World J Surg (2016) 40:2117–2122
DOI 10.1007/s00268-016-3581-3

ORIGINAL SCIENTIFIC REPORT

Orthopedic Activity in Field Hospitals Following Earthquakes in Nepal and Haiti

Variability in Injuries Encountered and Collaboration with Local Available Resources Drive Optimal Response

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Published online: 2 June 2016

Abstract

Background Field hospitals have been deployed by the Israel Defense Forces (IDF) Medical Corps in numerous disaster events. Two recent deployments were following earthquakes in Haiti in 2010 and in Nepal in 2015. Despite arrival in similar timetables, the mode of operation was different—independently in Haiti and in collaboration with a local hospital in Nepal. The pathology encountered in the two hospitals and the resultant treatment requirements were significantly different between the two events. The purpose of this study was to analyze these differences and their implications for preparation and planning of future deployments.

Methods Data were obtained from IDF records and analyzed using SPSS™ software.

Results 1686 patients were treated in Nepal versus 1111 in Haiti. The caseload in Nepal included significantly less earthquake-related injuries (26 vs. 66 %) with 28 % of them sustaining fractures versus 47 % in Haiti. Femoral fractures accounted for 7.9 % of fractures in Nepal versus 26.4 % in Haiti with foot fractures accounting for 23.8 and 6.4 %, respectively. The rate of open fracture was similar at 29.4 % in Nepal and 27.5 % in Haiti. 18.1 % of injured patients in Nepal underwent surgery, and 32.9 % of which was skeletal compared to 32 % surgical cases (58.8 % skeletal) in Haiti. 74.2 % of patients in Nepal and 34.3 % in Haiti were treated for pathology unrelated to the earthquake.

Conclusions The reasons for the variability in activities between the two hospitals include the magnitude of the disaster, the functionality of the local medical system which was relatively preserved in Nepal and destroyed in Haiti and the mode of operation which was independent in Haiti and collaborative with a functioning local hospital in Nepal. Emergency medical teams (EMTs) may encounter variable caseloads despite similar disaster scenarios. Advance knowledge of the magnitude of the disaster, the functionality of the local medical system, and the collaborative possibilities will help in planning and preparing EMTs to function optimally and appropriately. However, as this information will often be unavailable, EMTs should be capable to adapt to unexpected conditions.

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Introduction

On the morning of April 25th 2015, Nepal was struck by a 7.8 Richter scale magnitude earthquake killing 8856 persons and injuring 22,309 [1, 2].

In the hours following first reports of the disaster, the Israel Defense Force (IDF) initiated deployment of an early response mission. The mission included search and rescue teams, and a level 3 field hospital [3]. The teams arrived in Kathmandu on April 28th constructing the field hospital within 12 h and initiating activity on April 29th—82 h after the earthquake. The hospital was operational for 11 days, terminating activity on May 9th. The hospital functioned in close collaboration with the adjacent Shree Birendra Military Hospital (SB) in Kathmandu. We present a review of the orthopedic activity in the hospital and compare it to the activity in a similar IDF field hospital established following the earthquake in Haiti in 2010, initiating operation 89 h after the earthquake and functioning for 10 days [4].

The goal of the study is to compare the activity in the two hospitals, analyze the reasons for variability in their activities, and examine the implications for preparation and planning of future similar deployments.

Methods

The study was approved by the IDF Medical Corps institutional review board.

Seismic, demographic, and morbidity data regarding the two earthquakes was retrieved from published and web-based sources.

Data regarding the operation of the field hospitals were obtained from IDF records as well as previously published studies regarding the Haiti field hospital.

Statistical analysis was performed using SPSS™ software.

