BRIEF REPORT

Successful Hospital Evacuation After the Kumamoto Earthquakes, Japan, 2016

Takashi Nagata, MD, PhD; Shinkichi Himeno, MD, PhD; Akihiro Himeno, MD; Manabu Hasegawa, MD; Alan Kawarai Lefor, MD, MPH, PhD; Makoto Hashizume, MD, PhD; Yoshihiko Maehara, MD, PhD; Masami Ishii, MD, PhD

ABSTRACT

Two major earthquakes struck Kumamoto Prefecture in Japan in April 2016. Disaster response was immediately provided, including disaster medical services. Many hospitals were damaged and patients needed immediate evacuation to alternative facilities. The hospital bed capacity of Kumamoto Prefecture was overwhelmed, and transportation of more than 100 patients was needed. Hospital evacuation was carried out smoothly with the coordinated efforts of multiple agencies. The overall operation was deemed a success because patients were transported in a timely manner without any significant adverse events. Upon repair of facilities in Kumamoto Prefecture, patients were returned safely to their previous facilities. The management of inpatients after this natural disaster in Kumamoto Prefecture can serve as a model for hospital evacuation with multi-agency coordination in the future. Future efforts are needed to improve interfacility communications immediately following a natural disaster. (*Disaster Med Public Health Preparedness.* 2017;11:517-521)

Key Words: hospital evacuation, earthquake, incident command system, Fukushima nuclear accident

Kumamoto Prefecture has a population of about 1.7 million people, of which about 745,000 live in Kumamoto City. Kumamoto is located on the island of Kyushu, the southwest part of Japan, with active volcanos, several active fault lines, and 2 nuclear power plants. The prefecture includes 214 hospitals and 1482 clinics. Of all hospitals in the prefecture, 94 are in Kumamoto City. About 63% of the prefecture is covered by forest. There have been a number of natural disasters in the past in Kumamoto, including floods and an earthquake with the eruption of an active volcano (Mt. Aso) in 2015. A major earthquake was not generally considered as a possible disaster, however, and preparedness for an earthquake was not sufficient.

Kumamoto City Hospital is the fourth largest in Kumamoto Prefecture, a 556-bed general hospital that includes the regional perinatal medical center and serves as a tertiary referral center for children and women with high-risk pregnancies. This hospital serves as the major referral center for all health care providers in Kumamoto Prefecture. Kumamoto Central Hospital, a general hospital with 308 beds, is located in Oozu City (20 km from Kumamoto City). There are 4 tertiary emergency medical centers, all located in Kumamoto City.

The disaster plan for Kumamoto Prefecture divides the prefecture into 11 regions, called secondary medical blocks. Each secondary block contains designated emergency hospitals, which are intended to receive emergency patients. The prefecture has 2 helicopter transportation systems. There are 14 disaster base hospitals in Kumamoto Prefecture with at least one in each secondary block. A government report issued just before the earthquakes stated that the earthquake resistance of hospital buildings in Kumamoto Prefecture was rated at 63%, among the worst ratings in the country.

THE KUMAMOTO EARTHQUAKE AND SUBSEQUENT MEDICAL RESPONSE

On April 14, 2016, at 21:26, an earthquake measuring 6.5 on the Richter scale struck Kumamoto Prefecture.[1] This earthquake caused major damage in Masiki-town (population: 33,860). Nine people were killed and more than 1000 were wounded, including 70 major injuries. More than 2800 people were evacuated to shelters, and about 11,000 houses and buildings lost their water supply. A disaster response was immediately provided including the deployment of Disaster Medical Assistant Teams (DMATs).[2] Within 1 day of this earthquake, the situation in Masiki-town was stabilized. Initial rescue activities were completed by firemen, police, Japan Self-Defense Forces, and the local population. The medical response to this disaster moved from the acute phase (focused on trauma care) to the chronic phase (focused on health care for evacuees in the shelters).

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However, just 28 hours after the initial earthquake, another earthquake, measuring 7.3 on the Richter scale, affected a wide area of Kumamoto Prefecture on April 16, 2016, at 1:20. Kumamoto City and other major cities in Kumamoto Prefecture were affected. About 15% of the hospitals and clinics in Kumamoto Prefecture were affected, and 12 major hospitals were damaged (Table 1), which necessitated the moving of patients and medical staff outside of the hospital buildings overnight.

