Major incident response: aeromedical response to a remote location

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Abstract

- The occurrence of a multi-casualty incident in a remote location presents significant logistical problems to an aeromedical provider.
- Definitions of mass casualty situations, incidents and disasters should be understood by those personnel who may be required to respond.
- An understanding of the epidemiology of trauma deaths and the classic trimodal mortality pattern can help responders to know when and how they can alter the outcome for victims.
- It is important to understand the difference between facts, controversies and myths in disaster response, to ensure that high-priority tasks, such as provision of clean drinking water to survivors, are correctly identified and enacted by responders.
- The long-term psychological care of aeromedical providers involved in disaster response is an important part of mission planning.
- The concept of a surge capability should be considered by aeromedical providers.
- In this article, I outline the key concepts in conducting long-range aeromedical responses to disaster and mass casualty incident situations.

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THE OCCURRENCE OF A MULTI-CASUALTY incident in a remote location presents significant logistical problems to an aeromedical provider. Apart from the tyranny of distance, the responders will encounter a range of other issues, including difficulties with communications, command and control issues, threats from both the unfamiliar location and possible hostile elements, equipment and personnel problems, duty-time limitations, and the difficult clinical decisions involved in triage and patient selection.

Mass casualty incidents

Definitions

The definition of what constitutes a disaster or a multi-casualty incident or situation differs depending on the location, resources and culture of where the event occurs.[1] A multi-casualty situation occurs when there is more than one patient requiring medical aid, but where the available facilities are able to cope. A mass casualty incident (MCI) occurs when the local facilities are initially overwhelmed and only later able to cope. The term disaster is less well defined, but it implies that the local emergency services are totally overwhelmed or are themselves destroyed.[2]

Examples of mass casualty incidents

MCIs are typically manmade events and include aircraft, train and bus crashes, and limited terrorist actions. Disasters are more likely to be due to natural events such as hurricanes (cyclones), earthquakes, floods and tsunamis.[1] Disaster medicine is the all-embracing science developed to handle situations where the available resources are insufficient to meet the immediate need for medical care. Aeromedical evacuation is one part of the overall response to an MCI or disaster.

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Aeromedical response to mass casualty incidents

Aeromedical providers often play a role in responding to MCIs. The level of response depends on many variables, including proximity, international requests, and funding considerations. Recent examples of aeromedical response include the international response to airlift victims of the Asian tsunami in 2004–2005. In most cases, this involved the repatriation of holidaying victims to their home countries, where the flag carrier (usually funded by government) provided the heavy-lift capability. Some of the repatriation was also carried out by commercial providers; however, this was usually done for those travellers who were insured for this purpose. Military airlift also took place for the international repatriation of nationals. There was substantial rotary-wing

aeromedical transfer of the affected local population by United States and Australian military forces, as well as a component of strategic fixed-wing transfer by the Royal Australian Air Force.[3,4]

The terrorist bombings in Indonesia in 2002 and 2005 saw a similar response from the RAAF, with multiple aeromedical evacuations using C-130 RAAF airframes.[5-9] There was also a civilian response to these incidents, with SOS International involved with the early fixed-wing secondary and tertiary transfer of victims.

B707 crash, Zaire, 1997 — a mass casualty incident occurring in a remote location. Note the multiple survivors and post-crash fire. Photo: Marthin Sons. http://www.airdisaster.com/photos/fia707/photo.shtml (accessed Sep 2008).

Banda Aceh, Sumatra — the worst natural disaster in recent times was the Indian Ocean tsunami, 26 Dec 2004. Photo: Patrick Bonafede/ Getty. http://www.guardian.co.uk/gall/0,,1380645,00.html (accessed Sep 2008).

