CASE REPORT

Transport and Use of Point-of-Care Ultrasound by a Disaster Medical Assistance Team

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Abbreviations:
CT = computed tomography
DMAT = Disaster Medical Assistance Team
FAST = Focused Assessment by Sonography in Trauma

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Abstract
The role of ultrasound in disaster medicine has not been not well established. This report describes the transport and use of point-of-care ultrasound by a Disaster Medical Assistance Team (DMAT) responding to a mass-casualty incident due to a cyclone. Ultrasound-competent physicians on the team were able to use portable ultrasound on cyclone casualties to exclude intra-abdominal hemorrhage, pericardial fluid, pneumothoraces, and hemothoraces. Information obtained using ultrasound made initial patient management, and subsequent decisions regarding triage for transport safer and based on more detailed clinical information.

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Introduction
The role of ultrasound in disaster medicine has not been well established. This report describes the transport and use of point-of-care ultrasound by a Disaster Medical Assistance Team (DMAT) responding to a mass-casualty incident due to a cyclone.

Case Report
Scene
At 22:00 hours (h) on Thursday, 08 March 2007, Category-Four Tropical Cyclone George (Table 1) crossed the Pilbara Coastline in Western Australia (Figure 1). At 03:00 hours (h), the cyclone struck the on-site residence of Railway Camp One (Figure 2), an iron ore mining company located approximately 100 km inland.

The closest hospital to the on-site residence is Port Hedland Hospital, located 100 km north of the mining site. It is a 30-bed hospital with a computed tomography (CT) scanner, and serves a local community of 16,000 people. It is staffed primarily by local medical officers. The hospital has one general surgeon available and a number of general practitioners who perform some obstetric procedures as well some general practitioner anesthetists. The closest tertiary hospitals are in Perth, the capital of Western Australia, located approximately 1,400 km south-southwest of Port Hedland.

Impact
Following Cyclone George, there was widespread destruction of the mining campsite. (Figures 3, 4, 5). Initial unconfirmed reports from the scene suggested up to 30 seriously injured victims still were trapped under the debris. The cyclone also caused power disturbances at Port Hedland Hospital. While the power issue was resolved quickly, the CT scanner remained incapacitated. Road evacuation of casualties to Port Hedland Hospital from the mining campsite was not possible due to flood damage to roads and unavailability of suitable vehicles.

Category	Strongest Gust (km/h)	Typical Rffects (Indicative only)
1 (Tropical Cyclone)	Less than 125 (Gales)	Negligible house damage. Damage to some crops, trees and caravans. Craft may drag moorings.
2 (Tropical Cyclone)	125-169 (destructive winds)	Minor house damage. Significant damage to signs, trees, and caravans. Heavy damage to some crops. Risk of power failure. Small craft may break moorings.
3 (Severe Tropical Cyclone)	170-224 (very destructive winds)	Some roof and structural damage. Some caravans destroyed. Power failure likely.
4 (Severe Tropical Cyclone)	225-279 (very destructive winds)	Significant roofing loss and structural damage. Many caravans destroyed and blown away. Dangerous airborne debris. Widespread power failures.
5 (Severe Tropical Cyclone)	More than 280 (very destructive winds)	Extremely dangerous with widespread destruction.

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Table 1—Cyclone categories.
Source: Australian Bureau of Meterology[1]

