Military medical appreciation of mass casualty management and evacuation from a remote area. The Kutubu Oil explosion, July 1996[[1]](#footnote-1)

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Abstract

In July 1996, the Chevron Niugini IDT-11 oil well exploded causing 10 casualties, nine of whom required evacuation to a Level 5 health care facility in Australia. Staff from the Australian High Commission Medical Unit were involved in the medical response and casualty evacuation from the forward Level 1 medical facility to the Level 5 facility. The episode carried many parallels with a military situation, particularly that the incident occurred in an occupational setting rather than as a public disaster, that the site was isolated and supported only by a Level 1 facility, that a staged aeromedical evacuation was performed, and that the cases were predominantly burns. This article details the aspects of this operation relevant to strategic and clinical military medicine, including aeromedical evacuation, and analyses them within this framework.

Introduction

The forward area of the Chevron Niugini operations in the Southern Highlands of Papua New Guinea is one of the most isolated in this part of the world. The site is on the Iagifu Ridge at approximately 1 500 m (5 000 ft) altitude and 300 m (1 000 ft) above Lake Kutubu where the forward supply base and fixed wing airfield is located. Medical facilities in the area include a Level 1 facility on site, the Iagifu Ridge Medical Centre.1 The Southern Highlands Provincial Hospital is approximately a half day drive through the bush or a one hour flight. This Level 3 facility has three doctors, with basic surgical resources, no burns unit and rudimentary inpatient care capability. It is general undersupplied with Class 8 items. The Port Moresby General Hospital is a Level 3 facility, capable of surgical care and generalised intensive care, one hour flying time in fixed wing jet aircraft. Cairns Base and Calvary Private Hospitals (Level 4) are two hours’ flight away, though without specialised burns care resources. Royal Brisbane Hospital is the closest Level 5 facility with a burns unit, over 2 500 km away.

The Iagifu Ridge Clinic of Chevron Niugini is located close to the site of the explosion, and was being visited by the Company Regional Medical Superintendent at the time. Other staff on hand included one Nurse, one Physician’s Assistant and one Medical Assistant, with several local Health Extension Officers and locally trained nurses. The Australian High Commission Medical Unit responded with one Nurse and one Medical Officer in association with Milne Bay Air (MBA) Medevac Service Nurse, all based in Port Moresby.

The Explosion

The explosion occurred at 09:45. All casualties were evacuated to the nearby Iagifu Ridge Clinic and first aid care was administered by local Chevron medical staff. The initial call to the Australian High Commission for assistance was received directly at the medical facility at 11:15. Confirmation was received of casualty numbers (nine), all with in excess of 30 per cent burns, one with probable respiratory burns and another with a lower limb compound fracture and probable circulatory shock. The initial appreciation of two Priority 1 (P1) cases and seven Priority 2 (P2) cases was delivered to the Head of the Australian Defence Staff, PNG, and approval received for response directly.

The Response

The first response aircraft to the area was a MBA King Air, unconfigured and without medical personnel, on the ground at Moro Airfield at 12:40. This aircraft was loaded with the two lowest priority cases and despatched to Brisbane with a Chevron Medic in attendance. Both these cases have done well.

The second response aircraft was a re-directed MBA Beech 1900, unconfigured and without medical staff. This aircraft was held at Moro awaiting casualties. The third aircraft, an MBA Citation, arrived at Moro from Moresby with additional medical staff and equipment at 13:30. Equipment and staff were immediately transported to Iagifu Ridge by Hughes 500 and Boeing Vertol 107 helicopters.

On-site triage confirmed the initial casualty appreciation. First aid had been completed on most cases including the provision of oxygen, removal of clothing, dressing of wounds with silver sulphadiazine (SSD) cream and clean bandages, and initial intravenous access on some cases. Further initial preparation included urinary catheters and IV access for all cases. Medical resources were allocated as an MO and two Nurses for the P1 cases, and the Medical Superintendent, a Nurse and remaining local staff to the P2 cases. The Physicians Assistant remained in a roaming capacity. In this circumstance, having a medically trained person overseeing the operations is worthwhile. This position must be defined and clarified to prevent the incumbent’s role contracting to individual care only. This seemed to occur in this situation.

