Original Article

Investigation of Japan Disaster Medical Assistance Team response guidelines assuming catastrophic damage from a Nankai Trough earthquake

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Aim: Transporting critically ill patients outside of disaster-affected areas for treatment is an important activity of Japan Disaster Medical Assistance Teams (DMATs). We investigated whether this activity is possible after possible catastrophic damage from a Nankai Trough earthquake.

Methods: Japan was divided into three areas based on the level of predicted damage (definitely, possibly, and non-affected areas). A survey of DMATs and the locations of emergency base hospitals and intensive care units (ICUs) in each area was carried out, and the ability to support disaster areas was investigated. Next, a survey of wide-area medical transport by Self-Defense Force aircraft and the medical transport abilities of helicopter ambulances was carried out. The numbers of ICU beds in each area were compared, and the capacity to accept patients was investigated. Finally, subjects for further study were examined.

Results: The number of DMATs that could be sent from non-affected areas was insufficient. The number of patients that can be transported by Self-Defense Force aircraft and helicopter ambulance during the first 3 days was determined to be 1,443. The number of patients that can be accepted by ICUs in non-affected areas was insufficient. A system needs to be developed to provide medical treatment for critically ill patients within disaster areas during the acute phase. This will require DMAT operational reforms and the creation of logistics systems such as the supply of resources for earthquake-reinforced hospitals.

Conclusion: In addition to patient transport, systems to provide medical care inside disaster-affected areas are needed.

Key words: Disaster medicine, emergency hospital services, intensive care units, natural disasters, transportation of patients

AIM

THE CURRENT BASIC action plan of Japan Disaster Medical Assistance Teams (DMATs) for widespread disasters is to quickly dispatch to the affected area, ascertain the disaster status, and transport patients out of disaster-affected areas. A Nankai Trough earthquake is predicted to occur in Japan, causing catastrophic damage over a large area. It is estimated that there will be at least 9,300 critically ill patients[1] who need to be transported out of the affected areas. Given the assumption that the number of patients needing care will be the largest ever experienced, considerable difficulty is foreseen from the perspective of balancing the demand for and supply of medical support. We investigated the specific medical response capabilities and considered Japan DMAT activity guidelines that should be changed.

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METHODS

Assessment of current situation and identification of problems

Comparison of demand for medical care and support

BASED ON THE damage predicted to result from a Nankai Trough earthquake, regions were divided into those that would provide or receive support. The deployment and support systems for each DMAT were then investigated. According to Cabinet Office materials listing damage estimates published by the Executive Committee of the Japan Central Disaster Prevention Council in March 2015, Japan's 47 prefectures were divided into three regions based on whether or not damage is expected and, if so, the extent of that damage:[2] prefectures where high levels of damaged are predicted ("definitely affected areas"); regions where damage is predicted if the earthquake is massive ("possibly affected areas"); and areas where damage is not anticipated ("non-affected areas"). The number of DMATs that will be needed was calculated from the number of staging care units (SCUs) expected to be set up and the number of emergency base hospitals (EBHs) in the definitely affected area, and considered to indicate the level of required medical care. Emergency base hospitals are hospitals that the prefectural government has assigned to provide emergency care and support in the event of a disaster. The role of EBHs overlaps with that of emergency medical care centers specified by the Ministry of Health, Labour and Welfare (MHLW) of Japan. The number of DMATs outside of the affected areas registered in the Emergency Medical Information System as of March 2015 was surveyed, and considered to indicate the capacity for support that could be started immediately after the disaster occurs. Next, the demand and support capacity were compared.

Investigation of medical transport capacity of Self-Defense Force (SDF) aircraft and helicopter ambulances

An interview survey of the Japan Joint Staff, Ministry of Defense was carried out with regard to the schedule for insertion of SDF aircraft in wide-area medical transport (WAMT). The SDF's transport schedule was derived from the number of aircraft that can be currently operated and the flight time for fixed-wing aircraft and rotorcraft, and shown as the total number of flights. This was multiplied by the number of persons each aircraft can transport to calculate the number of patients that can be transported.

The maximum number of patients that can be transported was calculated using the following conditions for the local area medical transport capacity of helicopter ambulances: be operated from sunrise to sunset; located within 300 km of the affected areas transport patients; travel speed is 200 km/h; round-trip time is based on the actual transport results in government WAMT drills undertaken each year; distribution ratio for each prefecture is proportional to the anticipated number of injured people; and for each fixed flight, fueling takes 1 h and the pilot is given appropriate rest time (determined from interview survey of pilots).

Capacity of hospitals outside of affected areas to accept patients

The number of intensive care units (ICUs) and the number of hospital beds in each of the three classified regions was compared in regard to the capacity of hospitals to accept critically ill patients transported out of affected areas. The data used were the numbers reported in the Summary of Static/Dynamic Survey of Medical Institutions and Hospital Report from the Portal Site of Official Statistics of Japan as of FY2011 (http://www.e-stat.go.jp/SG1/estat/List.do?lid=000001102730).

