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Experience of a Korean Disaster Medical Assistance Team in Sri Lanka after the South Asia Tsunami

On 26 December 2004, a huge tsunami struck the coasts of South Asian countries and it resulted in 29,729 deaths and 16,665 injuries in Sri Lanka. This study characterizes the epidemiology, clinical data and time course of the medical problems seen by a Korean disaster medical assistance team (DMAT) during its deployment in Sri Lanka, from 2 to 8 January 2005. The team consisting of 20 surgical and medical personnel began to provide care 7 days after tsunami in the southern part of Sri Lanka, the Matara and Hambantota districts. During this period, a total of 2,807 patients visited our field clinics with 3,186 chief complaints. Using the triage and refer system, we performed 3,231 clinical examinations and made 3,259 diagnoses. The majority of victims had medical problems (82.4%) rather than injuries (17.6%), and most conditions (92.1%) were mild enough to be discharged after simple management. There were also substantial needs of surgical managements even in the second week following the tsunami. Our study also suggests that effective triage system, self-sufficient preparedness, and close collaboration with local authorities may be the critical points for the foreign DMAT activity.

Key Words : *Natural Disasters; Relief Work; Patient Care Team; Wounds and Injuries*

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INTRODUCTION

Tsunami, a kind of natural disaster, is a very large wave mainly generated by an earthquake that flows on to the land and causes massive destruction. Although such a sudden-impact natural disaster may severely damage the medical facilities and disrupt public health system, only few reports are available about the need of the medical care after tsunamis (1-3).

On 26 December 2004 at 7 a.m. (GMT: midnight, 25 December), an earthquake measuring 9.0 on the Richter scale struck the area located about 160 km off the coast of Indonesia's Sumatra Island. It was the fourth-largest earthquake since such measurement began in 1899, according to the U.S. Geological Survey's National Earthquake Center. The quake caused the huge tsunamis which reached as far as 1,600 km from the epicenter. At least five million people were affected in South-Asian countries such as Indonesia, Sri Lanka, Maldives, India, Thailand, Seychelles and Myanamar. The collective death toll from these countries exceeded 280,000 people, and at least one million persons were displaced (4). About two and half hours after the earthquake, the tsunami attacked the south-eastern coast of Sri Lanka. As a result of the tsunami, 29,729 people were killed and 16,665 injured according to the report of the government of Sri Lanka (5).

Two days after the disaster (28 December 2004), the Seoul National University Hospital began to organize the deployment of a disaster medical assistance team (DMAT) to Sri Lanka. The team has had the regular disaster drills in monthly basis since March 2004. The Korean DMAT was composed of 20 personnel: three emergency physicians, two surgeons (one general and one orthopedic surgeon), a physician, a pediatrician, a dermatologist, three general physicians, three nurses, two emergency medical technicians (EMTs), a pharmacist, and three support personnel. The DMAT carried the medications for resuscitation, antibiotics, antimalarial drugs, fluids for intravenous infusion, and surgical kits (general and orthopedic). Other medications, preventive medicine like tetanus toxoid, and medicines for chronic disease (hypertension, diabetes, asthma, etc.) were also taken. Two big tents (15 meter in length, 7 meter in width, and 2.5 meter in height) which can be automatically inflated within 10 min by the infusion of the air (Fig. 1), two electric generators, self-sufficient amount of foods, and potable water for at least 10 days were also prepared. On 29 December 2004, the DMAT departed for Sri Lanka and began to provide medical cares seven days after the disaster (2 January 2005). The Korean DMAT performed a total of 7 days of medical cares in 6 towns, from 2 to 8 January 2005. The names of towns were Weligama, Mirissa (town between Weligama and Matara), Matara, Thalalla (town near Dondra), Hambantota, and Dikwella, by the order of the date (Fig. 2). All towns but Hambantota were the parts of the Matara district. In the Matara district, there were more injured persons than the dead (8,288 vs. 1,158). In contrast, injured victims (estimated as about 500 people)

were much less than the dead in Hambantota, where about half of the total residents (about 4,500) were killed immediately after the tsunami (5).