Immediately after this second earthquake, the Kumamoto Prefecture Emergency Operation Center, which is the designated headquarters for disaster response and which coordinates all resources, responded to this situation. DMATs were deployed to the damaged hospital to aid in the evacuation. Patients were transferred by helicopters and ambulances. Kumamoto City Hospital was damaged and could no longer function. The hospital's water and power supplies became unreliable as a result of the earthquake, and there was concern about the structural integrity of the building. Other hospitals near Kumamoto City were also damaged. Patients admitted to these hospitals were transferred to major hospitals in Kumamoto City. Before noon on that day, the capacity to admit patients to hospitals in the area was overwhelmed, and it became necessary to transfer patients to hospitals outside Kumamoto Prefecture immediately. However, the hospitals in the surrounding prefectures were not ready to accept the deluge of patients. At this time, there was a rescue call from Kumamoto Central Hospital, located in Oozu town, near Kumamoto City. By the time of the second earthquake, the water tank on the roof was destroyed, and all floors of the hospital were flooded. Electric power was lost, and the building was also physically damaged. About 190 inpatients plus some of the medical staff were evacuated overnight and stayed outside for more than 10 hours. The weather forecast on April 16 predicted rain in the evening. Securing a safe place for 190 patients and medical staff was the immediate priority.

TABLE 1

Evacuation of Patients From Damaged Hospitals After the Second Earthquake, April 16, 2016

Hospital Name	Type	Beds	Number of Evacuated Patients on April 16
Kumamoto city	General and perinatal medical center	556	323
Kumamoto Central	General	308	200
Higashi Kumamoto	Chronic	52	43
Nishimura	Chronic	96	96
Miyakonomori	General	199	64
Mashiki	Psychiatric	210	[a]
Kibougaoka	Psychiatric	177	[a]
Yamanami	Psychiatric	270	[a]
Aoba	Psychiatric + chronic	178	[a]
Koyanagi	Psychiatric	198	[a]
Yamaguchi	Chronic	72	[a]
Jyonan	General	198	[a]

[a]In total, about 430 patients were transferred by April 20 collectively from all of these facilities.

In the aftermath of the Great East Japan Earthquake on March 11, 2011, we experienced the tragedy of delayed hospital evacuation in Fukushima.[3] Following the tsunami disaster and hydrogen explosions at the Fukushima Nuclear Power Plant, older patients in several hospitals and a nursing home were not evacuated expeditiously, and many died.[4] Several cases of hospital evacuations after natural disasters have been reported. Following Hurricane Katrina in New Orleans in 2005, the difficulties associated with hospital evacuations at Tulane University Hospital and Louisiana State University Hospital were reported.[5,6] In Japan, 2 hospitals sank under floodwaters in Joso-city, Ibaragi Prefecture, after a storm in 2015. At that time, all patients were evacuated by rescue teams of the Japan Self-Defense Forces, and rescue activities were not well-coordinated.[7,8] Hospital evacuation of critically ill patients remains challenging.

The Disaster Medical Coordination Team in the Kumamoto Prefecture Emergency Operation Center faced the need for another hospital evacuation at about noon on April 16. Kumamoto City Hospital was severely damaged by the second earthquake, and 323 patients were being transferred to other hospitals inside Kumamoto City. There was no capacity for more patients to be cared for inside Kumamoto Prefecture. The second earthquake led to added problems, because of further damage to more hospitals. While the hospitals outside Kumamoto City continued to transfer patients to Kumamoto City hospitals, the damage from the second earthquake prevented adequate function due to lack of power, lack of water, and in some cases structural damage that prevented use of all or part of the facility. It may have been preferable to transfer these patients outside of Kumamoto Prefecture, but a lack of adequate information and communications precluded this.

PATIENT TRANSFERS TO OTHER HOSPITALS

On April 16, 2016, more than 700 patients were transferred to other facilities in surrounding prefectures including Fukuoka, Saga, Nagasaki, Miyazaki, Ooita, and Kagoshima. Himeno Hospital (Fukuoka Prefecture) accepted the most patients of any single institution on that day.