Measures to counter identified issues

To overcome the issues identified in the investigation of medical transport capacity, items of consideration that are necessary for changing the formulation of DMAT activity guidelines and DMAT training are presented.

RESULTS

Assessment of current situation and identification of problems

THERE ARE 282 DMATs in the definitely affected areas, and 433 DMATs in non-affected areas. The most DMATs, 662, are in possibly affected areas (Fig. 1, Tables 1 and 2).

The places where DMATs should be sent with priority are EBHs and SCUs that conduct WAMT. There are 142 EBHs in definitely affected areas, and 335 in possibly affected areas. Assuming that, on average, one team is sent to support each hospital, at least 140 teams would be demanded in the definitely affected areas alone. The number of SCUs planned to be set up based on the local disaster prevention plans of each prefecture in the definitely affected area is 20 (Table 3). With the standard size of SCUs, the number of SCU operation teams that is commonly used in current

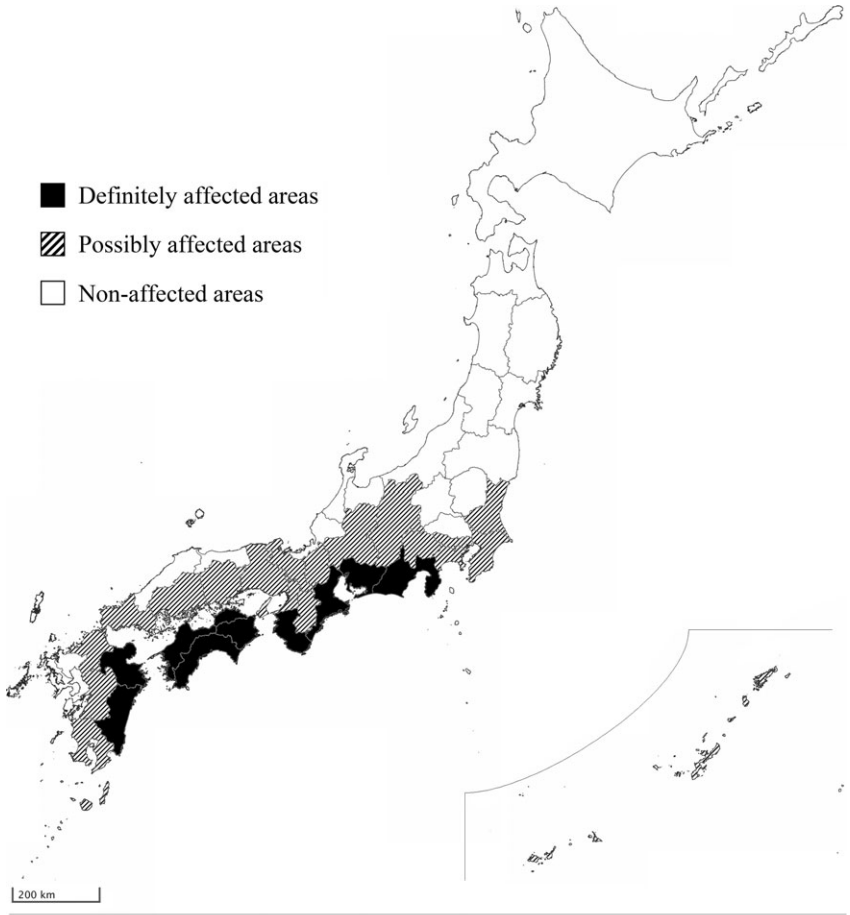

Fig. 1. Three areas of Japan divided according to the degree of damage expected from a Nankai Trough earthquake.

Table 1. Prefectures of Japan categorized according to predicted damage from a Nankai Trough earthquake

Definitely affected areas	Shizuoka, Aichi, Mie, Wakayama, Kagawa, Tokushima, Kochi, Ehime, Oita, Miyazaki
Possibly affected areas	Ibaraki, Chiba, Tokyo Metropolis, Kanagawa, Yamanashi, Nagano, Gifu, Shiga, Kyoto, Nara, Osaka, Hyogo, Okayama, Hiroshima, Yamaguchi, Fukuoka, Kumamoto, Kagoshima, Okinawa
Non-affected areas	Hokkaido, Aomori, Iwate, Akita, Miyagi, Yamagata, Fukushima, Niigata, Tochigi, Gunma, Saitama, Toyama, Ishikawa, Fukui, Tottori, Shimane, Saga, Nagasaki

Table 2. Number of Japan Disaster Medical Assistance Teams (DMATs) and emergency base hospitals (EBHs) within three areas in Japan with different degrees of predicted damage from a Nankai Trough earthquake

	Number of DMATs	Number of EBHs
Definitely affected areas	282	142
Possibly affected areas	662	355
Non-affected areas	433	218

training is 20 teams per location. Assuming demand for this number, 400 DMATs would be necessary.

