Tsunami and Flood

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11.1 Introduction

The earthquake occurred at 2:46 pm on 11 March 2011. The magnitude was 9. It was the Great Eastern Japan Earthquake. Thirty minutes after the earthquake, a tsunami occurred; the tsunami struck the northeast coast of Japan. At least 15,854 people died. There were more than 340,000 refugees, and 3155 people are still missing 1 year later.

Tsunami is a Japanese word meaning "harbor wave," which makes sense when you consider the fact that we have suffered the terrible effects of tsunami from ancient times. The northeast coast of Japan was savaged by a tsunami in May 869 and more recently in June 1869 [1]. Previous generations left an important warning: "After the big earthquake, a tsunami came."

In 2011, the Japanese people had a horrific experience: a huge earthquake, followed by a tsunami, and unexpected radiation pollution. We must document the facts since we have a responsibility to leave a message for the next generation.

In Eastern Japan, most of the damages and destruction were caused by the tsunami, not by the earthquake or fire. In the case of the tsunami, most people either managed to survive or drowned.

A previous study showed that sea water from a tsunami is not safe and contains virulent microorganisms. It can cause sepsis, serious lung infection, and severely contaminated wounds [2, 3]. Skin and soft tissues were the most commonly involved, especially the lower extremities [4]. The aims in the early stages of wound and fracture management are to diagnose the injuries, debride wounds, and immobilize fractures [5].

The Gustilo and Anderson's classification is often used for open fractures [6]. These wounds should be provided adequate initial treatments. Immediate stabilization of bone fractures with effective traction or splints is a basic principle of orthopedic care until definitive surgery in the second week [7].

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11.2 Type of Orthopedic Injury by Tsunami

There were 475 orthopedic-related patients on 11–20 March 2011, at Kesennuma Public Hospital in Japan. Laceration, contusion, and sprain were 209 (44 %). Fracture and dislocation were 48 (10 %) and lumbago 123 (26 %). Rheumatism and arthritis were 90 (19%). Tetanus toxoid (15 were stocked) was exhausted on that day (11 March 2011) [8] (Table 11.1).

In Thailand, data from three hospitals are involved with the tsunami incident on 26–31 December 2004 [5]. There were totally 2311 patients. Approximately 40 % (946 patients) suffered from salt water aspiration and orthopedic-related injury 61.4 % (1461 patients). Most common orthopedic injuries were minor [559 patients (24 %)] and major wounds [586 (25 %)]. Around 7 % sustained fracture dislocation. Minor wound was defined as abrasion, scratch, or small lacerations where there was no need for debridement. Major wounds were lacerated and included with or without skin loss, infected tissue, necrotic fasciitis, and open fracture. Two of eight necrotizing fasciitis cases had sepsis and died from puncture wounds [5] (Table 11.2).

Table 11.1 Orthopedic-related patients on 11-20th March 2011 at Kesennuma public hospital in Japan

Injury	Patients *n* (%)
Laceration	100 (21)
Contusion	95 (20)
Fracture	43 (9)
Dislocation	5 (1)
Sprain	14 (3)
Arthritis	43 (9)
Rheumatism	47 (10)
Lumbago	123 (26)

Table 11.2 Orthopedic-related patients on 26-31th December 2004 at three hospitals in Thailand

Injury	Patients *n* (%)
Minor wound	559 (23.7)
Major wound	586 (24.8)
Fracture	133 (5.7)
Dislocation	12 (0.5)
Spine injury	13 (0.6)
Necrotizing fasciitis	10 (0.4)

11.3 The Infections and Treatment of Wounds

Wound infection was the second most common health problem among the survivors of tsunami. Wounds occurred just after the tsunami and became infected within 72 h. Infections were more likely to occur in open wounds than in abrasion, contusion, or ecchymosis. Data was collected from 26 December 2004 to 31 January 2005 at four public hospitals in Thailand [9]. Wounds were contaminated with mud, sand, debris, and sea water and had an infection rate of 674/1013 (66.5 %). Most wounds (45 %) had polymicrobial infection with gram-negative rods such as Escherichia coli, Klebsiella pneumonia, Proteus, and Pseudomonas species (Table 11.3). Early treatment with antibiotics was protective for post-tsunami patients with wounds. Patients should be given broad-spectrum antibiotics targeted for gram-negative bacteria, polymicrobial infections, and with human tetanus immunoglobulin.

The risk of wound infection increased with size and presence of an open fracture. However, wound with small penetrating entrance should be considered dangerous and should not be underestimated by first triage. Case reports presented patients who walked in with a minor wound but died within 24–48 h as pathogens penetrated the skin and destroyed the underlying structure rapidly [10]. It caused widespread necrotizing fasciitis. In the later stages, multiorgan failure from sepsis occurred [11]. Late-stage infections may result in gangrene, necrotizing fasciitis, systemic illness, and sepsis. Treatment is with antibiotics (doxycycline and third-generation cephalosporin) or fluoroquinolone [12].