By using a community network, the Disaster Medical Coordination Team contacted the president of Himeno Hospital in Hirokawa-town, Fukuoka (adjacent prefecture) and asked to transfer as many patients as possible. Himeno Hospital is a private, community-based hospital with 150 beds, located about 70 km from Kumamoto Central Hospital, within 2 hours' drive. The new hospital building was opened in April 2015, and the old hospital building was still available. The hospital group has a geriatric health services facility, and a

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new nursing home was nearly ready to be opened at that time. The medical staff of that facility had joined the disaster medical activities of the Japan Medical Association Team following the Great East Japan Earthquake in 2011.[9] It is acknowledged that the availability of the old building at Himeno Hospital was a matter of good fortune. The building had electricity and water and could accommodate some patients. While the availability of the old facility was very helpful, had it not been available, the transferred patients could have been accommodated in the new building and the nursing home.

Himeno Hospital agreed to accept up to 150 patients. The Disaster Medical Coordination Team started preparations for hospital evacuation. Patient transfers across prefectures should be coordinated by the Emergency Operations Center in both prefectures. However, communications between Kumamoto Prefecture and Fukuoka Prefecture were not well established at that time, and the capacity for acceptance by Fukuoka's hospitals could not be ascertained by direct communications. Doctors at the Kumamoto Central Hospital triaged 190 patients, and 20 critically ill patients were distributed to several different hospitals by ambulance and helicopters. Among the last 170 patients, 111 were designated for transfer to Himeno Hospital. Of these, 71 patients could be transferred by bus, and 40 patients were transferred by ambulance. Five medical staff members accompanied the transfer. Patient transportation was carried out by fire ambulance, Japan Self-Defense Forces Ambulance, and private buses. One bus and 2 ambulances as the initial transport arrived at Himeno Hospital at about 5 PM, 8 ambulances made up the second transport, and 1 bus plus 5 Japan Self-Defense Forces ambulances made up the third transport (Figure 1). The patients were distributed to the different parts of Himeno Hospital (old and new buildings), the geriatric health services facility, and the nursing home according to individual patient status. Four doctors, 80 hospital staff, and an additional 100 off-duty staff members who were called to help joined the triage, assessment, and hospital reception. There were no adverse events during the emergency transportation. By 10 PM, all patients had been admitted safely to their new hospital rooms. Other patients were also transferred to hospitals in Saga (another adjacent prefecture) safely.

After transportation on April 16, 20 medical staff members including nurses and rehabilitation specialists from Kumamoto Central Hospital went to Himeno Hospital to take care of the 111 transferred patients every day by collaborating with the Himeno Hospital medical staff, enabling continuity of care and giving patients great peace of mind by having the same caregivers. In addition, by sending staff members along with the patients, the added burden on the staff at the receiving hospital was lessened. By April 28, Kumamoto Central Hospital was repaired, and all patients who had been transferred to Himeno Hospital returned safely.

LESSONS LEARNED

Prompt Decision-making

In aging societies in developed countries, many older patients are admitted to hospitals. If hospital operations cannot continue following a natural disaster, evacuation of the hospital is mandatory, and the decision should be made promptly, because delayed hospital evacuation may cause collateral damage for inpatients, especially older patients.[10]

Communications

One of the greatest challenges in the care of hospitalized patients after this natural disaster was the ability to establish

FIGURE 1

Japan Self-Defense Forces Ambulances in Front of Himeno Hospital, Japan.

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effective communications with facilities in the surrounding area that could accept patients in transfer. There are some communication systems available now that are not considered reliable. This event highlights the need for a clear and effective communication plan to allow all institutions to be aware of what facilities are available. In the future, a reliable automated system is needed, allowing information sharing among hospitals about available beds in the event of another disaster necessitating the transfer of a large number of inpatients.

Patient Distribution

In Japan, hospitals are regarded as a kind of community with patients and medical staff. Therefore, patients should be evacuated as a group as much as possible, and patient distribution to multiple facilities should be avoided. Also, medical staff and patient families should accompany patient evacuations when possible. Patients transferred from Kumamoto Central Hospital received the same quality of care after transfer to Himeno Hospital owing to the close collaboration of the accompanying medical staff and the staff of Himeno Hospital. On April 28, the building was repaired, and all patients could return to Kumamoto Central Hospital smoothly. In the Great East Japan Earthquake (March 2011), a lack of information, lack of coordination among agencies, and lack of leadership caused delays in patient evacuations from hospitals near the Fukushima Daiichi Nuclear Power Plant, and many patients died.[11]