Immediately after a disaster occurs, DMATs in possibly affected areas prioritize the gathering of disaster information

Table 3. Number of staging care units (SCUs) planned to be set up in 10 Japanese prefectures predicted to sustain damage from a Nankai Trough earthquake

Prefecture	Shizuoka	Aichi	Mie	Wakayama	Kagawa	Tokushima	Kochi	Ehime	Oita	Miyazaki
Number of SCUs	3	1	4	1	1	2	3	1	2	2

of the neighboring areas. Time is needed to assess the damage situation in the areas that they serve, and DMATs are sent to other regions only in cases when there is no major damage in their own. As a result, it is difficult to send teams from possibly affected areas to other regions immediately. The teams that are certain to be able start support activities in definitely affected areas immediately are the 433 teams in the non-affected areas only.

The maximum number of teams that can be sent quickly is therefore 433, compared with the 142 EBHs and 20 SCUs that need support from these teams. Thus, the support capacity is woefully insufficient.

The Ministry of Defense's plan for WAMT calls for 22 flights by fixed-wing aircraft and 41 flights by rotorcraft per 24 h. Eight patients can be transported per fixed-wing aircraft and four per rotorcraft, so 176 and 164 patients can be transported, respectively, for a total of 340 patients over 24 h. In 3 days, 1,020 people can be transported.

A maximum of 135 people can be transported by helicopter ambulance, such as transport of patients to SCUs that are used in WAMT, on the first day, and 423 people in 3 days after the occurrence of a disaster (Table 4).

Intensive care units in non-affected areas that can accept critically ill patients are present in 214 facilities and have 1,532 beds. However, it is extremely unlikely that all of these beds will be open. Assuming that 20–30% of the beds can be used to accept patients, approximately 300–450 beds would be available. In the definitely affected areas, ICUs are present in 141 facilities and have 1,217 beds. If the ICU function in these areas is lost, it will be necessary to transport both new patients injured in the earthquake and already hospitalized patients out of the affected area. It will therefore be difficult for ICUs in non-affected areas to adequately take in these patients (Table 5).

The above results indicate an overwhelming shortage in the number of responding DMATs, aircraft transport capacity, and the number of ICU beds available for the 9,300 critically ill patients who are estimated to need transportation out of the affected areas.

Measures

Japan DMATs need to operate with greater efficiency. Priority should be given to ensuring the necessary personnel to establish a command system and team activities to establish information gathering and communications systems. Next, given the difficulty of ensuring sufficient transport capacity, human and material support needs to be readied for DMAT support systems as follows. Invasive medical practices such as damage control surgery (DCS) and alternative functions for ICUs can be extended in affected areas. Triage to separate patients who should be given priority in medical transport, patients for emergency surgery within the affected areas, and patients who should be transported out of the affected areas after intensive care has been provided for a time is also important. We propose developing a new system to transport patients out of affected areas after providing medical care within the affected area for a certain time, and after patients have stabilized beyond the emergency condition. Therefore, it is necessary to construct the supply

Table 4. Distribution, transport time, and transport number of helicopter ambulances in areas of Japan expected to be definitely affected by a Nankai Trough earthquake

Prefecture	Shizuoka	Aichi	Mie	Wakayama	Tokushima	Kochi	Miyazaki	Total
No. of injured persons	92,000	100,000	66,000	39,000	34,000	47,000	23,000	401,000
No. of helicopters	4	4	3	2	2	2	1	18
Time for single transport (min)	60	60	60	60	75	120	75	–
No. transported on day 1	34	37	24	14	10	9	7	135
No. transported after 3 days	106	116	76	45	31	27	21	423

(–), not a cumulative value.

Table 5. Comparison of population, number of intensive care units (ICUs), and number of beds within three areas of Japan with different degrees of predicted damage from a Nankai Trough earthquake

	Population	No. of ICUs	No. of beds
Definitely affected areas	20,119,000	141	1,217
Possibly affected areas	71,090,000	482	3,896
Non-affected areas	35,873,000	214	1,532
Total	127,082,000	837	6,645

system for the following items. Equipment and materials for the continuation of medical care within affected areas is considered, such as those related to invasive medical practices, including DCS and interventional radiology, and those associated with management of critically ill patients, including monitoring functions, cardiorespiratory management functions, renal replacement therapy, and fluid/blood transfusion therapy.