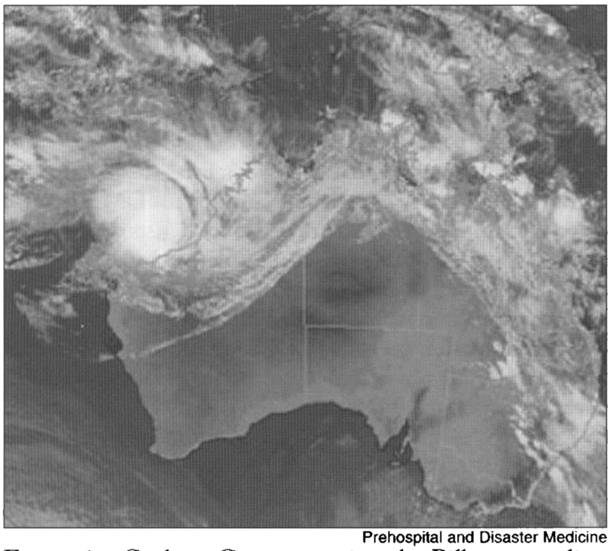

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Figure 1—Cyclone George nearing the Pilbara coastline Satellite image of TC George from Australian Government Bureau of Meterology Website. (Image courtesy of NASA)[1]

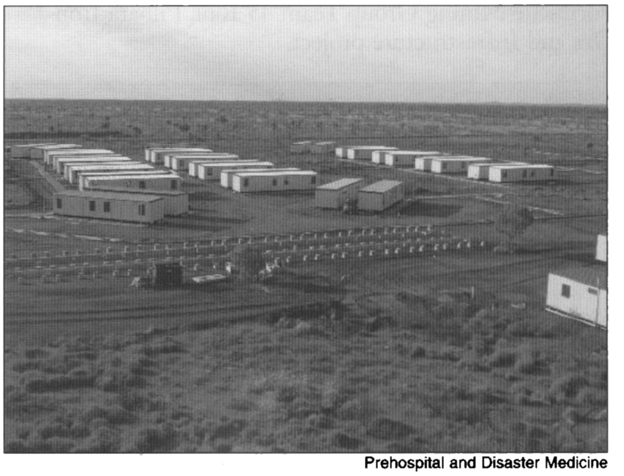

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Figure 2—Rail camp prior to Cyclone George Image from Australian Government Bureau of Meterology[13] Reproduced with permission from Fortescue Mining Group Team 45 Rail, Pilbara Iron Ore and Infrastructure project.

Response

Initial on-site medical care was provided by a single industrial paramedic who lived in the compound. The first outside medical support to Railway Camp One was provided by two district medical officers and nursing staff from Nickol Bay hospital, located approximately 100 km to the west of the mining site. This medical team was transported to the mine using local mining company helicopters. Patients from the mining site were triaged and evacuated to Port Hedland Hospital using these helicopters.

Given the initial estimated patient numbers and injury severity, there was concern that Port Hedland Hospital would be overwhelmed. A second Category-4 cyclone (Tropical Cyclone Jacob) was forecasted to strike the area 48–72 hours after Cyclone George. This had the potential to result in further injury to local inhabitants and add potential workload to the hospital. As a consequence, a DMAT was dispatched from Perth to Port Hedland to improve the local treatment capability and the State Health Emergency Operations Centre (SHEOC) was activated in Perth.

The DMAT consisted of two emergency physicians, an anesthetist, a general surgeon, two operating theater nurses, two emergency nurses, and four intensive care nurses. The team traveled with a medical disaster cache including portable ventilators, medical pumps, monitors, and an ultrasound machine, as well as additional antibiotics, analgesia, and adult diphtheria tetanus (ADT) medication.

The team and equipment was dispatched to Port Hedland aboard a chartered, twin-engine jet aircraft (Bombardier Challenger 604) and arrived at Port Hedland Hospital at

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Figure 3—Railway camp post-Cyclone George Image from Australian Government Bureau of Meterology[13] Reproduced with permission from Fortescue Mining Group Team 45 Rail, Pilbara Iron Ore and Infrastructure project.

Figure 5—Railway Camp post-Cyclone George Image from Australian Government Bureau of Meterology[13] Reproduced with permission from Fortescue Mining Group Team 45 Rail, Pilbara Iron Ore and Infrastructure project.

16:30, h 13.5 hours after Cyclone George first hit the mining camp. Upon arrival, a situation report was obtained, and the team was integrated into the hospital disaster plan.

