Operation Nightingale: The Role of BMH Dharan Following the 1988 Nepal Earthquake, and Some Observations on Third World Earthquake Disaster Relief Missions

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SUMMARY: Following a large earthquake in Nepal, the experience of a small hospital in dealing with the resulting casualties is described. The value of pre-planning and effective triage of the injured is stressed, and aspects of surgery and medical care specific to earthquake victims discussed. Clinical and administrative challenges encountered in mounting a major relief exercise in a Third World setting are also described. The frequent exercising of military hospitals and personnel in handling mass casualties is as applicable to civilian natural catastrophes as to battlefield medical support.

Introduction

The British Military Hospital (BMH) in Dharan is an 80 bed static acute unit located in a military cantonment in East Nepal. It provides specialist facilities to local civilians as well as British Gurkha personnel. The town of Dharan (pop approx 100,000) lies in an earthquake zone where the Indo-Australian plate subducts the Tibetan Plateau¹, and the single storey military hospital is designed to withstand major tremors. At 0450 hrs on 21 August 1988, an earthquake measuring 6.7 on the Richter scale, lasting about 40 seconds, devastated parts of the town of Dharan and many hill villages in East Nepal (Fig 1). Seven hundred and fifteen people were killed, 1,135 injured, and about 18,000 dwellings were destroyed or damaged.

The major accident plan for BMH Dharan was activated within an hour of the earthquake, and the hospital played a key role during the ensuing weeks in the provision of specialist care for the injured.

During "Operation Nightingale", the official British response to the disaster, aid in many forms was channelled through HQ British Gurkhas Nepal. This paper deals specifically with medical aspects of the relief exercise.

Effects of the Earthquake

Throughout the affected area most single storey concrete buildings other than those engulfed by landslides survived intact, as did houses constructed of wood. Many multi-storey blocks suffered damage, and the large majority of dwellings constructed of brick and clay-mortar (adobe) collapsed, entombing their occupants. A late monsoon deluge hampered rescue work and prevented helicopter evacuation from the hills. Roads and tracks were disrupted by landslides. Therefore the normally prolonged business of extracting earthquake victims from their homes was complicated by poor communications, leading to considerable delays before many patients received proper treatment. The earthquake caught many victims attempting to escape from their beds. Collapsing ceilings accounted for many axial skeletal injuries, pelvic and lower limb fractures.

The Response of BMH Dharan

At the time of the earthquake, the normal complement of staff (Table 1) was augmented by visiting Army dentist and 3 medical students on temporary attachment. The wives of serving British personnel on the camp provided one additional doctor.

Fig 1. Selective earthquake damage in Dharan. Note the relative vulnerability of adobe buildings and stability of wooden structures.

Table 1

BMH Dharan staffing for Operation Nightingale

	Qualified Staff complement at time of earthquake (80 beds)	UK reinforcing staff (212 beds)
General Duties MOs	1	2
Physicians	1	1
Anaesthetists	1	2
Surgeons	1	4
Gynaecologists	—	2
Nurses (RGN & ENG)	2	38
Midwives	8	4
Technical & paramedical	4	7
Medical assistants (CMT)	—	10
Administrators	1	1
	19	75

a radiographer and 7 nurses. For the first 48 hours, this *ad hoc* team of regular and volunteer staff, assisted by Nepali medical orderlies and technicians, produced the most significant medical relief effort in East Nepal, and provided the only sophisticated surgical facility.

After opening a Casualty Clearing Station (Fig 2a & b), the hospital was progressively expanded to 212 beds in tented wards, and a separate medical refugee centre was established in a large hall. This provided accommodation for those patients and a few relatives whose homes had been destroyed, and who required some form of ongoing treatment. At its peak 10 days after the earthquake, 157 individuals were being cared for in the refugee centre.

Specialist medical teams from Hong Kong and the UK reinforced the hospital, bringing orthopaedic, anaesthetic and nursing expertise to run a sophisticated surgical, obstetric and intensive care service. Enhancement of accommodation with supplies of electricity and water (Fig 3) allowed a reasonable normal level of ward activity to take place.

