Responding to Major Burn Disasters in Resource-Limited Settings: Lessons Learned From an Oil Tanker Explosion in Nakuru, Kenya

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Background: On January 31, 2009, a fuel tanker exploded in rural Kenya, killing and injuring hundreds of people. This article describes the care of >80 burn victims at a rural hospital in Kenya, Nakuru Provincial General Hospital, and provides lessons for care of a large number of burned patients in a resource-limited setting.

Methods: Data were obtained from retrospective review from hospital registers and patient files.

Results: Treatment was provided for 89 victims. Eighty-six (97%) were men; median age was 25 years (interquartile range [IQR], 19–32). Half of the patients (45) died, the majority (31, 69%) within the first week. The median total body surface area burned for those who died was 80% (IQR, 60–90%) compared with 28% (IQR, 15–43%) for those who survived ($p < 0.001$). Twenty patients were transfused a total of 73 units of blood including one patient who received 9 units. Eighty surgical interventions were performed on 31 patients and included 39 split-thickness skin grafts, 21 debridements, 7 escharotomies, 6 dressing changes, 4 contracture releases, and 3 finger amputations. Of the 44 survivors, 39 (89%) were discharged within 4 months of the event.

Conclusions: Mortality after mass burn disasters is high in Africa. In areas where referral to tertiary centers is not possible, district hospitals should have mass disaster plans that involve collaboration with other organizations to augment medical and psychologic services. Even for patients who do not survive, compassionate care with analgesics can be given.

Key Words: Mass burn disaster, Africa, Resource-limited setting.

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Burn disasters are defined by mass casualties and major loss of life.[1] Severely burned patients are resource-intensive to treat, often requiring intensive care, respiratory support, surgical debridement, split-thickness skin grafting, frequent dressing changes, intravenous pain medications, and psychologic counseling. Complications include multi-organ failure and sepsis; patients are best cared for at specialized burn centers where multidisciplinary teams of specialists work.

High-income countries have specialized burn centers, well-developed referral systems, and mass disaster plans.[2] In the United States, Australia, Belgium, the Netherlands, and the United Kingdom, mobile burn teams consisting of surgeons, anesthesiologists, nurses, and respiratory therapists are often deployed to the scene to assist in the initial evaluation and resuscitation.[3] Because each patient is resource-intensive to treat, any burn center will become overwhelmed after just a few severely injured patients, and in a mass burn disaster, patients should be stabilized and then transferred to other facilities. After a major fire in Volendam, the Netherlands, the 245 victims were triaged to 36 burn centers in 3 countries. Similarly, after a nightclub fire in Rhode Island, United States, 215 victims were cared for at 16 burn centers nationwide.[4,5]

In contrast, few low-income countries in Africa have deployable burn teams to stabilize patients in the field. If burn centers exist, they are located in urban areas, and their surge capacity is quickly exceeded with a few severely injured victims. Moreover, poor road conditions and the lack of ambulances make rapid prehospital transport of multiple victims difficult. As a consequence, burn-related disasters in Africa are often associated with a high number of deaths and casualties.[6] Kenya is a low-income country with nearly all its burn care facilities in Nairobi. This article describes the care of >80 burn victims at rural hospital in Kenya Nakuru Provincial General Hospital (NPGH) after an oil tanker explosion in Molo, Kenya, and provides some lessons for care of large numbers of burned patients in a resource-limited setting.

PATIENTS AND METHODS

Setting

On January 31, 2009, a fuel tanker overturned near Molo, a rural town 178 km northwest of Nairobi, Kenya. Large crowds gathered to collect the spilled oil, and shortly after, the tanker exploded, killing at least a hundred people.[7] Among the survivors, 122 severely injured were transported to the nearest hospital, NPGH, by bystanders and the Kenyan Red Cross Society.[8] Only 2 days earlier, a fire in a Nairobi supermarket killed 29 persons and injured at least 14.[6,9]

NPGH could not care for all these patients, and although there were other hospitals in the province, a large number of ambulances would have been required to move patients to these destinations, and most hospitals had only one

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ambulance or none at all. Nairobi had a high concentration of facilities and staff with the ability to handle severely burned patients. Therefore, 44 patients were airlifted by the Army in one plane to Nairobi's tertiary hospitals (Kenyatta National Hospital, Nairobi Hospital, Mater Hospital, and Aga Khan Hospital).[9] It was a faster and safer method of transfer of very sick patients compared with transfer by road.

