Brief report

Lessons learned from the total evacuation of a hospital after the 2016 Kumamoto Earthquake

Youichi Yanagawa MD.PhD., Hisayoshi Kondo MD.PhD.[1], Takashi Okawa MD.PhD. [2], Fumio Ochi MD,PhD. [3]

Department of Acute Critical Care, Shizuoka Hospital, Juntendo University
Secretariat, Japan Disaster Medical Assistance Team[1]
Medical, Western Army, Japan Ground Self Defense Force[2]
Kumamoto Hospital, Self Defense Force[3]

Correspondence author: Youchi Yanagawa
Zip code 410-2295, 1129 Nagaoka Izunokuni city Shizuoka, Japan
Tel: 81-55-948-3111
e-mail: yyanaga@juntendo.ac.jp
Running head: Civilian-military cooperation on Kumamoto Earthquake
Source, Presentation: None

Abstract

Background: The 2016 Kumamoto Earthquakes were a series of earthquakes that included a foreshock earthquake (magnitude 6.2) on April 14 and a main shock (magnitude 7.0) on April 16, 2016. A number of hospitals in Kumamoto were severely damaged by the two major earthquakes and required total evacuation.
Methods: We retrospectively analyzed the activity data of the Disaster Medical Assistance Teams using the Emergency Medical Information System records to investigate the cases in which the total evacuation of a hospital was attempted following the 2016 Kumamoto Earthquake.
Results: Total evacuation was attempted at 17 hospitals. The evacuation of one of these hospitals was canceled. Most of the hospital buildings were more than 20 years old. The danger of collapse was the most frequent reason for evacuation. Various transportation methods were employed, some of which involved the Japan Ground Self Defense Force; no preventable deaths occurred during transportation.
Conclusion: The hospitals must now be renovated to improve their earthquake resistance. The coordinated and combined use of military and civilian resources is beneficial and can significantly reduce human suffering in large-scale disasters.

Key words: civilian-military cooperation; Kumamoto; Earthquake

1. Introduction

Japan is located at the junction of four continental plates (the North-American, Eurasian, Philippine Sea and Pacific continental plates).In this region, earthquakes are a frequent occurrence. Since 1500, there have been more than 60 earthquakes with a magnitude of >6. These have caused numerous deaths in Japan. The worst case was the Great Kantō earthquake in 1923, in which approximately 105,000 people died due to earthquake itself and the subsequent conflagration. Since the Ise Bay Typhoon in 1959, which was postwar Japan's second-worst natural disaster, various efforts have been made to improve disaster preparedness—these include flood control (*i.e.*, forestry conservation, river improvement, and shore maintenance), meteorological observation, the development of forecast technology, systems for effectivelytransmitting disaster information, and the disaster prevention system, including the refuge system. Thanks to these improvements, no large-scale disasterscaused more than 1000 deaths until the Great Hanshin-Awaji earthquake of 1995.

The Great Hanshin-Awaji earthquake underscored the need to establish Disaster Medical Assistance Teams (DMATs) in Japan. Thus, the Japanese government's Central Disaster Prevention Council revised its Basic Disaster Management Plan to include the full deployment of DMATs in disaster areas and a new method for transmitting disaster-related information[1,2].Japan's DMATs are small-scale units that are designed to respond to the demands of acute emergencies[2,3]. The DMATs are trained, mobile medical teams that can be rapidly deployed during the acute phase of a sudden disaster. The average DMAT consists of two doctors, two nurses and one person to handle logistics. As of March 2015, more than 1400 teams had been created. The members of DMATs, who usually work in acute critical care and trauma centers, are dispatched to a disaster area after a disaster. The emergency medical information system (EMIS) is a new system that through which medical information about hospitals, patients, DMATs, medical evacuation, medical supplies and medications, shelter, and other relevant details are shared with all of the personnel who are involved in the medical response to a disaster[4]. The EMIS integrates this information in order to effectively deal with the disaster situation, and helps to adjust the distribution of patients, medical supplies, medications, DMATs and transportation.

The Great East Japan Earthquake (magnitude: 9.0 [Mw]) occurred on March 11, 2011.The earthquake triggered a powerful tsunami waves that reached heights of up to 40 meters. The earthquake and tsunami caused over 15,893 deaths and 2,556 people remain missing. Following this disaster, the Japanese government re-estimated the damage that would occur from a huge Nankai Trough earthquake in the Pacific Ocean. The Nankai Trough marks the boundary with the Philippine tectonic plate (**Figure 1**). Large earthquakes are generated at this location every 100–150 years. Historically, there have been several catastrophic Nankai Trough earthquakes, and a major Nankai Trough earthquake is predicted to occur in the near future. The Japanese government announced the results of their re-estimation on August 30, 2012. In the worst-case scenario for a huge Nankai Trough earthquake, a magnitude 9 earthquake would hit the central and western parts of Japan in the middle of the night in winter, generating a massive tsunami along the Pacific coast. It was estimated that such an event could cause as many as 323,000 deaths in Japan, in addition to extensive damage and large numbers of injuries[1].