Decision Making

The necessary degree of evacuation of all cases was determined to be to a Level 5 facility, and therefore to the Royal Brisbane Hospital Burns Unit. Direct communication with the receiving Unit was invaluable, permitting extensive preparation at the receiving end, including addressing logistic problems such as travel documentation. All aircraft were known to be capable of reaching this destination in one move given suitable conditions, with flight times between four and six hours. The Citation being the fastest aircraft and able to pressurise to the altitude of the Ridge was planned as the primary aircraft, with the remaining five P2 cases being carried in the Beech (the King Air having departed previously with two casualties).

Preparation for AME

Resuscitation procedures began with intubation of the most serious P1 case. This case had approximately 60 per cent burns to his trunk, arms and upper legs, as well as vocal cord ulceration evident on intubation. Despite the extent of his burns, his fluid balance was quickly addressed with six litres in the first five hours until airlift. He was producing urine unstained by blood. Given his condition, depolarising agents were considered suitable to use. Following induction with succinylcholine and thiopentone, he was intubated, paralysed (pancuronium used as vecuronium was unavailable) and given further morphine. After intubation, he developed marked sinus tachycardia with occasional ventricular ectopics which were managed by deepening his analgesia.

Laryngoscopy of this case was essential as facial burns were extensive. The procedure was conducted with the intention of, and preparation for, intubation, with cricothyroidotomy equipment on stand by. The endotracheal tube cuff was filled with air rather than fluid as the altitude of Iagifu Ridge is approximately the same as the ceiling requirement of the Citation jet with was identified as the likely evacuation aircraft for the P1 cases. As forward aeromedical evacuation (AME) also required minimal change in altitude (from Iagifu to Moro) pressure alteration problems were considered to be unlikely. Further, cases able to be stabilised at Iagifu were likely to be suitably evacuated with a cabin altitude (5 000 to 7 000 ft [1 500 to 2 100 m]) more efficient for aircraft endurance and airspeed.

This case was monitored with the only available Propaq, however poor access was available for the sphygmomanometer and only toes were available for the oxygen saturation probe. The bulk of the Propaq became a significant problem in loading and moving of this patient, occasionally disrupting probe sites and possibly damaging the equipment. Exposure to environmental elements such as rain and vibration certainly upset the Propaq in the exposed manner in which it was carried, attached to the side of the Ferno scoop. Similarly, the Oxylog and oxygen cylinders were difficult to manage. Employing a smaller oxygen cylinder for movement of the patient was a great benefit, however, access to larger units was necessary when difficulties arose in transit, loading the patients in the Citation at Moro.

In the 12 hours of the medical evacuation from explosion site to the Level 5 ICU, this case consumed in excess of 400 mg of pethidine, 60 mg of morphine and 40 mg of diazepam. As supplies of medications became exhausted in flight, he probably became light in the anaesthetic. No more suitable short acting narcotics were available. The value of copious quantities of analgesics in addition to similar availability of fluids cannot be underestimated in the management of burns cases, particularly under difficult circumstances.

As only one Oxylog was available, the second P1 case was not intubated. This case had approximately 30 to 40 per cent burns to his neck, arms, trunk and legs, and a compound fracture of the left tibia and fibula. His peripheral circulation was adequate in all limbs despite circumferential burns of both arms and the leg fracture. Two IV lines and a non-air filled splint were established and he was provided with large quantities of analgesics, antiemetics, ceftriaxone and tetanus toxoid. No back-up oximeter was available for monitoring of this case, therefore intermittent readings only were taken. For a conscious patient in pain about to be transported on two different aircraft and man handled to an fro, analgesia was essential, along with an antiemetic. Gauging analgesia to fall between pain relief and respiratory depression required communication with the patient and close monitoring. Unfortunately, in this instance, dedicated monitoring or staff were not available and, as is often the case on rotary wing evacuation, communication was difficult.