Given the limited medical resources of Port Hedland Hospital and the possibility of a second Category-4 cyclone, the goal of the disaster plan was to rapidly evacuate as many patients as possible to tertiary-level care in Perth. Evacuated patients were to be subjected to a flight 2–4 hours in length (depending on aircraft used) before reaching definitive care in Perth. This required triage and treatment of patients for transport. The DMAT needed to manage or exclude any significant injury that could be exacerbated by the physiological demands placed on the patient by flight or the time taken to transport the patient to definitive care.

Figure 4—Railway camp post-Cyclone George Image from Australian Government Bureau of Meterology[13] Reproduced with permission from Fortescue Mining Group Team 45 Rail, Pilbara Iron Ore and Infrastructure project.

Rationale for Including Ultrasound

When used by experienced personnel, ultrasound can detect free intra-abdominal fluid, hemothorax, pneumothorax, pericardial fluid, fractures, foreign bodies, and aid in invasive procedures.

Both emergency physicians from the DMAT were emergency medicine credentialed sonologists,[2] and used ultrasound in their daily practice. One (JR) has considerable advanced ultrasound training, while the other (SM) has extensive prehospital ultrasound experience. Since the initial information on the number and nature of casualties was scarce, both physicians decided that the addition of a portable ultrasound machine to the disaster medical cache could be of benefit. It was thought that ultrasound could be used during initial patient assessments and management, and help to prioritize patient evacuation to tertiary centers. The ultrasound machine taken weighs around 3.7 kg and has a reputation for robustness (Sonosite MicoMaxx, Bothell, WA). It can function from main power or by using a self-contained, rechargable battery. A 60 mm 5-2MHz curvilinear probe and a 38mm 10-5 MHz linear probe were selected as most appropriate for the likely requirements.

Patients and the Use of Ultrasound

Patients described how they were asleep in their accommodation when the cyclone hit. Their cabins were uprooted from supporting structures, overturned, and rolled by the cyclone. Beds, televisions, and wardrobes were thrown across cabins as they rolled, and some of the cabins also collapsed. This mechanism of injury mainly resulted in blunt force trauma and crush injuries due to patients being thrown or being struck by moving objects. One patient died on-site secondary to crush injuries to the chest prior to medical team arrival. A total of 22 patients evacuated from the mining site were seen at Port Hedland Hospital.

Ultrasound was used by the two emergency physicians on eight patients in whom, on the basis of history and examination, they felt it was clinically indicated. In these patients who had suffered significant blunt abdominal trauma, ultra-

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sound scans were incorporated as part of the patient assessment and management. In these patients, ultrasound was used to look for the presence of free intra-abdominal fluid. Presence of free fluid would have signalled intra-abdominal hemorrhage and the possible need for a trauma laparotomy prior to transport to definitive care. The incapacitation of the CT scanner by the cyclone meant there was no other non-invasive means to establish this diagnosis. No patients had free intra-abdominal fluid detected on Focussed Assessment by Sonography in Trauma (FAST) scan.

Chest trauma was common. Given the difficulties in diagnosing pneumothorax on supine chest radiographs, the FAST ultrasound was extended to look for pneumothorax in five patients where the history, examination, and/or chest x-ray was suspicious for pneumothorax. One patient required a chest tube thoracostomy due to a pneumothorax diagnosed by ultrasound causing respiratory compromise. Given the limited quality of portable supine x-ray on this large patient, as well as the concommitant changes on the film consistent with develping pulmonary contusion, it is unlikley that this patient would have had the pneumothorax diagnosed without the ultrasound. This could have led to significant problems in-flight if the pneumothorax had progressed, which is a significant risk with aeromedical transfer. A chest ultrasound was able to exclude traumatic pneumothorax, hemothorax, and pericardial effusion in the remaining patients.

All ultrasound scans initially were performed using the 5-2 Mhz curved array transducer. In one patient, the 10-5 MHz linear probe was used to confirm the absence of a pneumothorax. There were no problems obtaining the desired images in any of the patients scanned.