The 2016 Kumamoto Earthquake was an inland earthquake that occurred due to a gap on an active fault on April 14, 2016. Initially, a magnitude 6.5 foreshock occurred in the Kumamoto area on April 14, 2014. Then, on April 16, a stronger magnitude 7 earthquakeoccurred as the main shock[5]. This was the

first time in Japan (in recorded history) that a foreshock was followed by a more powerful main shock. Due to the two major earthquakes and after-shocks, multiple landslides occurred (**Figure 1**), 50 people died, more than 1000 people were injured and approximately 44,000 people sought safety in places such as public schools and public offices. Most of the deaths occurred due to crush injuries—the victims were found under the wreckage of collapsed houses (Asahi Shimbun April 16, 2016; http://www.asahi.com/articles/ASJ4H5173J4HTIPE04S.html).

A Mainichi Shimbun survey reported that the majority of houses and apartments that collapsed and killed people in the recent Kumamoto earthquakes were built before 1981, when the current earthquake resistance standards were introduced. (Mainichi Shimbun April 23, 2016; http://mainichi.jp/articles/20160423/k00/00m/040/128000c). In addition, some of the hospitals in Kumamoto were severely damaged and required total evacuation. Accordingly, we investigated the total evacuation from hospitals in the 2016 Kumamoto Earthquake.

2. Methods

The main objective was to clarify the weak points of hospitals, with regard to the necessary preparations for earthquakes, by investigating the problems that occurred during the evacuation and to evaluate the safety of the evacuation, in order to identify areas for improvement. We retrospectively analyzed the activity data of DMATsbased on the EMIS recordsin order to investigate the total evacuation of hospitals in the 2016 Kumamoto Earthquake.The data that we collected from the EMIS included the specialty of the hospital, number of beds, number of transported patients,age of building,reason for evacuation and the method of transportation. In addition, we also investigatedthe locations ofthe landslides that occurred in Kumamoto prefecture and the decision to attempt a total evacuation at the 17 hospitals, because the numerous landslides that occurred due to the earthquakes might have influencedthese decisions[6,7].

The protocol of this retrospective study was approved by the review board of Juntendo Shizuoka Hospital, and all of the examinations were conducted according to the standards of good clinical practice and the Declaration of Helsinki.

3. Results

Total evacuation was attempted at 17 hospitals (Table 1). In 1 hospital (Hospital G), the evacuation was cancelledbecause the authorities determined that the hospital could continue to operate under almost normal conditions. Most of the hospital buildings were more than 20 years old and 10 of the 16 hospitals had been built before 1981 (when the current quake resistance standards were introduced). Reconstruction has been planned at 3 of the 10 hospitals, but it has not yet been carried out due to budgetary issues.

The danger of collapse was the most frequent reason for evacuation. Hospitals B, G, and K had water damage due to the breakdown of sprinkler systems or water tanks, despite the fact that hospitals B and K were in compliance with the current earthquake resistance standards. A variety of transportation methods were employed, some of which involved the Japan Ground Self Defense Force. No preventable deaths occurred during transportation[8].

The locations of the landslides in Kumamoto prefecture and the decision to attempt total evacuation at each of the 17 hospitals are shown in **Figure 1**. Hospitals L and J were locatedclose to a landslide.

Most other hospitalswere not located near landslides. Thus, the decision to evacuate was made based on problems with the hospitals rather than landslides; these problems included the lower levels of earthquake resistance (this affected most hospital buildings) and water damage, which even occurred some hospitals that were in compliance with the current earthquake resistance standards.

4. Discussion

Cabinet offices and local governments that are located near the Nankai Trough are prepared for a major earthquake, based on the lessons learned from the Great East Japan Earthquake—a magnitude 9.0 (Mw) earthquake that occurred on March 11, 2011. However, Kumamoto prefecture is located in western Japan and it is not close to the Nankai Trough (**Figure 1**).It was therefore previously assumed that a lower level of earthquake preparedness was acceptable. Consequently,the preparedness—including the earthquake resistance of buildings—was insufficient. As a result, many hospitals were damaged by the earthquake, and the total evacuation of a large number of hospitals was necessary. Accordingly, these hospitals must now be renovated to improve their earthquake resistance.