Although the existing major accident plan was invaluable in the early response, the scale of the disaster required considerable support from Headquarters British Gurkhas Nepal, and from the Army's reinforced infrastructure. Effective leadership at all levels, and a seemingly infallible resupply chain, were the hallmarks of success.

Patients

Eight hundred and eighty-eight victims were treated in the casualty clearing station (CCS) (Fig 2a & b) before it closed, 18 days after the earthquake. Two hundred and sixty were admitted, and 628 treated as outpatients. A resumé of injuries leading to admission is given in Table 2. Four hundred and fifty patients were triaged in the CCS on the first day, and many more with minor injuries received first aid and were discharged without documentation. Eighty-nine of the most seriously injured were admitted. One was dead on arrival, one died in the CCS of presumed massive intra-peritoneal bleeding, and 8 patients subsequently died in hospital as a result of their injuries (Table 3). One hundred and seventy-five operative surgical procedures were performed on earthquake victims, and an additional 15 manipulations of fractures were carried out (Table 4). Many patients required multiple procedures. Twenty-seven emergency operations were carried out on the first day.

When maternity services in Dharan became paralysed

Fig 2a. Casualty Clearing Station (CCS) being constructed.

Fig 2b. Completed CCS prior to opening.

Fig 3. Sinks, gravity fed from storage bowzers, and electric lighting allowed near normal ward activities in tented accommodation.

Table 2	
Earthquake injuries leading to admission	
1. FRACTURES	
Lower Limb: Femur	38
Tibia	41
Pelvis	31
Spine	40
Upper Limb	32
2. Crush chest and rib fractures	31
3. Head injury	17
4. Abdominal trauma	9
5. Severe soft tissue injury	30
6. Established tetanus	2

Table 3	
In-patient deaths directly resulting from earthquake related injuries.	
Tetanus	
Peritonitis	
ARDS	
Head injury	
Heart failure	
Renal failure	

Table 4
Operations on earthquake victims
(to 30.09.88)

Wound excision and debridement	55
Skin graft	15
Rotation flaps	2
Drainage of abscess	3
MUA fractures, and/or POP application	155
Application of skeletal traction	7
Open fracture reduction: Internal fixation	39
External fixation	12
C1/C2 fusion	1
Amputations: Legs	4
Fingers & toes	3
Laparotomy for visceral damage	8
Suprapubic cystostomy, or repair ruptured urethra	8
Tracheostomy	4
Feeding gastrostomy	4
Others	10
Total procedures	330

due to structural damage to the local hospital, the BMH provided obstetric care for the civilian population on demand. This considerably increased the number of unbooked and complicated deliveries (Table 5).

Discussion

Surgical Considerations

The majority of victims who survived the earthquake did not sustain injuries that posed an immediate threat to life, and surgery performed during the first 24 hours was restricted to the management of the most severely injured (27/450). During this phase, surgical treatment consisted of measures to control severe haemorrhage or

Table 5
Obstetric deliveries, BMH Dharan. 25.8.88–30.9.88

	25.8.88 to 30.9.88	Preceding 3-year average for period
All deliveries	101	37
% unbooked cases	69%	3.4%
% stillbirths & perinatal deaths	7%	3.5%
% babies <2.5 Kg	9%	4.2%
% ruptured uterus	3%	—
% PPH >500 mls blood	7%	3.0%

to repair visceral damage, including bladder and urethral injuries secondary to major pelvic fracture. Additionally, debridement of severely contaminated wounds and manipulation of badly displaced fractures with or without the application of external fixators, was regarded as a relative emergency. The Army's battle field external fixator (Centrafix, Central Orthopaedic Ltd) proved extremely versatile and simple to use in the management of 12 patients, some with devastating injuries (Fig 4a, b & c). We are not aware of any previous reports of its use in civilian casualties. However, its relatively low cost and versatility make it ideal for use in the management of the large number of open contaminated fractures which occur during an earthquake. The high incidence of spinal, pelvic and lower limb fractures complicated by severe soft tissue injuries, highlights the compelling need to include well equipped orthopaedic teams in medical rescue missions to earthquake disaster areas. They should include physiotherapists and other skilled in rehabilitation. Paraplegic patients, however, face an uncertain future in the third world, particularly in the Himalayan foothills.