Epidemiology of trauma deaths

Historical background

The management of trauma victims has evolved over time. In the first century AD, Celsus addressed the casualty rate on the battlefield: at that time, it was estimated that 75% of victims did not survive their injury, and this trend continued into the 19th century.[10] In the mid 1700s, John Hunter espoused the benefits of delayed closure of wounds.[10] An important early initiative in the management of the injured is attributed to Dominique Jean Larrey, a Napoleonic war surgeon who revolutionised transport of the wounded with the introduction of *ambulances volantes* (flying ambulances).[11]

The trimodal pattern

The classic trimodal distribution of deaths following trauma was described by Dr Donald Trunkey in 1983[12] and remains one of the cornerstones of advanced trauma life support courses.[13] In this pattern, the three peaks of death occur:

1. Immediately at the scene (50% of deaths), primarily due to brain, high spinal cord or major cardiovascular injuries leading to apnoea;[14]
2. Between 1 and 4 hours later (30% of deaths), secondary to cardiovascular and neurological injuries; and
3. As late deaths up to 1 week later (20% of deaths), due to multiorgan failure.

Recent developments in the trimodal pattern

More recent studies have examined the epidemiology of trauma deaths to determine if the trimodal pattern is still applicable. A study by Demetriades et al found that the first peak still accounted for 50% of trauma deaths. They noted that the second peak was also still present, but the incidence of deaths had decreased to 18%, and that the third peak was no longer as significant,[15] with late deaths accounting for only 7.6% of deaths. It appeared that early and aggressive resuscitation had effected a decrease in the second peak of Trunkey's trimodal pattern, and that modern techniques were significantly decreasing deaths due to late organ failure and sepsis.[15]

Presentation timelines

Victims of an MCI will present to the nearest medical facility they can locate. This will occur wherever the event happens, whether it is a highly developed Western health facility or an undeveloped country's health facility. The US Centers for Disease Control and Prevention (CDC) has produced useful predictors of this presentation, based on past MCI events (Box).[16] About 50% of all MCI casualties will arrive at the nearest facility within a 1-hour interval; thus, the total expected casualties can be predicted by doubling the arrival number for this initial interval. Hospitals further afield will receive few, if any, casualties. Individuals who are not severely injured will present before some of those who are severely injured and will not have been triaged. These estimates will vary widely, depending on the proximity or remoteness of the accident and the local emergency infrastructure.

Application of the trimodal pattern and presentation numbers to remote aeromedical evacuation

Aeromedical providers who are tasked with providing assistance to MCIs in remote areas can utilise knowledge of the trimodal pattern of death to estimate the likely number of patients that may require transfer. Clearly, an international aeromedical response into a remote region will be unable to assist those victims who succumb in the first and second peaks of mortality — the aeromedical provider will simply take too long to arrive. However, the aeromedical provider can make a significant difference to the outcome of those victims who

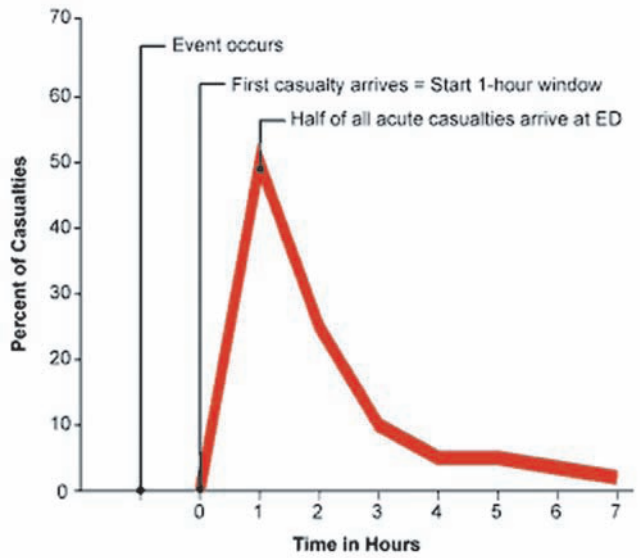
survive past the second peak (6 hours) and are within the region of the third peak (up to 1 week). During this 7-day interval, victims of an MCI are most likely to die from sepsis-related multiorgan failure. The transfer of victims to high-standard tertiary-level health care facilities will make a significant difference to mortality rates. This is the target group for an aeromedical provider tasked into a remote MCI.

