission following tsunamis was observed in India in 2004–2005.[19] On 30 March, 2011, a healthy foreigner visited Japan to collect data at the stricken areas, and then suffered a fever and systemic eruption on 6 April. The patient was diagnosed with measles, based on detection of the virus (genotype D4) in a throat swab sample by reverse transcription-polymerase chain reaction assay.[20] Measles is a highly contagious infectious disease with a significant public health impact among displaced people, and it is necessary to strictly monitor its onset.

5. Countermeasures

In April 2010, 10 members formed a study group on guidelines for first steps and emergency triage to manage elderly evacuees of natural disasters. Two types of guidelines were established: one for MCPs and another for non-MCPs (NMCPs) (the latter including, for example, volunteers, helpers and family members taking care of elderly relatives), public health nurses (PHNs), or certified social workers (CSWs). The guidelines for NMCPs, PHNs, and CSWs seemed to be more effective than those for MCPs, because there were limited MCP resources. The guidelines had three chapters as follows: (1) features and prevention of critical diseases in the elderly in evacuation areas; (2) signs of acute diseases in the elderly; and (3) symptoms of anxiety in the elderly at shelters.[21]

Figure 2 A community center for evacuees at Higashi-Matsushima city.

After the 2011 earthquake, 20,000 guideline booklets were sent by members of the JGS and the Japan Medical Association Team (JMAT) to NMCPs, PHNs and CSWs working in Iwate, Miyagi (Figure 2), and Fukushima.[22] The JGS and JMAT members were dispatched to these areas to care for evacuees. NMCPs, PHNs, and CSWs used the booklets to detect illnesses rapidly in elderly evacuees at shelters or homes. The aim of this study is to reduce morbidity and mortality from disaster-related illnesses including infectious diseases (influenza, pneumonia, gastroenteritis, urinary tract infection, cellulitis, tuberculosis) in elderly evacuees. Surviving older adults were largely left to their own devices, and were marginalized at shelters. Elderly refugees tended not to talk about their problems, so their suffering tended to be underestimated.[23] It is therefore important for NCMPs, PHNs, and CSWs to quickly detect medical conditions in this population.

Kanamori and his colleagues have described infection control campaigns at shelters in Miyagi after the 2011 earthquake.[24] The Tohoku Regional Infection Control Network acted functionally and collaboratively on the activities at the shelters and hospitals at the stricken areas. This network had four main activities: (1) infectious disease consultation; (2) infection control educational programs and training; (3) infection control interventions; and (4) regional cooperation with local government against infectious diseases. Similar network activities will be performed in other areas in the future.

6. Conclusion

A large number of evacuees were exposed to cold, unhygienic conditions and malnutrition because of power failures, insufficient food provision, and a lack of running water at evacuation centers (such as gymnasiums and school halls) after the 2011 earthquake. The refugees (especially elderly subjects and infants) faced the threat of infectious diseases. Therefore, MCPs, NCMPs, PHNs, and CSWs should pay special attention to medical conditions in these populations, because elderly or infant patients are susceptible to disaster-related death.

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