An increase in complicated obstetric deliveries at BMH Dharan, especially the sudden arrival of unbooked cases in advanced stages of labour (Table 5) created an additional burden on already overworked staff. Somewhat unorthodox deliveries were recorded on rickshaws and outside the physician's office. The arrival of an obstetric team among the reinforcements proved of unexpected value in an earthquake crisis.

Anaesthetic considerations

Prior to resuscitation, many patients, especially those with serious abdominal, pelvic and lower limb injuries, had suffered considerable blood and other fluid losses. This was compounded by dehydration secondary to delayed rescue and prolonged transportation to hospital. All patients with clinical shock, dehydration and established myoglobinuria, or those considered at risk of developing crush syndrome, were given liberal quantities of crystalloid with colloid supplementation required. Whole blood was only used to correct significant anaemia or per-operative losses, surprisingly little being required overall. Of 697 units obtained (51 imported, 197 locally bled donors), 470 were cross matched for 176 patients. Only 252 of the 697 units of blood were eventually used for the earthquake victims. This low usage rate has been noted by others².

No patient died from hypovolaemia after admission, and only one developed (and later died from) renal failure secondary to crush syndrome. This contrasts with other earthquake experiences^{3,4} where the syndrome reported in 3.5% of all victims, and up to 36% of those with fractured long bones. No facilities for haemodialysis or filtration existed in Nepal at the time of the earthquake. Chest infections were common, and one 10 year old male with chest injuries and multiple fractures

Fig 4a. 11 year old girl admitted 8 days after the earthquake, with a compound fracture of the upper tibia and extensive soft tissue injury.

Fig 4b & c. Stages in the management of these soft tissue injuries, using the field pattern external fixator (b) to stabilize the underlying fracture. Immediately prior to skin grafting (c).

died from post traumatic respiratory insufficiency.

Any anaesthetic team working in the Third World must be prepared for a lack of anaesthetic carrier gases, including oxygen. Late monsoon flooding in the wake of the earthquake disrupted the re-supply of bottled gases for over two weeks. This problem was overcome by the extensive use of the British Tri-Service pattern anaesthetic equipment, with supplemental oxygen provided by an electrically powered oxygen concentrator. Used in conjunction with the Cape TC50, an electric ventilator, the combined equipment (Fig 5) provided an extremely satisfactory and safe means of anaesthesia for all types of surgery. Any anaesthetic plan in such situations should provide for "draw-over" anaesthesia, oxygen concentrators and an independent electrical power supply.

Our experience identified the need to provide some form of high dependency or intensive care unit (ICU). Twenty-eight patients, including 6 on long-term ventilation, required this facility. The Cape TC50 and

Fig 5. Cape TC 50 and Tri-Service field anaesthetic equipment.

oxygen concentrators again proved invaluable and reliable in this situation, although power failure to the ventilator contributed to 2 deaths. An apnoea alarm fitted to the TC50 is strongly recommended. Intensive care is costly in both manpower and materiel, and benefits must be carefully assessed. However, there is a definite place for such units in the management of earthquake victims, especially if haemodialysis is to be performed.

Role of the physician

The requirement to separate the Triage area from Resuscitation following an earthquake is explained later. There is a compelling need to co-ordinate the activities of both units, and when surgical teams are tied up in the operating theatre and where there is no senior accident and emergency specialist, the physician plays a vital administrative and clinical role. In the major accident plan for BMH Dharan, the physician is tasked as resuscitation and triage officer, and the use of physicians in this role in major disasters has been reported elsewhere⁵.

We found that earthquake victims were particularly prone to develop severe chest infections, probably due to a combination of pre-existing lung disease, crush injuries to the thoracic cage, dust inhalation, and anaesthetic gas irritation. The physician plays an important role in the management of these gravely ill patients, especially in the intensive care unit.

In the context of preventive medicine, and in the absence of any effective local public health laboratory facilities, we found that the physician was influential as head of an environmental health team, especially in monitoring the local water supplies and in formulating a vaccination policy. Initially, the coliform colony count in town tapwater was in excess of 1000 per 100 mls, and after decisive action by the environmental health team, hyperchlorination reduced this to a consistently low level. One thousand eight hundred and twenty-seven military and key civilian personnel were vaccinated, mainly against cholera and typhoid. No cases were subsequently reported in Dharan, though both are common in the region. There was no reported increase in the incidence of any communicable disease following the earthquake, a finding confirmed previously^{6,7}.

