SPECIAL REPORT

Team Echo: Observations and Lessons Learned in the Recovery Phase of the 2004 Asian Tsunami

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Abbreviations:
ADF = Australian Defence Force
GAM = Gerakan Aceh Merdeka (Free Aceh Movement)
ICRC = International Committee of the Red Cross
IOM = International Organization for Migration
IV = intravenous
NGO = non-government organization
WHO = World Health Organization

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Abstract

The 26 December 2004 Tsunami resulted in a death toll of >270,000 persons, making it the most lethal tsunami in recorded history. This article presents performance data observations and the lessons learned by a civilian team dispatched by the Australian government to "provide clinical and surgical functions and to make public health assessments". The team, prepared and equipped for deployment four days after the event, arrived at its destination 13 days after the Tsunami. Aspiration pneumonia, tetanus, and extensive soft tissue wounds of the lower extremities were the prominent injuries encountered. Surgical techniques had to be adapted to work in the austere environment. The lessons learned included: (1) the importance of team member selection; (2) strategies for self-sufficiency; (3) personnel readiness and health considerations; (4) face-to-face handover; (5) coordination and liaison; (6) the characteristics of injuries; (7) the importance of protocols for patient discharge and hospital staffing; and (8) requirements for interpreter services.

Whereas disaster medical relief teams will be required in the future, the composition and equipment needs will differ according to the nature of the disaster. National teams should be on standby for international response.

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Introduction

On 26 December 2004, an earthquake measuring 6.8 on the Richter scale, with a momentary magnitude of 9.0, originated in the Indian Ocean about 160 kilometers off the western coast of northern Sumatra, Indonesia. The Earthquake was strong enough to alter the axis of the Earth's rotation momentarily.[1] The resulting Tsunami devastated the shores of Indonesia, Sri Lanka, South India, Thailand, and other countries, with waves up to 15 meters high.[2] The exact death toll may never be known, but of the 270,000 deaths counted, 200,000 were in Indonesia, making it the most deadly tsunami in Indonesia in recorded history.[3]

The territory of Aceh is known for its political independence and fierce resistance to occupation by "outsiders", including the former Dutch colonists and the current Indonesian government. Since 2003, it has been the site of renewed conflict between the Indonesian military (Tentara Nasional Indonesia) and Acehnese separatists (Gerakan Aceh Merdeka (GAM) (Free Aceh Movement)). Banda Aceh is the provincial capital and largest city in the Province. It has an elevation of 21 meters, and also was the closest major city to the Earthquake epicenter (250 km). At the time of the Tsunami, Banda Aceh had a population of approximately 225,000 inhabitants. Large areas of the city were destroyed by the Tsunami, which struck about 20 minutes after the Earthquake.

Normally an area restricted to journalists and aid-workers, the Indonesian government opened the region to international relief efforts after the event, and Indonesian troops were re-tasked from security-related tasks to relief

activity. Separatist forces agreed to a temporary cease-fire, although reports of sporadic armed clashes continued.

Immediate Response by Australian Government

The Australian Commonwealth Government Overseas Response Plan was activated on 27 December 2004, and an assessment team was dispatched. A large, public general hospital (Rumah Sakit Zainal Abidin) was unusable, but the TNI Hospital (Rumah Sakit Kesdam) was unaffected structurally, so Team Echo, a 23-member Australian team, was able to work in this hospital. Fakinah Hospital was a private, empty, locked, 80-bed hospital, located four kilometers from the coast, and on the edge of the destruction in Banda Aceh. With approval from the Indonesian Provincial Governor, military police authorities commandeered the hospital for the Australian teams. It was thought that about 50 of the 150 (one-third) of the hospital staff members had died during either the Earthquake or the Tsunami.

Deployment of Team Echo

Team Echo arrived in Banda Aceh on 08 January 2005, and returned to Australia 13 days later. The Team was preceded by two Australian Agency for International Development-funded medical teams (Alpha and Bravo), which were part of a multi-disciplinary task force. Team Echo consisted of a physician, an orthopedic surgeon, two plastic surgeons, one general surgeon, four anesthetists, one infectious diseases physician, one emergency department physician, eight operating theater nurses, one emergency department nurse, two paramedics, one logistician, three laboratory personnel, and equipment to assist in the bacteriological assessment of potential infectious disease outbreaks. The Team's anesthetic and surgical assets were used from the day they arrived.