Three of the hospitals had to be evacuated due to water damage. In the Great East Japan Earthquake, water damage (due to the collapse or malfunction of sprinklers) affected 26.3% of the buildings in the disaster area. As a result, the Fire and Disaster Management Agency decided to establish new regulations for earthquake-resistant sprinkler systems (Nikkei Financial Time 2013;August 15.http://www.nikkei.com/article/DGXNASDG08057_V10C13A8CR0000/). Although hospital K was in compliance with the current earthquake resistance standards, its sprinkler system was not. Thus, the hospital also needs to acquire earthquake-resistant sprinklers.

Liaisons from the Japan Self Defense Force (Army), the DMATs, the Red Cross, medical associations and administrative officers gathered at the disaster countermeasures office in Kumamoto prefectural office and shared the information on the disaster and the planned their daily medical activities. Inter-hospital evacuation was an important mission. The inter-hospital evacuation of critically ill patients requires trained physicians to provide care during transportation; however, the Japan Self Defense Force does not have sufficient numbers of emergency and critical care physiciansfor these medical activities. The total inter-hospital evacuation of critically ill patients requires transportation; however, DMATs do not have the capacity to transport multiple patients and have limited communication capabilities. In previous disasters, the Japan Self Defense Force and DMATs have successfully cooperated to compensate for these shortcomings[1,3,4,9,10]. In addition, the two organizations have recently undergone a number of disaster training sessions[1,9].These training sessions were important to the success of the hospital evacuations in Kumamoto prefecture. As a result, no preventable disaster deaths occurred during the total inter-hospital evacuations that took place after the 2016 Kumamoto Earthquake[8].

All resources need to be accessed if the response to a large-scale disaster is to be successful. The coordinated and combined use of military and civilian resources in such settings is beneficial and can significantly reduce human suffering[11]. Thus, the relationship between military and civilian resources should be strengthened to allow them to respond to large-scale natural disasters in the future.

5. Conclusion

The hospitals in Kumamoto prefecture must now be renovated to improve their earthquake resistance. The coordinated and combined use of military and civilian resources in the response to large-scale disasters is beneficial and can significantly reduce human suffering.

Conflict of interest

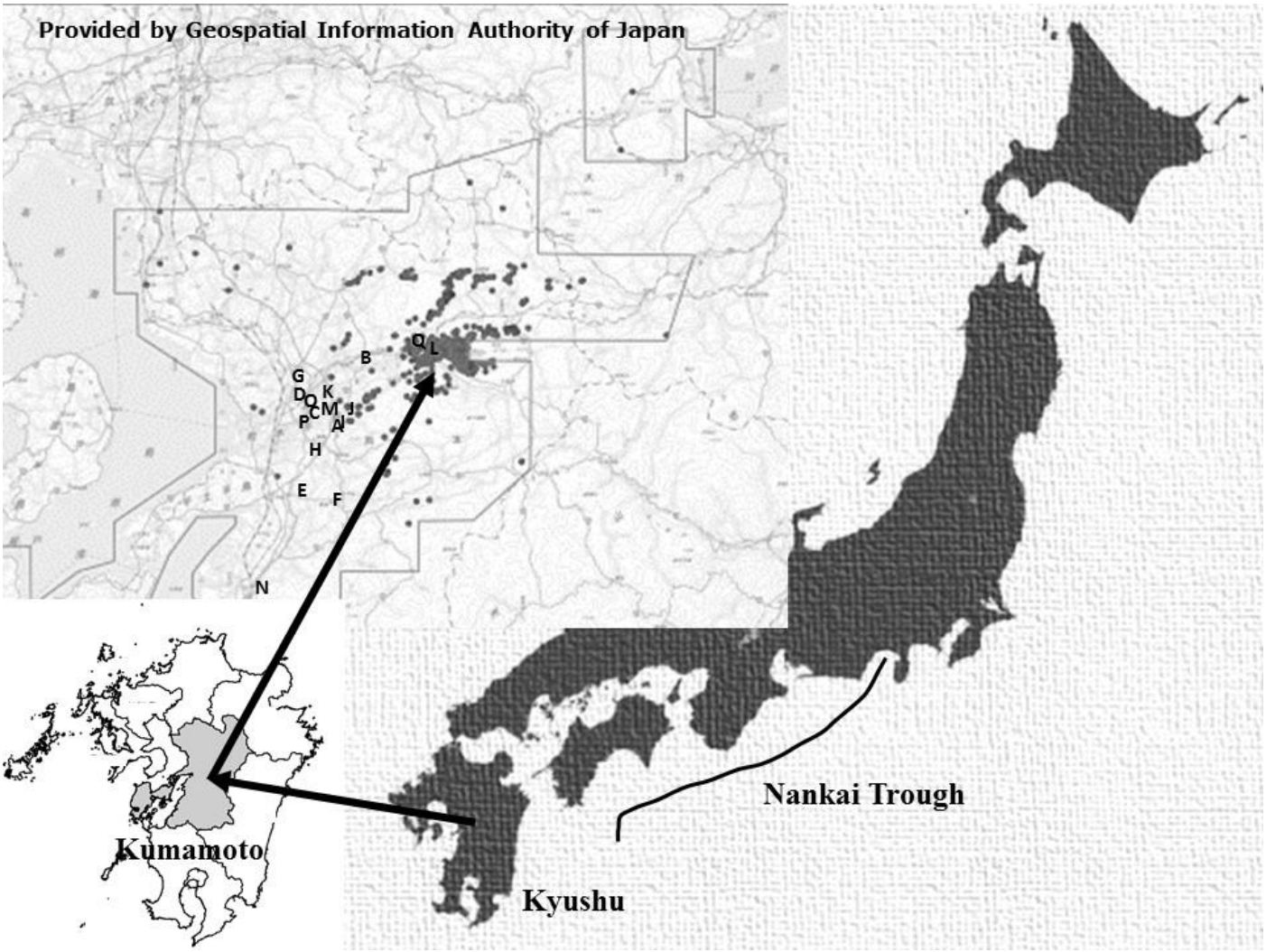
Youichi Yanagawa received research fund from MEXT-Supported Program for the Strategic Research Foundation at Private Universities, 2015-2019 concerning the constitution of total researching system for comprehensive disaster medical management, corresponding to a wide-scale disaster.