After the earthquake, a large number of patients later returned with uncontrolled diabetes, hypertension, heart failure and tuberculosis, resulting from their inability to reach out-patient clinics, or obtain resupplies of their medications. Physicians can expect busy clinics and increased admissions after disrupted communications have been restored.

Nursing considerations

The admission of 89 badly injured patients in the first 14 hours following the earthquake proved a considerable nursing challenge. Twenty-eight of

least severely ill existing patients had to be discharged, and 46 additional camp beds and litters were placed on verandahs and in tents to make room for new admissions. After initial deployment to the Casualty Clearing Station and Resuscitation, trained staff were supplemented on the wards by camp volunteers, as the huge problem of ward administration became apparent. Several Nepali nursing and paramedical staff lost their own homes or possessions as a result of the earthquake (Fig 6), yet none missed a day's work.

Earthquake victims are difficult and labour intensive patients to nurse. Most were covered in dust and rubble on admission, and all required routine bathing, de-lousing and de-worming. Nearly all had severe soft tissue wounds and multiple fractures, and many were paraplegic or had visceral injuries. Twenty-seven required post-operative monitoring on the first day.

This period of intense activity followed the frightening personal experience of a dramatic earthquake, and it is remarkable that few staff displayed any serious stress reactions. Throughout the relief exercise, trained nursing staff frequently worked in an "extended role", undertaking many duties normally performed by junior doctors. However, after the initial excitement of the earthquake, nursing tasks became physically tiring, unglamorous and emotionally taxing, especially for reinforcements unacclimatized to tropical monsoon conditions and unaccustomed to the cultural deprivation of Dharan.

Re-evaluation of needs and re-deployment of staff was required at least every day, and the value of regularized working shifts was quickly recognised, especially for local staff. A good "Matron" is invaluable in a disaster relief team, and nursing administration must be sensitive to the fact that stress amongst staff in such conditions can lead to decompensation.

Administrative considerations

The initiation and co-ordination of the major accident plan was followed by an urgent re-assessment of the requirement for materiel and personnel reinforcement. This proved particularly difficult, since there was no indication of the scale of the disaster in the Himalayan foothills, and estimation of the likely number of casualties was almost impossible. The expansion of existing hospital facilities and the creation of a medical refugee centre required careful planning, and as the National response became more co-ordinated, close liaison with the press, local politicians and senior civilian medical personnel proved very time consuming. This was not infrequently to the detriment of other clinical and administrative duties. A multitude of new problems arose daily, mostly relating to personnel or materiel reinforcement, or to patient welfare. Six hundred and six "immediate" or "priority" telegraphic signals relating directly to Operation Nightingale alone were sent from the Administrative Office between 21 August

and 30 September. The administrative and personnel officers played a vital role in co-ordinating the response and in handling the many problems that arose among reinforcing staff.

Daily meetings between the various heads of departments of HQ British Gurkhas Nepal (Fig 7) were crucial the resolution of both clinical and administrative problems. No clinician should under-estimate the value of such meetings in time of crisis, nor is there a time of greater need for decisive administration in all departments.

General

Although considerable technological advances have been introduced in Kathmandu hospitals in recent years, as in many developing countries, outside the capital lack of funds has precluded allocation of resources to rural hospitals to similar high standards. The staff of these hospitals work long hours and are unable to get the training needed to raise their standards to those of more

Fig 6. A Nepali operating theatre technician stands with his family in the ruins of his home.

Fig 7. Heads of Departments meet daily under the chairmanship of the acting Commander, British Gurkhas Nepal.

sophisticated centres. Apparently little pre-planning for major disasters had been possible, and therefore the initial medical response to the earthquake was somewhat disordered and at times ineffective. We found that volunteer and drafted medical personnel who first arrived in support of local hospitals were also poorly equipped, and that treatment delivered to the injured was occasionally inappropriate. Primary suture of severely contaminated wounds was the most common technical fault (Fig 8), and initially, little attention was paid to tetanus prophylaxis or adequate fracture splinting. This resulted purely from lack of the most basic resources, and reflects the degree of poverty in much of Nepal.