With the Indonesian relief teams, clinical protocols were established for the management of tetanus and tetanus-prone wounds, aspiration pneumonia, and sepsis. Only a portable ultrasound device (SonoSite 180+, SonoSite Inc., Bothell, Washington) was available; subsequently, x-ray facilities were provided by the Australian Army field hospital. Additional basic laboratory services, including a medical microbiologist and two senior laboratory scientists, also were provided. The medical record system lacked supplies and personnel, including interpreters. The Team primarily provided acute surgical care with a secondary focus on medical care. A total of 128 patients were treated over 11 days.

Team Echo Observations and Lessons Learned

Medical case observations

Thirty-five medical cases consisted of 17 patients with aspiration pneumonia, 10 cases of Tsunami-related, tetanus-infected wounds, three patients suffering from acute myocardial infarction, three patients with acute gastroenteritis (two of them children), one case of malaria (*Plasmodium vivax*), and one case of moderately severe asthma.

The aspiration pneumonia complications were termed "Tsunami lung".[4] Dyspnea and non-productive coughs were common. Mild to moderately severe cases were treated empirically with intravenous (IV) potassium clavulanate/ticarcillin sodium and oral ciprofloxacin. Unresponsive or more severe disease received IV meropenem trihydrate and oral ciprofloxacin. Oral trimethoprim/sulfamethoxazole later was included. Four deaths (11.4%) occurred.

The tetanus patients suffered either localized or generalized tetanus with moderate to severe muscle spasms. All received wound debridement, tetanus immunoglobulin, metronidazole, and high dose intravenous diazepam. Intravenous propofol also provided effective sedation. Two of these 10 patients died. Three critically-ill tetanus patients later were transferred to the International Committee of the Red Cross (ICRC) hospital. The high incidence of tetanus reflected a low immunization rate in the community, the lack of appropriate footwear, the contaminated, wet environment, and the vast array of sharp objects and debris. As a result of a worldwide shortage of appropriate tetanus immunoglobulin, anti-tetanus serum had to be obtained from a number of outside sources. The serum was equine in origin, and has been associated with a risk of anaphylaxis. Fakinah Hospital became the World Health Organization (WHO) supply point for this product.

Oxygen cylinders also were in short supply. Oxygen concentrators were supplied by the Swiss government. Relatives were trained to encourage patients to perform cough and chest physiotherapy consisting of blowing though a straw placed in a drinking bottle filled with water.

A shortage of food and money contributed to an inadequate diet. No prepared, nutritional supplements were available. Ultra-high temperature milk supplied by the team was used for nasogastric feeds in selected surgical and tetanus patients. Eventually, a catering service for hospitalized patients was funded by Team Echo.

Surgical Cases Observations

A total of 148 surgical procedures were performed on 93 patients; only seven were not Tsunami-related. No deaths were recorded.

Wound distribution and mortality—The characteristics of the disaster help to explain the body zones injured. A high proportion of lower limb wounds (80/106 (75%), for Team Echo, and 96/129 (74%) for Team Alpha-Bravo), and a low number of surviving children (10/93; 11%) for Team Echo, and 9/90 patients (10%) for Team Alpha-Bravo) were recorded (Table 1).[5]

A similar wound pattern was reported from the German and Finnish experiences.[6,7] Anyone struck or engulfed by the full strength of the wave was unlikely to survive; therefore, patients with major wounds to the upper torso were uncommon. Adults who were tall and strong enough to stand in the waning wave suffered leg wounds and survived. Children were overwhelmed by this phase of the wave. Most of the adults and children with major injuries died within the first few days after the Tsunami.

On arrival, Team Echo managed failed primary closures, wound debridement, and limb preservation as surgical priorities. Orthopedic procedures included revision of

Body Zone Affected	Number	% Total
Head and Neck	5	5
Upper Limb	17	16
Upper Trunk	2	2
Lower Trunk	1	1
Lower Limb	80	75

Table 1—Body zones affected for 92* patients (n = 105; *the area was not recorded for one patient)

three previously performed major amputations, and three minor amputations with delayed primary closure.