References

1. Yanagawa Y, Nakamori T, Ishikura K, Ishii F, Yamaguchi E, Kouzu S, Saruta M, Kitakawara S, Aoki M, Ohta M, Kogasaka N, Takekawa R, Koido Y: Disaster drill for a huge Nankai Trough Earthquake and the construction of a medical staging care unit on a navy destroyer in Japan. EMS World 2013; Nov 27.
2. Fuse A, Yokota H. An analysis of Japan Disaster Medical Assistance Team (J-DMAT) deployments in comparison with those of J-DMAT's counterpart in the United States (US-DMAT). J Nippon Med Sch. 2010;77:318-24.
3. Kondo H, Koido Y, Morino K, Homma M, Otomo Y, Yamamoto Y, Henmi H. Establishing disaster medical assistance teams in Japan. Prehosp Disaster Med. 2009;24:556-64.
4. Homma M. Development of the Japanese National Disaster Medical System and Experiences during the Great East Japan Earthquake. YonagoActamedica 2015;58:53–61.
5. Kato A, Nakamura K, Hiyama Y. The 2016 Kumamoto earthquake sequence. Proc JpnAcadSer B Phys Biol Sci. 2016;92:358-371.
6. Tsuji T, Ishibashi J, Ishitsuka K, Kamata R. Horizontal sliding of kilometre-scale hot spring area during the 2016 Kumamoto earthquake. Sci Rep. 2017;7:42947.
7. Petley D. Landslides from the Kumamoto earthquake in Japan. The Landslide blog. 2016, April 18. (http://blogs.agu.org/landslideblog/2016/04/18/kumamoto-earthquake-1/)
8. Nagata T, Himeno S, Himeno A, Hasegawa M, Lefor AK, Hashizume M, Maehara Y, Ishii M. Successful Hospital Evacuation After the Kumamoto Earthquakes, Japan, 2016. Disaster Med Public Health Prep. 2017 Feb 22:1-5.
9. Yanagawa Y, Omori K, Obinata M, Mishima K, Ishikawa K, Osaka H, Oode Y, Sakurada M, Muramatsu S. Shizuoka Prefecture Disaster Drill Involving the Japanese and US Military. Disaster Med Public Health Prep. 2015;9:476-7.
10. Yanagawa Y, Miyawaki H, Shimada J, Morino K, Satoh E, Ohtomo Y, Ichihara M, Kondo H. Medical evacuation of patients to other hospitals due to the Fukushima I nuclear accidents. Prehosp Disaster Med. 2011;26:391-3.
11. McCartney SF. Combined Support Force 536: Operation Unified Assistance. Mil Med. 2006;171(Suppl 1):24-6.

Figure legends

Figure 1. The locationsof Kyushu, the Nankai Trough and Kumamoto prefecture (left lower figure).
Kumamoto prefecture is located in western Japan and is not close to the Nankai Trough.
Thelocationsof the landslides (small black circles in the upper-left image) and hospitals that tried to carry out total evacuation (A-O in the left upper image). Information on the landslides was obtained from the Geospatial Information Authority of Japan.
Most of the hospitals were not located near landslides.



April 23, 2016