We began to see patients from 9:30 a.m. and finished at 5:00 p.m. to prepare the next day service. In the beginning of daily activity, we first made the two air tents inflated and used them as main building of our clinics. Other divisions such as pharmacy and observation area were also set up in small tents or available local buildings. When patients arrived at the team's field clinic, they first underwent triage by two emergency physicians. After the triage, mildly injured victims were directly sent to pharmacy or observation area for medication and injection. The other patients who required more specialized care were referred to the surgical or medical units. The surgical unit was composed of a general surgeon and an orthopedic surgeon, and the medical one consisting of a physician, a pediatrician, and a dermatologist. After the examinations in these units, the patients were guided to the pharmacy and observation area (Fig. 3).

Fig. 1. Two air-inflatable tents. The left tent was a surgical unit and the right one a medical unit. These tents were inflated by two electric generators within 10 min.

Fig. 2. The southern province of Sri Lanka where the Korean disaster medical assistance team served. Six towns were helped; Weligama, Mirissa (between Weligama and Matara), Matara, Thalalla (near Dondra), Hambantota, and Dikwella. The distance from Weligama to Hamabantota is about 100 km.

During the DMAT activities, security was maintained by local policemen, and the translation for communication was supported by 14 volunteers from the Korean International Cooperation Agency (KOICA) residing in Sri Lanka.

The purpose of this study is to characterize the epidemiology and time course of the medical problems seen by the DMAT during its deployment and the resources utilized by the DMAT during its deployment.

MAREIALS AND METHODS

Study design

We performed a retrospective study of logs and medical records maintained by Seoul National University Hospital DMAT during its deployment to Sri Lanka from 2 to 8 January 2005. This study was approved by the Institutional Review Board in the Seoul National University Hospital.

Study period

We performed the study from 15 January to 15 February 2005 at Seoul National University Hospital, Seoul, Korea.

Study population

We studied all patients in Sri Lanka presenting to our DMAT medical service for medical care from 2 to 8 January 2005.

Study protocol

Some authors extracted the demographic, epidemiological,

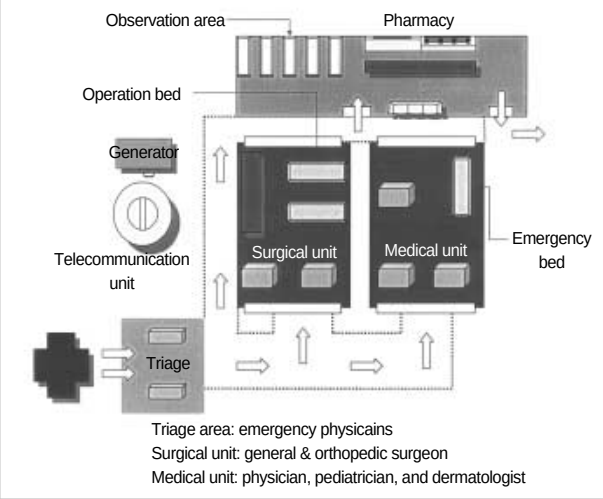

Fig. 3. Patients flow and relationship between of the parts of the field clinic. Arrows: the guided flow of the patients.

clinical and time course data generally considered as important points (6), from the logs and the medical records (Table 1). Demographic data included age, gender, and census of each day's deployment. We obtained clinical data, such as chief complaints, clinical diagnosis categories based on the 10th version of International Classification of Disease (ICD), and dispositions. If a patient had several complaints or diagnoses, each complaint or diagnosis was counted separately and included in this study.