“Forward/Tactical” AME

The two P1 cases were evacuated from Iagifu Ridge down to Moro Airfield in a Boeing Vertol 107 at 15:15. This aircraft is a twin rotor helicopter with a rear ramp for good access to the cargo hold and ample room for casualties. Unfortunately, the noise and vibration generated by this aircraft is great. Communication with the patients and staff was not possible. Ferno Scoops used for carrying these cases were loosely fixed directly onto the deck of the cabin. This transmitted much of the vibration to the patients resulting in the anaesthetised patient becoming light. It was evident from observation that the other case was expressing distress. Despite splinting and analgesia, the vibration was causing pain at the fracture site. It was also anticipated that the vibration would cause a degree of nausea in this case and he was loaded with antiemetics pre flight. A comparable phenomenon is seen in the larger and similar Chinook (CH-47), thought to cause nausea from low frequency vibration of the abdomen. Transmission of vibration to the patient could have been mitigated with a strap stanchion configuration.

Other problems encountered in the forward phase of the medevac related to the aircraft were the failure of the Propaq cuff to register blood pressure and the oxygen saturation probe misreading with the vibration. This is commonly seen in Army rotary wing evacuations. Personal experience is that hand held, peg style probe oximeters are less likely then the Propaq to malfunction in this way, and systolic blood pressure taken using the oximeter to indicate return of blood flow is more reliable. The Vertol employed here is a very capable aircraft for heavy lift, used extensively in US Naval operations for vertical replenishment operations at sea, however, as a working supply and replenishment aircraft is has very limited creature comforts such as vibration dampening systems and climate control. With inclement weather closing rapidly around the aircraft, the chill factor in the rather open cabin and the altitude of the operation, hypothermia encroached upon the patients and space blankets were difficult to keep fixed over patients. Unfortunately, the scoops provided were old and had inadequate straps for patient security.

Rapid evacuation from the forward point was necessary as cloud was moving over the Ridge. Warning of this circumstance was a notable benefit of having numerous bystanders overseeing the operation. Another benefit of additional people was the availability of stretcher bearers.

On arrival at Moro airfield, driving rain impeded loading of the P1 casualties into the Citation. The narrow access to the Citation cabin also impeded loading, as seats were not able to be removed, further limiting manoeuvring. Consequently, the cases were angled into the cabin through the emergency hatch, further highlighting the need for patient security on stretchers and portability of monitoring equipment. This movement caused pain and agitation for both cases, and damaged their intravenous access. At the time, IV function was determined to be satisfactory for the further evacuation. The Citation departed Moro at 16:20 with the P1 cases, a nurse and doctor.

The remaining five P2 cases were evacuated down to Moro on the return trip of the Vertol as the weather closed over Iagifu Ridge. A notable problem in transporting these cases in this aircraft was that three cases had sustained sufficient facial burns and periorbital oedema to close their eyes. Under circumstance of being badly injured and then transported down a mountain in a loud vibrating helicopter in bad weather, it is reasonable to assume anxiety levels would be high in all cases and highest in those unable to see. Close contact was maintained with these cases and information provided before the flight as to the nature of the subsequent experience. These cases were all PNG Nationals. Speaking to them in Melanesian Pidgin, which was used in Brisbane to facilitate history taking was found to significantly improve their morale, despite their familiarity with English. Communication and the anxiety engendered in these operations cannot be underestimated.

Strategic AME

The maximum carrying configuration of the remaining aircraft, the MBA Beech 1900, is conventionally four stretchered cases, however, the MBA nurse had experimented with carrying five cases by using the luggage hold (otherwise partitioned from the cabin). The value of practicing medevac was apparent and this experimental configuration was employed to complete the lift of all cases with available fixed wing aircraft as the Beech departed Moro at approximately 17:30 with two nurses and a doctor. In-flight monitoring and care of the cases aboard the Citation was difficult with the restricted space from this configuration.

The Propaq batteries endured to Brisbane, however the cuff again malfunctioned and the oxygen saturation probe failed as peripheral circulation closed down with the cold temperature in the aircraft, and compartment swelling in the lower limbs. Clinically, peripheral pulses remained detectable and blood pressure adequate, with central perfusion indicating adequate oxygenation. Fortunately, carbon monoxide poisoning was not suspected as this would have biased the clinical monitoring that became necessary as technology failed around us. Supplementary clinical monitoring became the only available means of determining observations in quite ill cases.