Mahoney⁸, reviewing the design of disaster medical care systems, stressed the importance of both

Fig 8. 8 year old girl, with a massive, contaminated, primary sutured cranio-facial wound. Discharged with a healed wound, 10 days after re-exploration and enucleation of left eye, and removal of cement debris from the orbital roof.

"timeliness" and "appropriateness" of aid. He also noted that well-meaning individuals often flock to disaster areas, frequently with little effect. Improved communications and co-ordination⁹ and the inclusion of sophisticated surgical facilities in disaster relief teams have been called for to improve the quality of response to requests for assistance.

In stark contrast to local facilities, the Casualty Clearing Station at the British camp was up and running within 90 minutes of the earthquake. Although limited first aid, resuscitation and holding facilities were provided here, more definitive treatment was instituted at the Resuscitation Unit established in the main hospital. We found that following the earthquake, the CCS became clogged with the minor injured, making triage more difficult and effective resuscitation impossible. The separation of Triage from Resuscitation was a critical factor enhancing our ability to process many casualties. More than 450 patients were triaged and treated in the CCS by 2 doctors and 3 nurses in the first 14 hours. Of these, 152 were transferred to Resuscitation for further treatment by 2 more doctors, a senior medical student and several medical orderlies. Eighty-nine victims were eventually admitted to wards on the first day. The nature of structural damage, especially to adobe buildings, and the resulting injuries encountered, accord well with those described following earthquakes in other Third World countries^{2,3,8,11,12}.

Large areas of relatively mountainous terrain were affected by the earthquake, and helicopter evacuation was crucial to successful casualty retrieval from isolated communities. Sufficient aircraft may not be available in many third world countries. However, Royal Nepal Army helicopters evacuated a large number of patients in difficult weather conditions (Fig 9). This resulted in a sustained level of admissions over many days. Although numerically far fewer per day were treated than immediately after the earthquake, the nature of the injuries became progressively more severe due to neglect. This pattern of admission differentiates natural catastrophes from other mass casualty situations such as air disasters or train crashes^{13,14} and requires a long-term commitment to triage as each batch of rescued victims delivered to hospital (Table 6 & 7).

The air-portable military hospitals of many armies possess ideal qualities in both materiel and personnel to respond to an earthquake. Their training in triage of mass battle casualties is equally applicable to civilian natural disasters, and the surgical principles involved in the treatment of missile injuries are also appropriate to the management of the major soft tissue wounds and fractures encountered in earthquake victims. Adequate debridement, no primary closure and external fixation of unstable open fractures with contaminated wounds were all principles applied with great success to our patients. The use of military surgical (especially orthopaedic) teams in such circumstances has been reported in many previous disasters^{2,3,7}.

Fig 9. Royal Nepalese Army helicopter delivering a batch of victims. Note the hazardous flying conditions, with the monsoon cloud base well down on the Himalayan foothills.

Reitherman¹⁵ pointed out that the construction of hospitals themselves renders them liable to be a major source of casualties in an earthquake. They are often large buildings with a high population density, and contain vulnerable machinery such as lifts, laboratory equipment and heavy plant such as boilers. Steinbrugge et al¹⁶ estimate that between 13% and 34% of all fatalities and serious injuries in the San Fernando Bay area of North America would be caused by damage to hospital buildings. Planning in earthquake zones should take account of these predictions, and hospitals should contain sufficient open ground to allow expansion into tented wards with triage and resuscitation areas. Although some hospitals were damaged in Nepal, we do not know of any fatalities or injuries that resulted. However, such damage severely curtailed local services in Dharan, adding particularly to our obstetric workload.