We also collected data on the proportions of injury and disease among the patients. We planned to analyze data from injured patients according to three subgroups, concerning the data of injury onset; before, during, and after the tsunami. We obtained data on the resources utilized for managements that the DMAT provided. We divided the dispositions of the patients into four categories such as discharge to home, transfer to local hospitals, follow up to our DMAT mainly due to inadequate preparedness of local hospitals and withdrawal. The withdrawal cases include the patients who had minimal injury and were sent home only after the registration.

We also observed the physical and mental conditions of the members of the DMAT using a designed questionnaire.

Table 1. Collected data from the logs and medical records of the Koran DMAT

Categories	Data points	Definitions/examples
Demographic and epidemiologic data	Age	
	pediatric	0-14 yr old
	adult	15-64 yr old
	geriatric	≥65 yr old
	Gender	
	Daily census	
	Others	
	visiting mode	by walk, three-wheel car, car
	residence	home, relative's house, refugee camp
Clinical data	Chief complaint*	
	onset	
	Clinical diagnosis*,†	
	injury	injured by trauma
	disease	chronic medical or surgical conditions
	Management	
	medical	oral medication, injection
	surgical	wound repair, debriment, etc.
	Disposition	
	discharge	sent home after management
	transfer	to local hospitals
	follow up	to the DMAT
	withdrawal	sent home without management
Time course data	Proportions of injury and disease	

*Several complaints and diagnoses of a patient were counted separately and included. †Based on the 10th version of International Classification of Disease (ICD).

Data analysis

We divided all the patients into three age groups, pediatric (0-14 yr old), adult (15-64 yr old), and geriatric group (more than 65 yr old) for the purposes of comparison. We used simple statistics to summarize our data and compared among three age groups. We tried to find significant tendency of the proportions of injury and disease through the deployments by using Spearman's correlation coefficiency.

RESULTS

Demographic findings

A total of 2,807 patients visited our DMAT for the 7 days and all were included for this study. The number of daily patients ranged from 193 to 606, and the average was 401. The male to female ratio was 1:1.4 (1,159 vs. 1,637). The number of patients in pediatric, adult, geriatric group and unidentified were 719 (25.6%), 1,834 (65.3%), 245 (8.7%), and 9 (0.3%), respectively (Table 2). The proportions of male in pediatric, adult and geriatric group were 46.9%, 38.4%, and 48.2%, respectively. Compared to the pediatric and geriatric groups, there were more female patients in the adult group (Fig. 4).

Clinical findings

A total of 2,807 patients underwent the triage. After triage, the patients who needed further management were guided to the first, sec, and third department in order and disposed. The numbers of patients to be disposed to the first, second, and third department were 1,217, 1,200, 356, or 34, respectively (Fig. 5).

A total of 2,807 patients had 3,186 chief complaints. The number of patients with one, two, or three complaints were 2,798, 360, or 28, respectively. The most common complaints were respiratory ones (33.0%) including cough, sputum, rhinorrhea, and throat pain. The second and third complaints

Table 2. The number and demographic data of patient encounters

Date	Jan 2	Jan 3	Jan 4	Jan 5	Jan 6	Jan 7	Jan 8	Total	
	N	N	N	N	N	N	N	N	%
Pediatric (0-14 yr)	100	115	45	129	141	151	38	719	25.6
Adult (15-64 yr)	209	274	245	276	412	284	134	1,834	65.3
Geriatiric (≥65 yr)	16	50	33	51	52	23	20	245	8.7
Unidentified	3	0	1	2	1	1	1	9	0.3
Sum	328	439	324	458	606	459	193	2,807	100.0

N, Number; %, Percent.

were orthopedic (21.9%) and dermatologic problems (12.6%), respectively (Fig. 6).

A total of 3,259 clinical diagnoses were made except uncertain 110 cases. Of these diagnoses based on the 10th version of ICD, the most common diagnostic category was respiratory disease (32.0%). The second and third most common diagnoses were injury (17.6%) and musculoskeletal disorder (11.6 %), respectively (Table 3).