Trauma to the IV lines on earlier movement resulted in failure of both of the lines into the second P1 case. Replacement of the line in-flight with inadequate space for procedures, particularly in a large burn case, underlined the importance of stabilisation and preparation pre-flight. Other significant issues of preparation resulting in in-flight problems on both aircraft included inadequate supply of Class 8 items. Oxygen was necessary for both P1 cases, however only when the non-intubated patient became agitated and required further sedation with benzodiazepines and morphine, and the oximeter failed, was supplemental oxygen provided from the limited supplies. Priority for this limited resource was given to the intubated patient. Oxygen supply was exhausted three minutes after landing in Brisbane and the intubated case was extracted using hand ventilation on air.

An uneventful descent at no greater than 500 ft (150 m) per minute was executed by the Citation into Brisbane airport, landing at 20:20. At this time, we had completely exhausted supplies of major analgesics and sedatives. Fortunately, fluids were not in limited supply, as all parties brought extra bags of IV fluid recognising the great need in burns cases. Clearly, this response should have included extra analgesia.

Aboard the Beech, initial supplies were limited from the beginning, however, further supplies were obtained during stages through Cairns and Townsville with offloading of one case, reclassified as P1, in Townsville. On the final flight from Townsville to Brisbane, the crew aboard the Beech expended all supplies of oxygen. With the aircraft cabin altitude at 4 000 ft (1 200 m), oxygen saturation of cases was being maintained by delivery via Hudson masks. The aircraft was forced to descend to a flight level at which cabin altitude approached sea level to maintain oxygen saturation of all cases above 95 per cent. As a consequence the air speed of the aircraft was reduced marginally.

The value of in-flight communications and familiarity with receiving and possible staging medical facilities was underlined for both the Citation crews and the Beech crews. The doctor on board the Beech was familiar with the possible staging facilities at Cairns and Townsville and was able to contact these facilities inflight by mobile telephone to arrange resupply, reassessment of a case, and ultimately offloading of a case. Aboard the Citation, we had exhausted many supplies, however were able to telephone the RBH and Ambulance Service to identify the need for certain supplies on arrival, as well as updating the condition of the patients before landing in Brisbane. The response of ground crew was significantly more appropriately as a result.

The Beech arrived in Brisbane approximately 6.5 hours after departing Moro. The two nurses had provided special care to two seriously ill cases each, in a confined, sometimes hypobaric space, with minimal monitoring equipment, after spending five hours preparing these cases. This is a truly Herculean feat and highlights the need to take as many medical staff as possible to care for seriously ill patients.

Discussion

A mass casualty situation is likely to exceed equipment and supply resources. This certainly occurred here. Greater preparation in terms of carrying analgesics was foreseeable and should have been addressed. Equipment backup in the event of failure should also be planned, with additional maintenance of clinical monitoring skills. Large, awkward equipment becomes a liability during difficult moves. Smaller equipment such as hand held oximeters are probably more valuable if larger equipment is unable to be readily stowed in such apparatus as the Mobile Intensive Care Rescue Facility (MIRF). Clearly, the latter stretcher creates significant logistic problems for opportunity aircraft designed for passenger access rather than stretcher access.

Knowledge and familiarity of aircraft capabilities, performance, dimensions, configurations and problems is essential, as is practice on the airframe, particularly in reconfiguring. Some problems, such as the dimensions of the hatch, are difficult to alter in opportunity aircraft. Altitude presented an interesting circumstance in this episode as the retrieval altitude was comparable to that of the maximum transit cabin altitude of the aircraft and the transit altitudes from “forward/tactical” AME to strategic AME were minimal, removing many of the concerns regarding pressure changes and hypobaric transportation.

As in most rotary wing evacuations, fear, communication and vibration were a problem. Weather has been identified as a limiting factor for rotary wing medevac since the procedure was first employed in Asian theatres of war over 40 years ago. This remains a real pitfall to beware of.