On occasions, our own specialist expertise and operating theatre and intensive care facilities were under-used when poorer local civilian services were placed under extreme pressure. We found that the apparent reluctance to transfer severely injured patients on time for specialist treatment resulted in increased morbidity and possibly mortality (Fig 10). These delays were in addition to those inevitably resulting from collapsed buildings and disrupted communication. Such hesitancy in accepting offers of both material aid and outside skilled medical assistance¹⁷ however, demonstrates that disaster relief can only be invited by and not imposed upon host governments. Nevertheless, the Armenian experience^{18,19} confirms the constructive international role that skilled medical personnel can play in the management of these severely injured patients. In many of the world's earthquake areas specialist units such as dialysis and orthopaedic teams

Table 6

Comparison of an earthquake and two rail disasters. The very large numbers of earthquake injured make triage and effective resuscitation more difficult, although a smaller proportion may be severely injured. Three individual hospital experiences.

	Nepal earthquake 1988 BMH Dharan	Clapham rail disaster 1989 St Georges Hospital ¹³	Purley rail disaster 1989 Mayday Hospital ¹⁴
First day's casualties	450+	130	84
First day's admissions	89 (<20%)	43 (33%)	39 (46%)

must be brought to the patients if benefit is to be achieved.

Such benefits are not cheap, and when added to the cost of structural damage, few Third World countries can afford the price of the "high-tech" medicine and long-term rehabilitation required by many earthquake-injured patients. A conservative estimate of the cost of Operation Nightingale is put at approximately £0.4 million. (£155,000 for drugs and equipment, £155,000 for transport and movement of personnel and materiel, and £90,000 for reinforcing personnel costs.) Where death and disease are commonplace anyway, Third World governments may identify other priorities on which to spend such sums of money.

Conclusions

Disaster contingency planning is as important in the

Third World as elsewhere, although at the time of the East Nepal earthquake such plans were apparently lacking in civilian hospitals. Our experience at BMJ Dharan indicates that a well organized team of medical and paramedical staff, however small, can respond effectively to the large number of casualties from an earthquake, pending the arrival of medical reinforcements. Although the major accident plan for BMJ Dharan was invaluable during the early phase of the response, the magnitude of the disaster requires considerable materiel and manpower enhancement of the hospital. Ultimately, the effectiveness of the response is only as good as the infrastructure supporting it. Poverty in Third World countries may preclude the proper development of this critical infrastructure.

Under these conditions, natural catastrophes beg the creation of sophisticated air-portable medical units.

Table 7
East Nepal Earthquake 1988 – Pattern of Admissions

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Fig 10. Untreated severe cranio-facial wound with underlying skull fracture, 8 days after injury. Patient died of tetanus 2 days after admission.

organized, staffed and adequately funded under the auspices of internationally acceptable agencies. Such units should exercise regularly under field conditions. Prompt arrival at the scene of the disaster is crucial if lives are to be saved, though in the context of an earthquake their role is probably better directed at the provision of specialist expertise and rehabilitation of survivors. Political factors may delay the arrival of such units until after their life-saving potential has expired.

Good communications and leadership and a responsive re-supply chain are required to produce a rational and effective reply to a natural catastrophe, especially where medical teams are operational outside their normal areas. Following an earthquake, units sent in support of small hospitals must include orthopaedic facilities, ICU, obstetric and environmental health expertise may add considerably to the effectiveness of these emergency teams.

Many victims surviving an earthquake have severe orthopaedic injuries, but most of these can await the

arrival of specialist expertise. Careful triage allowing incumbent surgeons to salvage those with life threatening injuries. In these circumstances, we recommend that triage, which can be performed by relatively inexperienced staff under supervision, should be carried out in an entirely separate area from resuscitation. The most severely injured patients can, after transfer, receive intensive treatment in resuscitation from doctors unencumbered by the hundreds of minor injured clamouring for attention, distressed relatives, press and others.

Currently, air-portable military field hospitals probably offer the best available facilities in response to natural disasters. Administrative and personnel officers should accompany any sizeable contingent, especially when reinforcing a remote unit in the Third World.

Can one measure the value or effectiveness of medical relief exercise such as Operation Nightingale? One objective assessment was offered by Paul Bell², Latin American Advisor, United States Office for Foreign Disaster Assistance (OFDA), who stated in his report on the US earthquake relief programme: "— the level of sophistication of the attention and surgery is comparable to that in London. What the British have done in this hospital deserves our highest praise. In my years in responding to disasters, I have never seen anything comparable."

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