Nakuru Provincial General Hospital

The majority of the 89 victims left at NPGH were severely injured (>60% total body surface area [TBSA] burns). NPGH is the referral hospital for the district and has four major departments—surgery, medicine, obstetrics/gynecology, and pediatrics—and a 600-bed capacity. Staff general surgeons and medical officers performed elective and emergency operations in four operating rooms. A small intensive care unit (ICU) had five beds with two ventilators. Laboratory capacity included a blood bank and basic diagnostic capabilities (hematocrit, platelets, electrolytes, and creatinine).[10] NPGH did not have specific resources to treat severely burned patients.

RESULTS

Burn Care Response

The hospital was immediately overwhelmed by the large influx of severely burned patients. The staff were occupied caring for the routine patients and could not attend the critically ill newcomers. In the first night, nine patients died. The Ministry of Health made an appeal for international assistance to Médecins sans Frontières (MSF), a medical humanitarian organization that had been working in Kenya since 1987. With the help of MSF, the hospital provided curative care for the burn victims. An empty ward was allocated to the patients and the first task was to provide beds and blankets. MSF provided a physician who began triage by assessing each patient and recording the location and severity their burns on an injury triage sheet. Intravenous fluid resuscitation was initiated using the Parkland formula. Later, adequate urine output was used as the endpoint. Patients who were able to drink were encouraged to take oral fluids. This was challenging given that many had bilateral hand burns or were not strong enough to drink liquids independently. There was a shortage of nursing staff to assist, and family members had limited access to the burn ward. Pain medications were started. Before the disaster, NGPH did not supply meals; family members provided food for patients. However, burn victims were given milk, eggs, vegetables, fruit, and high-protein and high-energy peanut-based food (Plumpy'nut).

Burns were cleaned, debrided, and covered with sulfasalazine cream. Wounds were dressed with sterile gauze every 3 days or sooner where there were clinical signs of infection (fever, discharge, and increased pain). Several teams of volunteer international and national surgeons worked alongside local staff for ~2 weeks. Thereafter, a dedicated MSF surgeon continued surgical care for an additional 8 weeks. Other nongovernmental organizations (NGOs) also provided physicians and other medical staff to care for the patients.

Baseline Characteristics

Among the 89 burn victims treated at NPGH, 86 (97%) were men; their median age was 25 years (interquartile range [IQR], 19–32). Half of the patients (45) died, the majority (31, 69%) within the first week (Fig. 1). The TBSA affected by burns was recorded for 42% (19 of 45) of the patients who died and all patients who survived (44%). The median TBSA for those who died was 80% (IQR, 60–90%) compared with 28% (IQR, 15–43%) for those who survived ($p < 0.001$). Twenty patients were transfused a total of 73 units of blood including one patient who received 9 units.

Operative Interventions

In total, 80 interventions were performed on 31 patients and included 39 split-thickness skin grafts, 21 debridements, 7 escharotomies, 6 dressing changes, 4 contracture releases, and 3 finger amputations. No patients died in the operating theater; however, 5 patients whose TBSA were >50% died after surgical intervention (6–29 days postoperatively). Of the 44 survivors, 25 (57%) had skin grafting with 13 patients undergoing more than one graft. The majority of the 19 survivors who did not have skin grafts had burns <25%.

Long-Term Outcomes

Of the 44 survivors, 39 (89%) were discharged within 4 months after the event. Four patients remained in stable condition on the burn ward. Nine of the discharged patients were counseled at a local health clinic because of the ongoing psychologic problems after discharge.

DISCUSSION

Fuel tanker explosions are common in Africa.[6] The Molo fuel tanker explosion was a mass burn disaster that resulted in hundreds killed and injured. Mobile burn teams do not exist in Kenya, but government and NGOs worked together to quickly transport victims to nearby hospitals. Unfortunately, the number of severely injured patients outnumbered available beds at burn centers. Patients who needed specialized care but were more likely to survive (TBSA, 20–30%) were triaged to higher level care. More than 80 victims, including those most severely injured, were left at NPGH.

The hospital was overwhelmed with the number of patients and the severity of injuries. However, this experience demonstrated that even in a resource-limited setting, a number of steps that can be taken to strengthen the treatment of patients in a mass disaster. With the assistance of international NGOs, curative treatment was provided despite limited

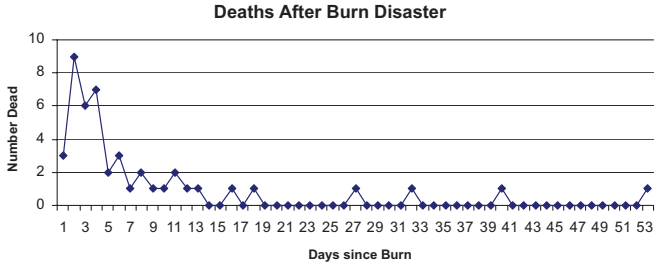

Figure 1. Timeline of deaths after fuel tanker explosion.