Results

Seismic data and casualties

The Nepal earthquake magnitude was 7.8 on the Richter scale. The epicenter was at a depth of 8.2 km, and it occurred 82 km northwest of Kathmandu. The Haiti earthquake magnitude was 7.0, and the epicenter was at a depth of 13, 25 km from Port au Prince. The resultant casualties were 8656 dead and 22,309 injured in Nepal compared to 100,000–300,000 killed (conflicting data) and 300,000 injured in Haiti [1, 5]. When adjusted to national population size the injury figures are 79/100,000 in Nepal and 3000/100,000 in Haiti.

Patients treated (Table 1)

Nepal

1686 patients were treated in the hospital. 1506 patients had adequate medical records available and were included in the cohort. 388 patients (26 %) were treated for earthquake-related injuries with 315 of them (81 %) suffering from musculoskeletal injuries. 126 fractures were treated in 110 patients (28 % of injured patients). 37 (29 %) of the fractures were open. 74 fractures (59 %) were in the lower limbs, 29 (23 %) in the upper limbs, and 18 (14 %) in the axial skeleton. A detailed distribution of the fractures is given in Table 2. 61 patients (16 %) sustained soft tissue wounds without fractures. Seven patients (2 %) had joint dislocations, and 118 (30 %) suffered minor contusions and sprains. 6 (2 %) of the patients were admitted to the hospital following amputation in a different facility.

Haiti

1111 patients were treated in the hospital. 66 % were treated for earthquake-related injuries with 92 % of them suffering from musculoskeletal injuries. 47 % of injured patients sustained fractures, 28 % of which were open, and 30 % of the injuries were in the soft tissues without fractures. Fracture distribution is given in Table 2. 62 % were in the lower limbs, 23 % in the upper limbs, and 14 % in the axial skeleton. 2 % suffered dislocations and 3 % of patients were admitted after amputations. 13 % suffered mild contusions or sprains [6].

Table 1 Injury patterns

	Haiti	Nepal	*P* value
Total patients	1111	1686	
Total cohort	1041	1506	
Earthquake related	684 (65.7 %)	388 (25.8 %)	<0.001
Musculoskeletal injuries	656 (95.9 %)	315 (81.2 %)	<0.001
Fracture patients	320 (46.8 %)	110 (28.4 %)	<0.001
Fractures	360	126	
Open fractures	99 (27.5 %)	37 (29.4 %)	0.730
Soft tissue injuries	207 (30.3 %)	61 (15.7 %)	<0.001
Dislocations	18 (2.6 %)	7 (1.8 %)	0.528
Minor injuries	89 (13.0 %)	118 (30.4 %)	<0.001
Amputations	22 (3.2 %)	6 (1.5 %)	0.113

Table 2 Fracture distribution

	Haiti	Nepal	*P* value
Total fractures	360	126	
Total upper limb	84 (23.3 %)	29 (23.0 %)	1.000
Total lower limb	227 (63.1 %)	74 (58.7 %)	0.396
Total axial skeleton	42 (11.7 %)	18 (14.3 %)	0.435
Clavicle/scapula	4 (1.1 %)	4 (3.2 %)	0.214
Humerus	36 (10 %)	7 (5.6 %)	0.148
Forearm	26 (7.2 %)	11 (8.7 %)	0.563
Hand	18 (5.0 %)	7 (5.6 %)	0.816
Femur	95 (26.4 %)	10 (7.9 %)	<0.001
Tibia/fibula	109 (30.3 %)	34 (27.0 %)	0.570
Foot	23 (6.4 %)	30 (23.8 %)	<0.001
Pelvis	38 (10.6 %)	9 (7.1 %)	0.298
Spine	4 (1.1 %)	9 (7.1 %)	<0.001
Skull	7 (1.9 %)	5 (4.0 %)	0.313

Treatment administered (Table 3)

In the Nepal field hospital, 72 surgical procedures were performed in 57 (18 %) of the patients treated for musculoskeletal injuries. 44 were performed in the operating theater under general or regional anesthesia. 28 procedures were performed in the orthopedic treatment tent under local anesthesia or regional blocks. The distribution of orthopedic and plastic surgical procedures is given in Table 3. 13 patients underwent external fixation for extremity fractures, 12 of these were open fractures. 39 patients underwent soft tissue debridements and ten had plastic surgical procedures. Six amputations were performed. Two children with femoral fractures were treated by spica casting. In addition, IDF surgeons took part in 22 procedures performed in SB hospital by combined teams.