DMAT System

In the Kumamoto Earthquakes, many hospitals such as Kumamoto City Hospital and Kumamoto Central Hospital were forced to evacuate. Still, most patients could be transported within 24 hours after the second earthquake. The immediate hospital evacuations may have helped prevent medical complications, which might have been caused by delay. There are several reasons for this successful disaster medical response. As of 2016, about 9000 people belong to about 1800 registered DMAT teams. These teams conduct periodic training and drills on a regular basis. In the Great East Japan Earthquake, 380 DMATs were deployed to the area for critical patient transportation. However, only 19 patients were transferred in a wide-area medical evacuation, because most fatalities were caused by the tsunami and there were relatively few injured patients. Additionally, transportation was lacking between the coastal area and the Staging Care Unit at the major airport at that time.

The Ministry of Health, Welfare and Labor reflected on this experience and modified the guidelines for DMAT activities. DMAT training was improved, and plans for DMAT functions in disaster action plans in prefectures, cities, and hospitals were clearly described and defined.[12]

Coordination of Efforts

The leadership of the Ministry of Health, Welfare, and Labor realized the importance of coordination to manage the overall disaster medical response. Following the Hanshin Earthquake in 1995, the government designated 676 disaster base hospitals in Japan. These hospitals are intended to be disaster-resistant, self-sufficient, capable of deploying medical teams, and able to respond to mass casualty incidents.

In the Great East Japan Earthquake, disaster medical teams from different organizations and backgrounds were deployed to the scene and the overall lack of coordination led to confusion.[13] In 2013, a new training course focusing on disaster coordination was initiated nationwide, and the principle of the "Incident Command System" was applied in this training.[13] Stakeholders in disaster response from all 47 prefectures in Japan including personnel from DMATs, the Japan Red Cross, the Japan Medical Association, public health leaders, and prefectural government officers joined the training and shared the same principles. These efforts and human network contributed to the successful hospital evacuation in the Kumamoto earthquake.

The Disaster Countermeasure Basic Act, which serves as the basis for disaster planning in Japan, was revised after the Great East Japan Earthquake in 2011. Several improvements were made in the act, including the availability of shelters, importance of coordination, and changes to enhance collaboration among multiple agencies, especially to enable sharing of information.

Specifically, the effectiveness of the DMAT system in hospital evacuation was partially due to action by the government after the Great East Japan Earthquake to formalize this as one of their duties. These specific system changes, made in response to the Great East Japan Earthquake, were felt to contribute to the effective evacuation of hospitals after the Kumamoto earthquakes, with all patients safely evacuated and returned.

CONCLUSIONS

The Government of Japan made important changes in disaster planning after the Hanshin Earthquake (1995) and the Great East Japan Earthquake (2011), including an improved DMAT system, the use of disaster base hospitals, and improved disaster training. Despite these changes, the events in Kumamoto show that there is much work to be done, especially to facilitate communication among facilities in the immediate aftermath of a disaster and to improve multi-agency coordination.

Many experts figured out the importance of preparation for a successful hospital evacuation; however, the solution remains challenging.[14,15] Japan is always faced with the possibility of a major earthquake, such as the predicted Tokyo Metropolitan Mega-earthquake and Nankai-Sea Trough earthquake, and preparation including hospital evacuations is a national priority. More than 100 patients were transported after the earthquakes in Kumamoto Prefecture with the coordination

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of many agencies and resources in the early phase after the earthquakes. The care of these patients after 2 successive earthquakes is deemed a success because patients were transported in a timely manner and without any adverse events and then safely returned to their original facilities. This can be a model for hospital evacuation with multi-agency coordination in the future.

About the Authors

Kyushu University, Faculty of Medical Sciences, Department of Advanced Medical Initiatives, Fukuoka, Japan (Drs Nagata, Hashizume); Department of Orthopedic Surgery, Himeno Hospital, Hirokawa, Japan (Drs S Himeno, A Himeno); Shimonoseki-city Department of Public Health, Shimonoseki, Japan (Dr Hasegawa); Jichi Medical University, Department of Surgery, Shimotsuke, Japan (Dr Lefor); Department of Advanced Medical Initiatives, Kyushu University Faculty of Medical Sciences, Fukuoka, Japan (Dr Hashizume); Department of Surgery and Science, Kyushu University Graduate School of Medical Sciences, Fukuoka, Japan (Dr Maehara), and Japan Medical Association, Tokyo, Japan (Dr Ishii).