The proportion of disease was higher (82.4%) than that of injury (17.6%). There were more injured victims in the adult group than in the pediatric or geriatric age groups and in male rather than in female (Table 3). The proportions of the injured victims among before- (32%), during- (34%) and after-tsunami (34%) were not so different by the date (Table 4). The tendency of the proportion of injured victims was analyzed by the date and the census using the Spearman's rho (Fig. 7). The correlation curve showed the marginal negative correlation between the date after tsunami and the proportion of injured victims ($r=-0.75$, $p=0.052$).

Information on the disposition was available for all the patients. Most patients (92.1%) were safely discharged after short-term observation and management. Relatively, a few patients (6.4%) were transferred to local hospitals for further managements (Table 5). Surgical procedures for injuries were as follows; 133 dressings, 31 simple sutures, 22 debridements

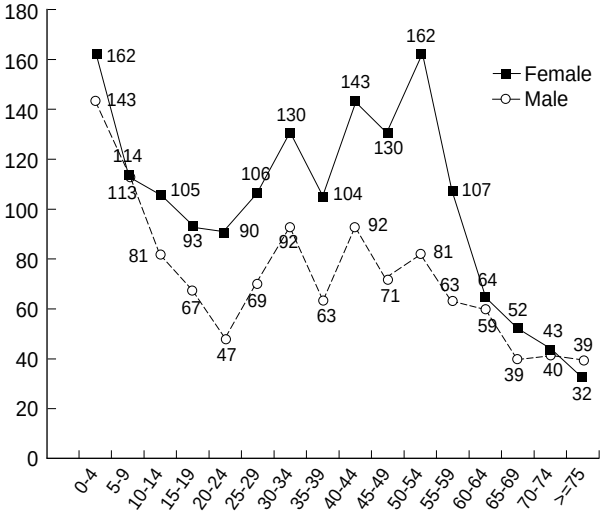

Fig. 4. Distribution of the enrolled patients by gender and age group.

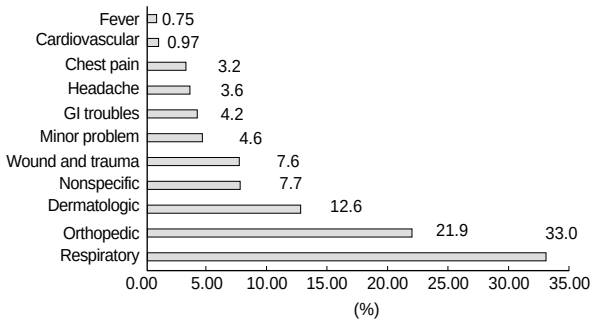

Fig. 6. Distribution of chief complaints.