In the field hospital in Haiti, 210 patients (32 % of trauma patients) underwent surgery under general or regional anesthesia. Surgical procedures are detailed in Table 3. External fixation was performed in 73 cases. 39 of these were for closed femoral fractures and 34 were for open fractures. 16 closed femoral fractures in children were treated with a spica cast. Three patients underwent rotation flaps and four had split thickness skin grafts. 23 amputations were performed [6, 7].

Discussion

Earthquakes cause more musculoskeletal injuries than any other disaster [8]. In most situations, the treatment needs will far exceed the surge capacity of the local health systems, prompting an international effort of humanitarian aid [9]. Foreign emergency medical teams will usually start arriving 3–4 days after the earthquake [10–12]. At this point in time, patients suffering from severe systemic injuries will either have perished or will have been treated, and the majority of earthquake-related injuries will be musculoskeletal with a high incidence of fractures, many of them open, as well as severe soft tissue injuries [6, 8]. The caseload encountered by an incoming medical team will also depend to a large extent on the capabilities and functionality of the local medical system as well as the evacuation abilities to medical centers outside the disaster zone. In addition, the teams will encounter varying numbers of patients suffering from acute and chronic pathologies unrelated to the earthquake. The exact caseload is hard to predict in the early hours and days after the earthquake when the medical team is being assembled, and therefore, it is the policy of the IDF MC to dispatch a full level 3 field hospital with a wide range of surgical and medical capabilities. The hospital personnel number around 120 health professionals from a wide range of professions and subspecialties. In addition, the team is made up of a combination of regular military servicemen and women and reservists and combines individuals with previous disaster experience and those with first time exposure thus utilizing previous expertise while increasing collective disaster medicine experience. This, together with task shifting within the hospital, enables response to the specific scenario encountered [11]. The orthopedic capabilities of a field hospital usually include external fixation and treatment of soft tissue injuries. Due to transport payload limitations as well as the suboptimal sterility achievable in most surgical theaters, internal fixation hardware and C arm fluoroscopy are not included in the hospital's armamentarium, and the orthopedic capabilities are limited to damage control treatment comprising fracture stabilization with external fixators and treatment of soft tissue injuries [11–19]. Patients requiring internal fixation or secondary definitive treatment will be referred to centers having these capabilities within or outside the disaster zone.

Despite the fact that the IDF field hospitals in Haiti and Nepal were deployed in a similar timetable, initiating operation 89 and 82 h after the earthquake and operating for 10 and 11 days, respectively, the caseload encountered by the teams and the subsequent treatment workload were significantly different in the two hospitals.

In Nepal 25.8 % of the patients were treated for earthquake-related causes of which 81.2 % suffered musculoskeletal injuries, compared to 65.7 % earthquake-related causes of which 95.9 % had musculoskeletal injuries in Haiti. These differences were statistically significant. The severity of injuries were also significantly different with 46.8 % of the injured sustaining fractures and 30.3 % with soft tissue injuries in Haiti compared to 28.4 % fractures and 15.7 % soft tissue injuries in Nepal. In contrast, the