Evacuation

Of the 22 patients treated at Port Hedland Hospital, 15 were airlifted (in four separate airlifts) to tertiary referral centers in Perth. Six patients required stretcher transport and more intensive medical support during transport. These patients were airlifted on three separate flights in Pilatus PC 12 turboprop planes by the Royal Flying Doctor Service. Nine patients with less significant injuries were airlifted seated as "walking wounded" aboard the twin-engined jet aircraft that had been used to transport the DMAT and its equipment. A further three patients were admitted to Port Hedland Hospital.

All patients transported from Port Hedland to Perth arrived at their definitive care destination hospital. No patient who received a point-of-care ultrasound at Port Hedland Hospital experienced any physiological deterioration en route. Of the 22 patients assessed at Port Hedland, one subsequently died as the result of major head injuries received at the time of the cyclone.

Subsequent radiological investigations on patients scanned by ultrasound at their definitive care destinations revealed no free intra-abdominal fluid, pneumothoraces or hemothoraces, apart from the one pneumothorax diagnosed and treated in Port Hedland.

Discussion

There is little literature discussing the use of ultrasound in the mass-casualty scenario. This is likely the result of a number of factors. The critical care disciplines of emergency medicine, intensive care, and anesthesia, which often are at the forefront of a DMAT response, only recently have widely embraced the expanded use of ultrasound for diagnosis and intervention guidance. Medical deployments to mass-casualty incidents often are to less than ideal environmental locations. Most point-of-care ultrasound machines have not been robust enough to withstand the forces to which they could be subjected. However, the development of portable, compact, robust ultrasound machines, often with a military use in mind, has meant that this technology now can be considered for use in a wider field of practice including more remote environments.[3] This robustness, portability, and rapid boot-up has seen their uses extend beyond the hospital into the prehospital and retrieval environment.[4–7]

Two reports that describe the use of ultrasound in the disaster or mass-casualty scenario were found.[8,9] A 1991 paper described the use of ultrasound to assess for the presence of intra-abdominal free fluid and/or renal injury in 400 casualties following an earthquake in Armenia in 1988.[8] The authors concluded that sonographic screening during disasters is a quick and effective means for detection of abdominal and renal injuries. The second paper reported the use of ultrasound to manage renal complications following crush injury in a mass-casualty incident following an earthquake in northwestern Turkey.[9] The authors concluded that renal Doppler ultrasonography might provide predictive information about recovery from acute renal failure resulting from crush injury. In both of these reports, the patients were bought to the ultrasound. In the multiple-casualty incident discussed in the current paper, the ultrasound machine was taken to the patients.

The potential use of ultrasound as a mass-casualty triage adjunct has been discussed in the literature.[10,11] Reports of portable ultrasound use by DMATs as part of patient assessments and treatment during mass-casualty incidents have not been identified, although portable ultrasound was part of the medical cache by disaster response teams in response to the Boxing Day Tsunami in Banda Aceh, Indonesia in 2004.[12]

During the mass-casualty incident described in the current article, a DMAT included a portable ultrasound in the medical cache transported with the team. Ultrasound-competent physicians on the team were able to use portable ultrasound to exclude intra-abdominal hemorrhage, pericardial fluid, pneumothoraces and hemothoraces. Although there was only one positive ultrasound scan in this collection of patients, the ability to exclude intra-abdominal hemorrhage and/or the presence of pneumothorax made initial patient management and subsequent decisions regarding triage for transport safer and based on more detailed clinical information.

Conclusions

It is possible to include a portable ultrasound machine as part of the medical cache transported to a mass-casualty incident. The addition of a portable ultrasound machine adds little overall to equipment bulk or weight. The use of ultrasound by ultrasound-competent physicians as part of a DMAT adds considerably to the team's ability to accurately exclude or diagnose significant chest and intra-abdominal injury. This assisted management and transport triage decisions during this mass-casualty incident.

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