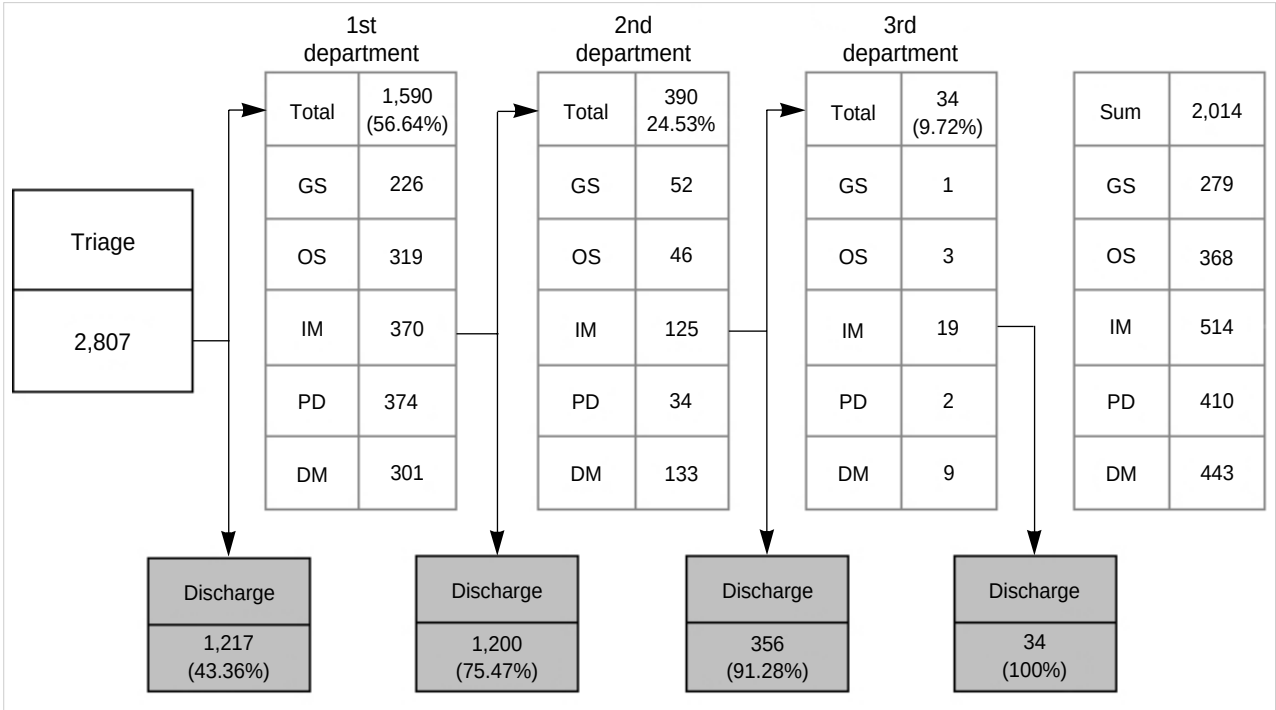

Fig. 5. Patients flow according to the areas and the departments. GS, general surgery; OS, orthopedic surgery; IM, internal medicine; PD, pediatrics; DM, dermatology.

and sutures, 14 immobilizations, and 5 other surgical procedures including closed reduction. Other medical treatments included oral medicine (480 cases), intra-muscular or intravenous injections (252 cases), ointment application (94 cases), tetanus prophylaxis (33 cases), and so on. Antibiotics were prescribed as parenteral and oral forms in 72 patients, oral form in 492 patients and topical form in 142 patients.

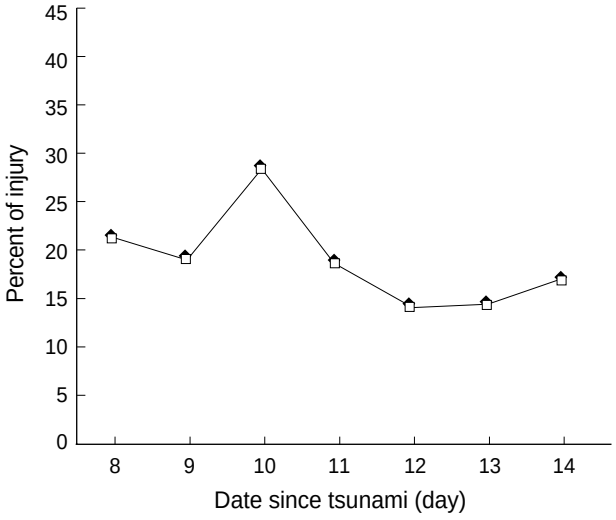

Fig. 7. Correlation between the percent of the injured out of total daily patients and the date since the Tsunami disaster (r=-0.75, *p*=0.052 by Spearman's rho).

Self reports from the DMAT members

There was no severe illness among the members of DMAT. The most common complaint was only mild fatigue, which failed to interrupt our activity. Until four weeks after the return to our country, there have been no reports of disease or injury.