Table 11.3 The type of bacteria cultured from wound from 26th December 2004 to 31st January 2005 at four public hospitals in Thailand

Bacteria cultured from wound	Frequency *n* (%)
Escherichia coli	26 (16.8)
Klebsiella pneumonia	19 (12.3)
Staphylococcus aureus	18 (11.6)
Proteus vulgaris	14 (9)
Pseudomonas aeruginosa	14 (9)
Proteus mirabilis	9 (5.8)

The high rate of infection was related to resource-limited situation, despite most of the patients (94.9 %) received antibiotics. Sand embedded in the tissues can be removed by a toothbrush. In case of unavailable sterile saline, bottle water or tap water should be an acceptable substitute [13]. The wounds should be left open, using ample absorbent gauze dressings, or covered temporarily with a vacuum-assisted closure (VAC) system [14]. The wounds should be re-explored and re-debrided 24–48 h after initial procedures. Excluding the risk of infections, delayed primary closure of wounds is recommended approximately 5 days later.

Choice of limb salvage or amputation should be carefully judged. Discrepancy in the treatment modalities may be related to surgeons' experience and judgment. Surgeons need to be familiar with a wide range of injuries and advanced techniques in soft tissue and bone management. Although there is not sufficient evidence, reconstruction should be considered as soon as possible once the wound bed is clean [15].

11.4 Communications and Cooperation

We went to the disaster area as a Disaster Medical Assistance Team (DMAT) on 11 March 2011 the same day that the earthquake struck. The first DMAT in Japan was established after reflection on the lessons of the Kobe earthquake of 1995. It was realized that such teams could have saved many lives immediately after such a large earthquake. A DMAT is a specially trained team that conducts rescue work and provides emergency medical treatment and transportation of seriously injured victims within 48 h after a disaster. The DMAT brings medical supplies and personnel to the disaster area and airlifts victims out of the area, because the roads are often blocked.

In the Kobe earthquake, many buildings and roads collapsed as a result of earthquake tremors or were destroyed by fire. Many people were injured. In the case of earthquake accompanied by the collapse of buildings, there is a real need for orthopedic surgeons. In Sri Lanka, many houses were destroyed by the tsunami; there was a need for many orthopedic surgeons too [16]. When disaster strikes, it is necessary to secure orthopedic surgeons for emergencies.

Most deaths associated with tsunamis are related to drowning. Injuries such as broken limbs and head injuries are caused by debris in the water. These high-energy extremities wounds caused by tsunami are similar to those of war wound injuries [14]. Military troop or sealift command hospital ships, for instance, USNS Mercy, supported orthopedic care after the 2004 Asian tsunami. The ship has 1000 beds, intensive care unit (ICU), 12 operation rooms, and military transport helicopters. Hospital ship is effective for tsunami due to their proximity to the coast [17].

11.5 Medical Facility and Relief

The Municipal Shizugawa Hospital was exceeded by a wave 15 m in height (4th floor) on 11 March 2011 in Miyagi Japan. Seventy-two patients and three staff members were lost to the tsunami [1]. It is necessary that hospitals be built at high altitudes or more than five floors high. The Ishinomaki Red Cross Hospital was relocated on a high hill when it was rebuilt in Miyagi, Japan. The hospital was almost undamaged by the earthquake and tsunami and was able to function at over peak capacity after the disaster. We learned that the units must be self-sustaining for 72 h. Hospitals should have communications (satellite phone), supplies of antibiotics, insulin, tetanus antitoxin, dialysis, and an emergency electric power source.

In big cities located near the coast at low altitudes, there is a risk for tsunami after large earthquakes. Tsunami over 15 m high can occur within 30 min after an earthquake. The average distance a person can move in 30 min after an earthquake is only 500 m. The use of a vehicle is not possible in floods and tsunami since two feet of water can carry away most automobiles, and road obstruction and traffic jams are common in the early period after a disaster. Thus, it is vital that people evacuate as soon as possible. When fleeing a tsunami,

there is no time to gather clothes and food. We recommend that people should not waste precious time looking for survival kits; instead, they should immediately escape to higher ground. Most victims were those who failed to escape, not those who had starved to death.

11.6 Learning from Tsunami Experience and Damages

In the case of the 2004 December 26 tsunami, most of the wounded people survived. Those who perished have drowned. The number of serious injuries was much lower than many emergency medical teams expected [18]. In the Great Eastern Japan case, there were few severe injuries despite the number of victims, and surgeons were not necessary. It is necessary to change the type of rescue work depending on the type of disaster. For instance, when most of the damage is caused by the tsunami, it seems better to send medical teams and supplies to evacuation areas. Many people lost usual drugs and prescription refills.

There were extreme shortages of gasoline and oil in Eastern Japan for about a month after the earthquake. Cities should prepare for a lack of regular energy sources in the wake of a disaster.

Another big problem in the aftermath of the Great Eastern Japan Earthquake has been radiation pollution [19]. The radiation pollution was level 7, which was the same level as that of the Chernobyl disaster in Ukraine (Union of Soviet Socialist Republic) in 1986. The radiation pollution has been a real obstacle to the recovery from the disaster. In Fukushima Prefecture, many people are still evacuated. The Great Eastern Japan Earthquake has been an eye-opening experience that has made us reconsider the wisdom of relying on nuclear power plants and has made us realize the need to look for safer sources of sustainable energy for the future of the world.

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