Table 3 Surgical procedures

	Haiti	Nepal	*P* value
External fixation			
Femur	48 (65.8 %)	2 (15.4 %)	0.001
Tibia	24 (32.9 %)	9 (69.2 %)	0.027
Humerus	1 (1.4 %)	1 (7.7 %)	0.281
Forearm	0 (0 %)	1 (7.7 %)	0.151
Total	73	13	
Ex fix % of surgery	33.0 %	18.0 %	0.017
Spica cast			
Femur	16	2	
Joint reductions			
Shoulder	3		
Hand	0	1	
Hip	5		
Knee	3		
Ankle/foot	7	1	
Total	18	2	
Amputations			
Hip disarticulation	0	2	
Above knee	4	1	
Below knee	6	1	
Foot	6	1	
Above elbow	3	1	
Below elbow	0	0	
Hand	4	0	
Total	23	6	
Amputations % of surgery	10.4 %	8.3 %	0.820
Musculoskeletal trauma patients	656	315	
Surgical patients	210	57	
Surgical/trauma patients %	32.0 %	18.1 %	<0.001
Total orthopedic/plastic surgery	221	72	
Total skeletal surgery	130 (58.8 %)	23 (32.9 %)	<0.001
Total soft tissue surgery	91 (41.2 %)	49 (67.7 %)	<0.001

percentage of patients with minor injuries—30.4 %—was significantly higher in Nepal compared to 13.0 % in Haiti (Table 1). These differences also affected the surgical workload with 32.0 % of trauma patients in Haiti requiring surgery versus 18.1 % in Nepal (Table 3).

We identified several factors responsible for these differences.

(A) The magnitude and intensity of the disaster was significantly worse in Haiti where there were 300,000 persons injured. This was probably due to the epicenter being only 25 km from capital city of Port au Prince with a high population density and an urban building milieu. This was also where the field hospital was established. In contrast, the epicenter of the Nepal earthquake was 82 km from the major urban center of Kathmandu, in a rural area, resulting in a much lower casualty figure of 22,309 injuries.

(B) The local medical infrastructure was almost completely destroyed in Haiti due to the destruction in the capital, while numerous local hospitals in Kathmandu remained partially or fully active.

(C) The field hospital in Nepal was established adjacent to the Shree Birendra Military Hospital in Kathmandu and worked in close collaboration with it. The hospital, although suffering significant damage in the earthquake, rapidly returned to operation at partial capability treating acute phase patients from day 1.

Both damage control and definitive surgical procedures were performed; however, the caseload far exceeded the surge capacity of the hospital and upon arrival of the IDF hospital several hundreds of patients were awaiting surgery. Coordination was established between the two hospitals both at the management level and the orthopedic department level. Hospitalized patients were allocated to treatment in one of the two hospitals in daily coordination meetings. Newly admitted patients were allocated to one of the two hospitals according to their surgical needs. Patients requiring damage control surgery, external fixation, soft tissue surgery, and amputations were directed to the field hospital, whereas patients requiring internal fixation, external fixation of juxta-articular fractures, or spinal surgery were operated in SB hospital where sterility conditions were better and C arm and internal fixation including spinal fixation capabilities were available. Joint surgical teams were assembled and worked in both hospitals, enhancing the collaborative effort as well as adding subspecialty care such as pediatric orthopedics and plastic surgery to the local system. In addition, the availability of a high level intensive care unit in the field hospital enabled transfer of complicated cases from the SB hospital to the field hospital for post-surgical care.

In contrast in Haiti, the near complete destruction of the local medical infrastructure dictated the operation of the hospital as a freestanding independent facility with most of the patients being admitted to the hospital directly from the site of injury or from a facility with limited surgical capabilities. Although collaborations were established with other foreign medical teams, these consisted of incorporation of volunteer personnel into the IDF hospital, admission of patients for surgery from other facilities and transfer of patients to these facilities for postoperative care, thus freeing bed space for more surgical cases. The variation between the two operational scenarios dictated significant differences in the patient caseload as well as in treatment strategy.