All operative cases received IV potassium clavulanate/ticarcillin sodium. The majority of cases were performed under ketamine hydrochloride anesthesia with a sedative (diazepam or midazolam), and an opioid. Oxygen was required for a minority of cases reaching the operating theater.[8] The nature of the injuries being treated meant that some cases returned to the theater on a number of occasions. Nineteen patients had two procedures, four needed three procedures, while one patient required five anesthetics over a period of 13 days (Table 2). Case scheduling was complicated by the predilection for patients to eat before surgery, thinking this would provide needed sustenance during the operation. This was corrected once interpreters became available.

Split-skin grafting with hand meshing was used successfully for soft tissue wounds where suturing was not feasible. Of the 58 cases in which this technique was performed, none had failed up to the time of departure. Similar success was noted following the Aitape Tsunami.[9] A mechanical mesher is critical for the treatment of larger wounds, as it allows greater expansion of a graft. Planning for sudden-onset disasters should include such a device as well as a significant amount of Plaster of Paris used for splinting limbs after grafting.

For some of the wounds, pulsatile lavage was considered useful, but it is not a substitute for surgical debridement. A number of selected patients had polymethacrylate antibiotic impregnated cement placed in their wounds for the interval between dressings. This approach ensures high levels of antibiotics locally, but its efficacy in soft tissue wounds has not been assessed under these circumstances.[10] Soft tissue injuries accounted for the majority of operations performed by Team Echo. One hundred and thirty-nine of the 148 operations were related directly to wound management and included debridement (58), split skin grafting (58), rotation flaps (6), suturing (9), and dressings (8) (Table 3). The value of a plastic surgeon under these conditions must be emphasized.

Resources to make external fixators using pins and polymethacrylate cement are used most likely in the early stages after such a disaster. In Banda Aceh, there was a high expectation of limb preservation among the population. Amputations generally were considered unacceptable because there was no prospect for receiving any prosthesis. Patients with major limb injuries frequently resisted being transferred for advanced care because of a perception that this meant amputation was inevitable.

Number of Anesthetics	Patients	% Total
1	69	74
2	19	20
3	4	5
4	0	0
5	1	1

Table 2—Number of anesthetics administered to 93 patients

Operation	Events	% Total
Debridement	58	39
Split Skin Graft	58	39
Rotation Flaps	6	4
Suture	9	6
Dressing	8	5
Other	9	6

Table 3—Nature of surgical procedured performed on 148 patients

Seven operating theater nurses staffed four operating teams at any one time. One nurse was dedicated to equipment sterilization and packaging. Operating schedules followed ward and dressing rounds, and were restricted to a maximum of 13 cases per day, allowing for the re-processing of instruments and providing recovery time for the operating staff. With no running water, an ethanol hand gel was used instead of the standard three-minute surgical scrub. All operating theater staff wore battery-operated headlights, which were indispensable during power failures. Because of the humidity and high temperatures, sterile gowns were abandoned for sterile, disposable, plastic aprons.

Sticker-marked and dated surgical dressings indicated when and where redressing was needed. Patients identified for surgery on the morning surgical round were tagged with a bright green triage tag. This system was challenged, when upon returning to the ward, patients passed the tag on to relatives or the patient in the next bed to ensure operative care. Subsequently, the tags were removed in the operating theater.

Body bags, constructed of heavy-duty plastic with six handles were available and used for lifting and transporting patients. Patients frequently used these bags, which proved durable and easy to clean, as hospital bed covers.

Under the prevailing conditions, blood transfusions were a logistical challenge. This required the identification of a volunteer donor, blood collection with typing and matching, and was achieved on only one occasion with assistance from the Australian Defence Force (ADF). Some health teams had O-negative blood available. Soon after this event, the Indonesian Red Cross established a blood bank system.