Correspondence and reprint requests to Takashi Nagata, MD, PhD, Kyushu University, Faculty of Medical Sciences, Department of Advanced Medical Initiatives, Fukuoka, Japan (e-mail: nagata.takashi@gmail.com).

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REFERENCES

1. Cabinet Office, Disaster Management, Government of Japan. The situation update of Kumamoto Earthquake, 2016 [in Japanese]. http://www.bousai.go.jp/updates/h280414jishin/index.html. Accessed May 10, 2016.
2. Ministry of Health, Welfare and Labor, Government of Japan. The situation update of Kumamoto Earthquake, 2016 [in Japanese]. http://www.mhlw.go.jp/stf/seisakunitsuite/bunya/0000121431.html. Accessed May 10, 2016.
3. Murakami M, Ono K, Tsubokura M, et al. Was the risk from nursing-home evacuation after the Fukushima accident higher than the radiation risk? *PLoS One*. 2015;10(9):e0137906. https://doi.org/10.1371/journal.pone.0137906.
4. Yanagawa Y, Miyawaki H, Shimada J, et al. Medical evacuation of patients to other hospitals due to the Fukushima I nuclear accidents. *Prehosp Disaster Med*. 2011;26(5):391-393. https://doi.org/10.1017/S1049023X11006418.
5. Sanford C, Jui J, Miller HC, Jobe KA. Medical treatment at Louis Armstrong New Orleans International Airport after Hurricane Katrina: the experience of disaster medical assistance teams WA-1 and OR-2. *Travel Med Infect Dis*. 2007;5(4):230-235. https://doi.org/10.1016/j.tmaid.2007.03.002.
6. Krane NK, Kahn MJ, Markert RJ, et al. Surviving Hurricane Katrina: reconstructing the educational enterprise of Tulane University School of Medicine. *Acad Med*. 2007;82(8):757-762.
7. Ojino M, Ishii M, Nagata T, et al. Activities of Japan Medical Association Team (JMAT): the Great East Japan Earthquake and the Kinugawa Flooding. *Kyukyu-Igaku*. 2016;40(3):313-316.
8. Cabinet Office, Disaster Management, Government of Japan. Working group for evacuation and emergency response for flood [in Japanese]. http://www.bousai.go.jp/fusuigai/suigaiworking/. Accessed May 10, 2016.
9. Nagata T, Halamka J, Himeno S, et al. Using a cloud-based electronic health record during disaster response: a case study in Fukushima, March 2011. *Prehosp Disaster Med*. 2013;28(4):383-387. https://doi.org/10.1017/S1049023X1300037X.
10. Zane R, Biddinger P, Hassol A, et al, Hospital Evacuation Decision Guide. Agency for Healthcare Research and Quality, US Department of Health and Human Services. http://archive.ahrq.gov/prep/hospevacguide/. Accessed May 10, 2016.
11. Hatamura Y, Abe S, Fuchigami M, et al. *The 2011 Fukushima Nuclear Power Plant Accident: How and Why It Happened*. New York: Woodhead Publishing Series in Energy; 2015:110-112.
12. Anan H, Akasaka O, Kondo H, et al. Experience from the Great East Japan Earthquake response as the basis for revising the Japanese Disaster Medical Assistance Team (DMAT) training program. *Disaster Med Public Health Prep*. 2014;8(6):477-484. https://doi.org/10.1017/dmp.2014.113.
13. Nagata T, Ishii M, Hasegawa M, et al. *Incident Command System Guide Book*. Tokyo: Hoki Publishing; 2014.
14. McGinty MD, Burke TA, Resnick BA, et al. Legal preparedness for Hurricane Sandy: authority to order hospital evacuation or shelter-in-place in the Mid-Atlantic Region. *Health Secur*. 2016;14(2):78-85. https://doi.org/10.1089/hs.2015.0068.
15. Haverkort JJ, Biesheuvel TH, Bloemers FW, et al. Hospital evacuation: exercise versus reality. *Injury*. 2016;47(9):2012-2017. https://doi.org/10.1016/j.injury.2016.03.028.