DISCUSSION

To our knowledge, this study is the first report to describe the operation of a DMAT after tsunami disaster. Previous stu-

Table 4. The proportion of injured patients by the date and the onset of injury

Date	Before tsunami	During tsunami	After tsunami	Total
	%	%	%	N
2 Jan 2005	30	40	30	43
3 Jan 2005	29	35	36	69
4 Jan 2005	15	38	47	72
5 Jan 2005	53	24	23	66
6 Jan 2005	42	33	25	77
7 Jan 2005	23	39	38	61
8 Jan 2005	25	32	43	28
Total	32	34	34	416
Unknown onset				143

N, Number; %, Percent.

Table 3. The proportion of clinical diagnoses

Diagnosis by ICD-10*	Sum		Pediatric		Adult		Geriatric	
	No.	%	No.	%	No.	%	No.	%
Total†	3,259		770		2,179		310	
Respiratory disorder	1,042	32.0	470	61.0	519	23.8	53	17.1
Injury	572	17.6	49	6.4	480	22.0	43	13.9
Musculoskeletal disorder	377	11.6	12	1.6	280	12.9	85	27.4
Skin and subcutaneous disorder	355	10.9	69	9.0	260	11.9	26	8.4
Digestive disorder	169	5.2	49	6.4	110	5.1	10	3.2
Unspecified symptoms and signs	157	4.8	45	5.8	95	4.4	17	5.5
Eye and ear disorder	136	4.2	32	4.2	92	4.2	12	3.9
Circulatory disorder	134	4.1	3	0.39	96	4.4	35	11.3
Nervous system disorder	86	2.6	6	0.78	74	3.4	6	1.9
Endocrine and metabolic disorder	59	1.8	2	0.26	49	2.3	8	2.6
Viral, fungal and parasite infection	57	1.8	10	1.30	43	2.0	4	1.3
Urogenital disorder	37	1.1	4	0.52	27	1.2	6	1.94
Psychotic and behavioral disorder	32	0.98	10	1.30	19	0.87	3	0.97
Pregnancy and delivery related disorder	15	0.46	1	0.13	14	0.64	0	0
Neoplasms	13	0.40	3	0.39	8	0.37	2	0.65
Bacterial and mycobacterial infection	8	0.25	2	0.26	6	0.28	0	0
Hematology and immune system disorder	7	0.21	1	0.13	6	0.28	0	0
Congenital disorder	3	0.09	2	0.26	1	0.05	0	0
Perinatal disorder	0	0	0	0	0	0	0	0
Unknown age	9							

*The International classification of disease 10th version. †The number of unknown cases was 110. Of these, 53 male patients 57 female patients. The number of cases with more than two diagnoses were 566 (21.0%) of all patients. %, Percent.

Table 5. The proportion of disposition after management

Disposition	Pediatric (0-14 yr)	Adult (15-64 yr)	Geriatric (≥65 yr)	Unknown age	Total, No. (%)
Discharge No. (%)	669 (93.1)	1,689 (92.1)	220 (89.8)	8 (88.9)	2,586 (92.1)
Transfer No. (%)	35 (4.9)	121 (6.6)	22 (9.0)	1 (11.1)	179 (6.4)
Follow up No. (%)	3 (0.4)	4 (0.2)	0 (0.0)	0 (0.0)	7 (0.25)
Withdrawal No. (%)	12 (1.7)	20 (1.1)	3 (1.2)	0 (0.0)	35 (1.2)
Total, Number	719	1,834	245	9	2,807

dies mainly dealt with the function of a field hospital (1), orthopedic procedures (2), or medical needs after tsunami except for the clinical experience of a DMAT. Although a tsunami is not a common natural disaster, it seems to be inevitable especially in the tsunami-prone Pacific region. This report will be helpful for those who prepare the DMAT response to the possible tsunamis in future.