Team Characteristics and Preparedness

Team composition

Relief team composition must take into account the anticipated needs of the community and the spectrum of medical conditions likely to be faced. The experience following the Aitape Tsunami suggested the pattern of injury the Team would encounter during the 2004–2005 Tsunami response, but could not provide any indication of the number requiring treatment. Whereas an estimated 200,000 persons died in Indonesia, the number of survivors requiring care was lower than expected. A team able to perform soft tissue surgery and treat infectious conditions was considered the most appropriate. The inclusion of an emergency physician was beneficial in giving a wider range of skills compared to the ADF military model of a general surgeon, orthopedic surgeon, anesthetist, and intensivist. Echo team members included experienced ADF reservists; they were well-prepared for any medical, dental, physical, and/or stress-related matters. However, to ensure the rapid selection of team members with specific skill-sets, an expanded database of screened volunteers with basic information such as skill base, previous experience, relevant disaster medicine training, availability, vaccination status, and passport data is needed.

Team supplies and equipment

Whereas the Australian teams arrived well-equipped, the teams arriving later from other nations, many representing non-governmental organizations (NGOs), had little equipment or means of support. The strategy of absolute self-sufficiency for 14 days is demanding, and requires a large cache of essential equipment to be ready. Team Echo spent considerable time prior to departure formulating a load inventory in Sydney, Australia. This proved invaluable when it came to assembling supplies. However, surgical supplies extracted from the public hospitals of Adelaide, South Australia left those hospitals in short supply.

Essential items were packed in water-resistant, durable, plastic equipment cases. Tonnage and transport restrictions required these cases to be marked in order of priority. The final load list included four tons of drinking water. Using an established hospital facility meant tents were not needed.

Portable ultrasound proved invaluable as it has an established role in trauma (Focused Abdominal Sonogram for Trauma), in assisting in vascular access and a wide range of other conditions. It is compact and easy to use. The SonoSite 180+, initially developed for US military purposes and used on a number of ADF missions,[11,12] should be incorporated into any team entering a zone where there is no infrastructure or means of imaging.[13]

Personnel requirements and support

Team members need current and enduring passports and should be physically fit, healthy, and appropriately vaccinated. Team members were required to perform heavy work on a number of occasions in conditions of high humidity and heat. In these circumstances, those with physically limiting or unstable medical conditions, or those requiring medications for chronic illnesses, may compromise the mission.

The checklist of mandatory personal items included: (1) long trousers and long-sleeved shirts of appropriate material; (2) head protection; (3) a torch [flashlight]; (4) work boots; (5) non-aerosol insect repellent; (6) sunscreen (SPF 30+); (7) foot powder and topical anti-fungal cream; (8) sanitizing hand gel; and (9) personal water supply, i.e., Camelbak (water consumption is >5 liters (L) (1.32 gallons) per day).

This type of list is essential, particularly for inexperienced members, to ensure that they depart with the right equipment that is in good working order. After arrival in Banda Aceh, team members were required to have an evacuation pack with them constantly, in case another earthquake or tsunami required immediate evacuation. This pack contained: (1) a passport; (2) a set of clothing; (3) food; (4) a knife; (5) a torch; and (6) money.

Each team member took doxycycline (100 mg) daily as malaria prophylaxis, and were cautioned as to its potential adverse effects in sunlight. This was monitored by a designated team physician. Team policy required use of mosquito nets while resting or sleeping, and insect repellent sprays, long sleeves, and trousers were mandated from before dusk.

This deployment was characterized by hot, wet, monsoonal weather, ongoing earthquakes, disrupted communications and utilities, traffic congestion, poor sanitation, and a lack of adequate supplies of potable water. There were rumors that GAM would target foreign aid providers, adding to the underlying concerns of potential risk to team members. The planning for the immediate evacuation of a critically ill team member highlighted the unreliability of available air assets, the difficulty of landing in Banda Aceh, and the unpredictable nature of the weather. Evacuation contingency plans were aided by the availability off the coast of the United States aircraft carrier USS Abraham Lincoln.

Team members were encouraged to include diversionary recreational activity such as books or writing material. A personal counseling service was available upon return with direct, unrestricted access to a skilled counselor. Qantas Airline personnel donated toys for children, and these proved extremely popular and helped to engender goodwill.

Team handover

To ensure good care, the handover of medical care to a follow-up team is critical. Unfortunately, the previously deployed teams (Alpha and Bravo) departed on schedule, but the arrival of Team Echo was delayed, making a direct handover impossible, and placing physical assets left behind at risk. When Team Echo arrived, some accommodation areas already were occupied by another medical group, and diplomacy and goodwill were required to restore the status-quo.