On a strategic level, alternative solutions to the operation include a “scoop and run” approach to the nearest Level 2-3 facility for resuscitation, splitting the casualties to employ Level 2-3 facilities closer to the site, or moving Level 5 resources forward to a staging point.

The first option could be considered given the large numbers of aircraft available and facilities within range, such as the Southern Highlands Provincial hospital or even Port Moresby General Hospital. The policy of Chevron is to provide the most appropriate care to all employees,2 and rapid movement with the Beech and King Air of the P1 cases to Port Moresby would be a real option. However, the facilities would be overwhelmed and casualties would ultimately require movement to a specialty burns care provider. Southern Highlands Provincial hospital is certainly within the range of the Vertol aircraft, of which numerous were available to fly direct from Iagifu Ridge to Mendi, however information previously gathered indicated that supplies of primary treatment modalities of fluid replacement and analgesia would have been rapidly exhausted and facilities overwhelmed. Other aeromedical evacuations recently conducted by this Unit from this location provided the additional information that the airfield (also at 1 500 m [5 000 ft] altitude) not uncommonly becomes unserviceable due to weather.

Regarding the latter solution, moving high level medical resources forward from another country carries many logistic details, such as entry visas, landing permits and licenses to practice medicine, which are occasionally overlooked by private medevac providers. Additional logistic uncertainties of organising sufficient able staff, equipment and an aircraft along with the transit time to the site or staging point are restrictive factors to this option.

Notable in this situation was the departure from convention in terms of casualty break down. Australian Army conventional casualty rates derived from World War II, the Korean War and the Yom Kippur War indicate that P1:P2:P3 ratios to be expected are 15:20:65 and the stretchered:ambulant ration to be 40:60 (all originally expressed as percentages).3 Civilian conventions suggest 80 per cent of injuries in most disasters require routine treatment for superficial injuries, and 20 per cent suffer single major injuries.4

Yet another aspect of modern warfare, perhaps not reflected in Health Service doctrine, though well displayed in this incident, is the publicising of the incident. This held two obvious consequences. Chevron medical services were quickly re-employed in media liaison following initial casualty management duties. Secondly, that all casualties were evacuated to the highest care facility feasible, reflects the need to be seen to provide the best care in the shortest time. In this case, all casualties were transferred from their country for this care. It is highly likely that this will also be the template for mass casualty circumstances in modern theatres of war, *viz* striving to achieve best care rather than care appropriate for operational contingencies.

Finally, conceptual issues of disaster management highlighted here include the fortuitous manoeuvring around the lack of specific planning and preparation for this contingency. Had the nursing staff and doctors not incidentally worked together previously, the outcome of this episode would probably have illustrated the lack of firm planning for such a situation. This factor undoubtedly influenced the response along with the major protractors, Chevron, MBA, and the military, being well organised bodies able to make rapid command decisions, with effective communication contributing heavily to success. The last aspect of disaster management is that of recovery, including stress management. This is essential, though beyond the scope of this review.

Conclusion

That nine serious burn cases arrived alive and stable at a Level 5 facility over 2 500 km away within 14 hours of an explosion in a location as isolated as the Southern Highlands of Papua New Guinea, is a tribute to all who were involved. The lessons to be gained from this have been summarised, though are not greatly different to those taught since the instigation of AME and the practice of modern military medicine.

References:

1. Manual of Land Warfare 1.1 Section 4, 1986. Adapted form of reference:

Level 1. First Aid, initial medical care.

Level 2. Resuscitation.

Level 3. First formal surgery and medical care.

Level 4. Definitive surgical and medical care.

Level 5. Specialised surgical and medical care.

1. Medical Superintendent, Chevron Niugini
2. Manual of Land Warfare 5.2 “Aide Memoire”, 1987
3. Commonwealth Department of Human Services and Health. The Australian Emergency Manual of Disaster Medicine. 1995

1. Kitchener S, Caldwell D. Military medical appreciation of mass casualty management and evacuation from a remote area. The Kutubu Oil explosion, July 1996. *Aust Mil Med* 1996; 5(3):7-11 [↑](#footnote-ref-1)
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