From the orthopedic surgical standpoint, in Haiti, no advanced surgical treatment was available initially. Therefore, all closed fractures were treated non-surgically with the exception of femur fractures in adults, which were treated by external fixation. In Nepal, these fractures were treated by internal fixation, similarly to treatment in a non-disaster situation. Although treatment was delayed due to the case overload, the unloading of the system by the transfer of the damage control treatment to the IDF hospital enabled earlier treatment of these patients. The difference in the mode of operation explains the statistically significant differences in the type of surgical procedures performed in the two hospitals. In Haiti 58.8 % of musculoskeletal, surgery included bony procedures and 41.2 % were only on soft tissues. Conversely in Nepal, only 32.9 % of procedures were bony and 67.7 % were soft tissue surgeries. The percentage of and treatment of femur fractures treated in the two hospitals were also significantly different. In Haiti, femoral fractures comprised 26.4 % of all fractures treated. 48 external fixators applied to femurs (65.8 % of all external fixators applied) and 39 of them (81 %) on closed fractures. In Nepal, femoral fractures comprised 7.9 % with only two external fixators were applied to femurs (15.4 % of fixators applied). One was for an open fracture and one for nursing purposes in an unconscious patient with a closed fracture. Conversely, 69.2 % of external fixators applied in Nepal were for tibial fractures versus 32.9 % in Haiti. All were open fractures. In addition, there were significantly more foot fractures treated in Nepal (23.8 vs. 6.4 % in Haiti) as these fractures mostly required debridement without internal fixation and were therefore treated in the IDF hospital rather than at SBH.

The significant difference in spinal fractures (7.1 % in Nepal vs. 1.1 % in Haiti) is probably explained by the fact that at the acute phase, no CT or surgical treatment was available for these patients in Haiti either in the IDF hospital or elsewhere on the island, and therefore, excepting severe injuries, many of these fractures remained undiagnosed and untreated. In contrast, in Nepal, patients initially diagnosed in the IDF hospital with spinal fractures were transferred to the SB hospital for CT imaging and surgery when required.

The percentage of non-earthquake-related injuries among the patients at the field hospital in Nepal was significantly higher than that encountered in Haiti (77 vs. 33 %). This was due to several factors. In Haiti, the overwhelming number of injuries dictated prioritizing treatment to earthquake-related injuries and postponing treatment of non-urgent routine medical problems. The situation in Nepal, although exceeding the local surge capacity, was not as overwhelming. However, at the time of operation of the IDF hospital, the local medical system was still totally devoted to earthquake-related injuries and treatment of non-urgent routine medical problems was temporarily discontinued. As the IDF hospital personnel included all medical and surgical specialties and admitted patients with non-earthquake-related medical problems, an increasing number of patients with medical problems arrived for treatment at the hospital as word got around that such services were available.

The numbers were probably increased due to the fact that a high percentage of health expenditure in Nepal is out of pocket [20], and all medical services in the IDF hospital were provided free of charge.

This collaborative mode of operation between a field hospital and a local functional hospital with wide surgical capabilities had not been previously performed in any of the IDF field hospitals deployed in earthquake zones [11]. It proved to be effective in providing appropriate care for the wide variability in patient profiles, optimizing resource usage in this complex disaster situation. In addition, the operation by mixed surgical teams enhanced the surgical capabilities in both hospitals including subspecialty treatment, exchange of knowledge, and bridging cultural gaps with the patient population.

Conclusions

Despite deployment in similar disaster scenarios and timetables, foreign emergency medical teams may encounter a wide variability in patient caseloads and treatment needs, and local capabilities. Our findings in the variability of orthopedic activity may well be applicable to additional medical fields. This wide variability affects the number and types of the personnel required—physicians, nursing staff, and auxiliary services. It also significantly affects the payload of equipment required for appropriate treatment in the hospital. These factors will usually be unpredictable at the time of preparation of a mission deployed during the acute phase of a disaster. Policy makers and organizations dispatching foreign medical teams to disaster zones should be aware of this variability and unpredictability during the planning and preparation phase, and on arrival, the teams should be prepared to adjust their operational mode to the encountered situation. Collaboration with local operational medical facilities can greatly enhance the surge capacity and increase the effectiveness of treatment administered to the population in a disaster situation.

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