Sanitation and infection control

The basic sanitation infrastructure was damaged. Rubbish, including body parts and excreta, was discarded onto a refuse pit with the intent of incineration. Standard local practice was to dispose of "sharps" and contaminated waste into an operating theater rubbish bag, and subsequently

into one of two waste pits for incineration 20 meters (66 feet) from the hospital site. Burning was infrequent, and the fires often were extinguished by heavy rain. Scavenging animals had free access to the pits.

Toilet facilities and ablutions were regulated by the availability of water. Several days without rain created a major problem. An ADF water purification plant capable of producing 320,000 L (84,535 gallons) of water/day/city was required.

Patient support

A large number of patients were transported by American helicopters from remote areas to the military airport in Banda Aceh. They were processed by doctors from the International Organization for Migration (IOM) and triaged to appropriate facilities. Some were transferred to the ICRC hospital for ongoing care. The IOM was the critical organization in establishing identity and tracking patients, checking on clinical progress, and arranging transfer to a resettlement camp. Frequently, patients found themselves lacking social support when discharged from the hospital in order to make room for new casualties. They were removed from their home environment, often had no surviving relatives, were homeless, and had no transportation or money.

Hospital staffing

Surviving staff generally were occupied with finding missing family members. There was no established process for providing a salary for those who were available and willing to work. Teams of Indonesian doctors from other provinces departed after several weeks without replacements. Night nursing rosters presented a particular problem, as insufficient numbers of trained staff meant that the delivery of medications and detection of deterioration in a patient's condition was not assured.

Language difficulties

Some Indonesian medical staff and senior police officers had English language skills, but few patients or nurses had such skills. Two volunteer interpreters (one Australian and one Indonesian) were attached to Team Echo and functioned in communicating diagnosis, pre-operative necessities, operative intent, and post-operative care. They also interpreted orders and procedures in the operating theatres, with the help of the Indonesian medical and nursing staff. Interpreters observed that patients generally expressed a high degree of confidence in the skills and professionalism of Team Echo, but at times were distressed by their inability to communicate directly. A high level of fluency and cultural communication skills were as important as a mastery of medical vocabulary, especially given the degree of psychological trauma.[14] Consideration must be given to recruiting qualified interpreters to the team.

Post-script

This disaster was characterized by a multinational response, and presented a significant coordination challenge. Eventually, medical elements from Estonia, Canada, Japan, and Korea arrived at Fakinah Hospital. Indonesian nursing teams and specialists from other provinces were extremely valuable. The Australian team worked in the operating area, the Estonians, assisted by the Japanese and Koreans, worked in the emergency department, and the Indonesians cared for the wards with assistance from the Australian specialists. At one stage, there were more medical staff than could be used effectively. This microcosm of medical interaction was reflected outside the small hospital when well-equipped mobile hospitals arrived from Australia, Germany, Norway, and Russia. Team Echo's leader spent much of his time as an advocate and negotiator with the international community, a task carrying considerably greater significance than had been anticipated. Coordinating aid under the banner of the WHO similarly presented challenges. By late January 2005, there were 22 international and United Nations agencies, 35 national bodies, and 92 NGOs within the area.[15] Seventy-four (80%) of these NGOs were involved in the delivery of some form of "health" assistance.

Conclusion

There is an ongoing need for disaster medical relief teams, and their composition and equipment needs will differ according to the nature of the disaster. Early, efficient deployment is contingent upon an established database of appropriately skilled, healthy personnel currently vaccinated, combined with a dedicated cache of equipment. An international commitment presupposes valid travel documents and an ability to negotiate in a multi-national setting. Difficulties in gaining access to the disaster region can be expected, and effective coordination at every level of the mission is necessary for success.

The nature of injuries and medical requirements associated with a tsunami can be predicted with the needs changing as time passes. For a team arriving 13 days after the event, a combination of general and plastic surgical, anesthetic, and infectious disease skills proved effective. Success requires enthusiastic logistical support, a skilled linguist, and ongoing attention to the morale and health of team members. For a team with an intense workload in a disaster setting, one to two weeks exposure is sufficient. The composition of subsequent teams should reflect changing circumstances with input from those deployed previously.

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