Rapid response is critical for the effective emergency medical services after natural disaster. Liang et al. pointed out that most of life-saving responses were needed within 24 hr after a disaster (7). Pretto et al. also suggested that deaths might have been prevented if the victim had received medical attention in the first 6 hr after an earthquake (8). However, a previous study revealed that even in the same countries, only 20 % of DMATs were able to reach the disaster scene within 24 hr. The causes of this delay were discussed as the destroyed transportation and communication (9). Our arrival time in Sri Lanka, seven days following the tsunami, was too late to take care of critical, life-threatening patients. When we arrived at the disaster site, the patients with severe injuries were already evacuated and transferred. Although this may be a major flaw of our activity, long distance international trip and other administrative problems prevented us from starting early medical care. In earthquakes in foreign countries, other Korean DMATs also arrived at disaster site so late that they could not care patients in the acute phase after disaster. They suggested that the appropriate medical supports according to the type of disaster and the time from the onset of disaster should be required (10, 11). In fact, it is not so feasible to reach the foreign disaster site within 7 days following the occurrence of disaster (3). On the other hand, because of the natural character of a tsunami, incredible strength and impossible timely warning, it can cause immediate deaths rather than injuries. Therefore, there may not be a place for the life-saving cares by foreign DMAT activity (12). If the critical emergency care immediately after the tsunami is only concerned task, it is the best way to set up an effective local disaster medical system.

Most patients visiting our field clinic had minor medical problems. Of these patients, larger portion had medical diseases (82.4%) and most of them could be sent home (92.1%). This finding is similar to that of the previous study at a field hospital following the hurricane Andrew in the United States (13). In the study, the authors described that 290 (18.8%) out of 1,544 patients had injury. In another study after the hurricane Inki, however, injury problems were more common than medical ones (40.4% vs. 38.6%) (14). Our data suggest that medical resources, not surgical, trauma-related resources is required in this DMAT setting.

According to our study, complaints and clinical diagnoses related to the respiratory system were the most common. Those seemed to be the consequences of the respiratory infection which is easily propagated and aggravated due to the poor environments and the crowded shelters of the victims. The second and third common diagnoses were orthopedic and dermatologic ones, respectively. These findings indicate the medical needs were required even one week after the tsunami disaster.

Among the injured patients, young adults predominated. It may be related to the characteristics of injury pattern after tsunami disaster. Because tsunami's attacking speed and power are so overwhelming, extreme aged people can not escape fatal injury (12).

While medical problems are more common than injuries, the proportion of trauma patients was not small (17.6%), and their needs for medical care should not be underrated. Considering the time sequence of injuries, about a third of the total injuries (34%) was the tsunami-related. The proportion is surprisingly high in terms of the period of our medical activity, which was done in the second week. This finding is different from those of studies in developed countries or other disasters. In a study conducted in the United States, authors reported that only 1.2% of injuries were attributable to a Hurricane and most of injuries were caused during clean up activities (13). According to our report, however, there were substantial patients with injury by tsunami even after a week, and numerous procedures, medications, and preventive measures were also required for those patients. This aspect of our DMAT activity may be associated with the taking an aetion in a developing country. In developing countries, the impact after natural disaster is amplified than in developed countries. They have much less resources of medical facilities, transportation, and communication (15). Even after several days, the injured patients could not be treated appropriately and they had to visit our clinics. Therefore, in a country with limited resources, both medical and surgical requirements should be met for a reasonably long time and it may be accomplished by foreign DMATs. Another supporting data on inadequate resources in developing countries are that one-third of injuries seen in patients began before the tsunami (32%) and one-third began after the tsunami (34%), suggesting the need to match medical resources with baseline needs in the affected population.