DISCUSSION

ANALYSIS OF THE 2,702 trauma patients from the Great Hanshin-Awaji Earthquake in 1995 revealed that transporting crush syndrome patients and those with severe organ damage out of the affected area at an early stage for intensive care management was important in raising the survival rate.[3] Based on this lesson, Japan DMATs were established and WAMT systems were developed.[4] A plan drawn up in March 2007 calls for WAMT of 584 patients in the event of a Nankai Trough earthquake.[5] Wide-area medical transport was used for the first time after the Great East Japan Earthquake in 2011 to move 19 patients,[6,7] and 15 helicopter ambulance teams acting in concert with DMATs air-transported 149 patients.[8] The Great East Japan Earthquake, from which there were more than 18,000 dead and missing, affected mainly the four prefectures of Iwate, Miyagi, Fukushima, and Ibaraki. There are 49 EBHs in that region, and SCUs were set up in three locations. In comparison, the affected area in a Nankai Trough earthquake is estimated to be very large, and the number of deaths is forecast to be 320,000.[2] The number of critically ill patients that should be transported out of the affected areas is placed at $\geq$ 9,300.[1] This is the estimated number of patients based on an investigation of the Great Hanshin-Awaji Earthquake. This does not mean that patients who need to be transported can be saved simply by transporting them over a longer period. Providing high-level medical care in the acute disaster stage is crucial, and if it is difficult to transport patients out of affected areas at an early stage, high-level care needs to be provided within affected areas.

In the maximum damage estimates for a Nankai Trough earthquake, the number of persons injured is shown to reach 477,000 in the definitely affected areas and 175,350 in the possibly affected areas.[9] In that case, the balance in supply and demand would be clearly skewed. Moreover, it is unlikely that all 433 teams in the non-affected areas would be able to start support activities immediately. In the Great East Japan Earthquake in 2011, approximately 380 DMATs were operating for the 6,150 injured.[7] Considering that at the time there were 849 DMATs stationed across the country (the number of teams that had completed training by March 2011: unpublished data, DMAT Secretariat of the MHLW), the number of teams that can actually be dispatched is thought to be approximately half of the number of teams in place.

Looking into ways to achieve significant results by carrying out activities efficiently even with a lack of external support is important. Establishing a command system, an information gathering and communications system based on command and control, safety, communication, and assessment, as well as basic concepts in disaster medicine, is essential for the efficient operation of a possibly small number of DMATs. In addition, various transport system mechanisms have been created based on the triage, treatment, and transport concept.[6] In the present investigation, however, transport was found to be the bottleneck. With only the chief provision of previous DMAT activity guidelines to transport injured patients out of affected areas, there is a possibility that the lives of many injured people will be lost. As with the setting up of first-aid stations to conduct emergency relief activities in local disasters, DCS and intensive care that can save lives need to be provided in affected areas. In the future, we intend to undertake research to ensure further means of transport. However, consideration of building support systems to continue treatment in affected areas and triage that does not depend simply on the level of urgency or level of severity is also unavoidable.

Earthquake reinforcement of EBHs has been progressing in recent years, and stockpiling of fuel and food is recommended. Thus, the continuation of medical treatment within affected areas can be considered. Emergency base hospitals in affected areas will not necessarily lose all functioning, and people will not always be forced to evacuate them like a disaster site. Considering the above, we may expect medical functioning in the acute stage using hospital structures and materials. There is a possibility of increasing the disaster medical response functions by inserting DMATs and medical equipment into structures that withstood the quake. In

such cases, the standard equipment of conventional DMATs would be insufficient, and new consideration of things such as enhancement of local disaster preparedness plans and strengthening of logistics teams is needed. If a system like this could be created to transport patients who are no longer in critical condition out of affected areas by first providing medical care within the affected area for a certain time, it would be possible to transport patients over a longer period and ensure the availability of beds.

It is also necessary for large facilities with insufficient surgical materials and inpatient functions to investigate possible external resources. For example, they should consider SDF field operation system facilities, equipment and materials, and personnel, or the use of field medical treatment facilities/hospitals. Consideration of dispensing transfusion blood from the Japanese Red Cross Society to temporary medical facilities is also essential.

This study has the following limitations. Only DMATs were considered in the present study; however, DMATs are not the only medical teams operating within affected areas during the acute stage; various others include Japanese Red Cross relief squads and Japan Medical Association Teams. In addition, although medical institutions in definitely affected areas include many hospitals other than EBHs, they were not considered in this study. The different levels of damage to EBHs in definitely affected areas were also not considered.

CONCLUSION

ANALYSIS OF THE current DMAT deployment status and transport capacity of aircraft reveals several important issues regarding current disaster medicine capabilities in Japan in the event of a catastrophic Nankai Trough earthquake. In addition to transport systems out of affected areas, it was shown that improving systems to provide medical care to critically ill patients within affected areas for a certain time should be considered.

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CONFLICT OF INTEREST

NONE DECLARED.

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