resources. Although not a burn center, the hospital was relatively well equipped and had a small ICU, an operating theater, a laboratory, and surgeons and physicians. It was recognized early that humanitarian assistance would be needed especially for the increase in material and human resources needed. MSF provided dedicated staff for the burn victims so that the hospital staff could continue to care for the nonburn patients. Hospital infrastructure was upgraded by adding additional beds, medications, surgical capacity, and essential human resources. A surgeon was dedicated to the care of burn victims for 2 months to perform the multiple surgical interventions. A physician, who did not have other responsibilities in the hospital, coordinated the ward care of the patients. A mental health team provided psychologic support given the high risk of posttraumatic stress after this type of event. From this experience, a number of essential requirements for effectively responding to a mass burn disaster in a resource-limited setting can be identified. These are listed in Table 1.

Most of the patients were severely burned and half died; three-quarters of all deaths occurred in the first week. Even in resource-rich countries, mortality in severe burns is >50%.[11] In our setting, deaths in the first 72 hours were caused by the severity of the burns and limited human resources. Once MSF intervened, maximal support was given to each patient including fluids, nutrition, antibiotics, wound debridement, skin graft, and other surgical care. Compassionate care was offered once the severity of a patient's condition surpassed existing resources.

TABLE 1. Lessons Learned for Treating Mass Burn Victims in a Resource-Limited Setting

In the first 24 h
Triage critically burned patients to specialized centers if possible.
Assess the facility and human resources. Find other stakeholders to assist if not adequate.
Establish a burn ward and beds for all patients.
Immediate assessment of TBSA burned and degree of burn by medical professional.
Place intravenous line, urinary catheter, begin fluid resuscitation, and record urinary output and fluid received.
In the first 72 h
Dedicate a medical team to care for burn patients. They should not have other hospital duties.
Provide mental health support for patients and their families.
Increase nursing staff accounting for labor intensive daily dressing changes.
Estimate the supply and medication needs for the next few weeks; find suppliers and donors as hospital's stock will be quickly depleted.
Ensure operating theater is functional. Provide sterilization equipment, supplies, and staff.
Establish blood bank if it does not exist.
In the first week
Surgical debridement of all dead tissue including escharotomies as needed.
Pain medications for patients with multiorgan failure (respiratory, renal, and cardiac).
In the subsequent weeks/months
Provide physical therapy to prevent contractures.
Provide occupational therapy so that burn victims can prepare to return home.
Treat sepsis.
Ensure adequate nutrition.

After the first week, mortality dropped to 27%, although median TBSA was 39%. Deaths after the first week were usually caused by multiorgan system failure and sepsis. Specific challenges in this context included the lack of medical staff with burn experience, the inability of the laboratory to process the high volume of requests, the occupancy of the operating theater by nonburn trauma cases, and the lack of a larger ICU. A major cause of morbidity was inappropriate fluid management. Many patients received less fluid than recommended for severe burns and developed oliguria and acute renal failure.[12] No dialysis machines were available. Others acquired pulmonary edema after high-volume resuscitation and needed respiratory support, but the ICU only had limited space and one ventilator. Patients were anemic after multiple wound debridements, and blood products were limited. Wound infections were difficult to treat appropriately without appropriate microbiology. Thrombocytopenia was a major problem. Other studies have identified independent predictors of mortality that include sepsis, ventilator dependency, and low platelet counts.[13]

Although many of these limitations were because of the lack of proper infrastructure or expensive monitoring devices, certain inexpensive improvements may have improved care such as point-of-care hemoglobin monitoring, glucometry, better urine output monitoring, supplemental oxygen machines, and bedside pulse oximetry. Finally, an operating theater dedicated to burn care would also have improved outcomes.

Psychologic support was found to be an essential component of the disaster response. MSF provided psychologists and counselors who initially worked with the medical staff to ensure that all burn victims had received analgesics, clean bedding, and mattresses. Once patients were medically stable, grief counseling for victims and their families was provided. The importance of surgical procedures such as skin grafts or amputations were explained. Many patients expressed concerns about physical disfigurement and returning to the community, and these concerns were addressed in individual and group counseling sessions. Vulnerable patients were followed by the Ministry of Health counseling team after MSF assistance was completed.

Unfortunately, in a low-income country such as Kenya, economic pressures often outweigh risks to personal safety, even when the risks are known, and the potential for a repeat of this tragedy cannot be ruled out. Ideally, Kenya should have national disaster plan and provide appropriate training for the staff. However, given the limited resources of many of Kenyan government hospitals, this may not occur in the near future. In the meantime, additional training in burn care should be provided. Mapping of available organizations with the capacity for disaster response and their resources are urgently needed. Finally, networks between governmental and nongovernmental institutions should be established so that the interagency response to future disasters will be streamlined.

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