When we examined whether there was the decreasing tendency of injured patients, our data showed marginal negative correlation. It is a new finding compared to an earlier reports,

which showed constant decrease in number of injured victims (1, 16, 17). This finding may be associated with the regional variation on mortality and morbidity. Compared to the Hambantota area, the Matara district showed more injured patients than the dead (Table 2). When tsunami strikes relatively large area, there may be differences in destroying power which may cause different casualty pattern between some regions. In area such as Matara, where many victims were rather injured than dead, the surgical needs could not be met after several days. In Hambantota, because about half of the residents were dead, survived people were not surgical patients but medical patients who lost their chronic medication and pharmacy. On the contrary to some previous studies which indicated the reducing need of trauma patients, our reports showed that geographical difference can make clinical difference after tsunamis.

Our DMAT service was successful in many aspects. First of all, our study describes the largest number of patients by a DMAT, 2,807 comparing with previous studies that reported the number of patients from 134 to 2,090 (1, 2, 9, 13, 14, 16). We also covered fairly wide regions of the damaged country, in two districts, from town Weligama to Hambantota. The distance between two towns at both ends is about 100 km away and it takes about five hours by bus in Sri Lanka. In spite of relatively hard works, there was no trouble in physical and mental health of our members. Daily surveyed self-reporting questionnaires revealed no significance illnesses. At the other point, unlike an earlier study, the shortage of critical drugs was not a problem of our team (14). Though our resuscitation medication and fluids were not consumed at the sites, there was no lack of important medications such as antibiotics, tetanus toxoid and insulin.

Our successful outcome may be attributable to some features of the team. First, we utilized the same triage system as that of our own emergency department. When a DMAT acts at post-impact phase of disaster, triage of DMAT is suggested to follow the typical procedure for most emergency department (18). By adopting this effective, familiar triage system, we could see a great number of patients fast and offer more specialized care for severe patients. After the triage by the emergency physicians, the complicated patients were referred to two separate units, surgical and medical. The system accomplished the combined objectives of traditional DMAT function, surgical intervention and definite care (19, 20). They were also the most required role of our team in that damaged area.

Second good facet of the team was vigilant preparedness of self-sufficient equipments and foods. A DMAT can not rely on the local resources which may be quite limited and unavailable. So, we brought all the food, potable water and sleeping bags we needed. Using the electric generators, we could inflate our tents, which made it possible to change our service sites day by day. They could be used as fine accommodation under the poor condition if needed. And this effectiveness of performance was achievable due to the regular and repeated drills we had had before the disaster.

Third part is the close cooperation with local authorities and volunteers. The local authorities offered the security and gathering of patients which is the critical aspects of DMAT activity. The translation between a patient and a foreign doctor by the devoted volunteers facilitated the flow of the patients. Although the reports of the foreign DMAT function are scarce in medical literature (21), collaboration with local personnel was one of the most valuable experiences in our team. Without their assistance, our paramount goal, providing care for wounded people, could never be reached.

This study has some limitations. First, there may be questions of whether the DMAT activity was truly beneficial for the affected population in Sri Lanka. The types of medical problems we saw were relatively minor and could have been seen by local medical care providers. Supporting evidence that the DMAT was beneficial, however, is that we saw thousand of patients and were self-sufficient in terms of our material support. Second, we failed to collect enough data to provide the extent of the severity among the patients, such as injury severity scores (ISS). We also failed to obtain the mortality data of the patients who died during our DMAT activity or subsequently at a hospital. Because this was not a prospective study, we did not collect the data on injury severity scores or mortality. Future studies concerning disaster assistance activity should consider that aspect of care. Third, the study does not show the information on the local medical resources and epidemiologic data about medical problems or injuries before the tsunami in the country. As a foreign DMAT, we had no way to collect the information. Lack of the data prevented us from analyzing the baseline needs in affected population.

In conclusion, the majority of victims had medical problems, and most conditions were mild enough to be discharged, seven days after the South-Asia tsunami disaster. There were also substantial needs of surgical managements even in the second week. Our study also suggests that effective triage system, self-sufficient preparedness, and close collaboration with local authorities may be the critical points for the foreign DMAT activity.

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