Triage

History of triage

The word triage is derived from the French word *trier*, meaning "to sort", and is now used almost exclusively in specific health contexts.[17] Apart from instigating the use of *ambulances volantes*, Dominique Larrey recognised the need to categorise and prioritise wounded soldiers during battle. Larrey recommended treatment be provided to those who are "dangerously wounded" as the first priority, "without regard to rank or distinction". A further refinement to this process was provided in 1846 by British Naval Surgeon John Wilson, who argued that to make medical attendants' efforts more effective, surgeons should focus their attention on those who need immediate treatment and for whom treatment is likely to be successful.[17] By World War I, military surgical manuals were recommending an approach that brought about "the greatest good of the greatest number".[17] This describes the current approach to triage during an MCI or disaster scenario.

Predicted emergency department (ED) casualties



Graph depicts the usual time distribution of patients arriving at an ED following a mass casualty incident.
Source: US Centers for Disease Control and Prevention.[16]

The rationale for and use of triage in a mass casualty incident

The use of a triage system during an MCI recognises that resources and personnel are limited. In any disaster situation, the use of triage is recommended. MCIs present very large numbers of casualties and it is likely that many of the victims will not be triaged before presentation to a hospital. This scenario is more common than not, with a review of US disasters showing the majority of victims do not undergo out-of-hospital triage, because victims are often brought to medical facilities by bystanders.[18]

Aeromedical response

Search and rescue considerations — some logistics and facts

The provision of sophisticated medical care in an austere environment is very challenging.[3,19] The logistics of preparing and transporting advanced life support equipment and personnel on an international aeromedical mission is problematic enough, without the exigency of an unregulated and chaotic environment.

Aeromedical planners should be aware of reported observations relating to MCI and disaster scenarios. First, the effectiveness of medical teams is limited by their delay in arrival. Second, the responders need to be acutely aware that most successful rescues take place within 24 hours of an MCI, and that most lives are saved not by medical personnel but by other survivors. The aeromedical responders to a remote MCI should not have any notion of being involved in the search and rescue phase. Their role will be to safely facilitate the movement of identified survivors to tertiary-level care — and hopefully to minimise the third peak in disaster deaths. Third, in these types of scenarios, major head and chest injuries are usually fatal. Peripheral limb injuries will present the most common cause for aeromedical transfer.[20]

Preparation and training

An aeromedical responder that becomes involved in a combined international effort to move MCI victims must be well prepared, and its personnel well trained. Preparation for aeromedical personnel would include them being adequately rested before flight, mission-prepared with appropriate vaccinations and prophylactic medication (eg, antimalarials), appropriately insured and licensed to practise, and having appropriate passport and visa clearances.

Command, control and communication (C3)

Experience has repeatedly shown that aeromedical missions in disaster situations are most often compromised by issues relating to command and control, and communication

Royal Australian Air Force personnel assist United States Navy and Indonesian colleagues with unloading aeromedical evacuation patients during Operation Sumatra Assist, 4 Jan 2005. Photo: US Department of Defense. http://www.defence.gov.au/optsunamiassist/images/gallery/050105a (accessed Sep 2008).

issues.[3,5,6] The aeromedical providers should have a clear understanding of who is directing their mission. All operational decisions should be conducted via the mission director, who in turn will liaise with his or her desk officer and the authorities in the country where the MCI has occurred. Language differences are compounded by sociopolitical differences and inexplicable cultural nuances that the aeromedical provider must be alert for (and sensitive to). Communication problems detract from most aeromedical missions in this way.

It cannot be emphasised enough that aeromedical providers should carry multiple layers of communication systems, including radios (aircraft-fixed and handheld), mobile phones with global roaming, and satellite phones. Consolidated lists of personnel and company phone numbers should be carried by all aeromedical personnel. In addition, it is wise to carry a list of embassy contacts for assistance with negotiating border clearances and diplomatic assistance. International aeromedical missions in the past have encountered many of these problems.[21]

Mission planning

It is important to match the severity of the MCI to the assets deployed into the area of operations.[3,6] An accurate projection of the likely needs of the aeromedical personnel is vitally important. Military aeromedical evacuation systems modularise their capability into a series of subunits called capability "bricks". This method of executing an operation is simple and easily understood. As the severity of the event becomes known, the mission planners can employ a matched hierarchical deployment of their aeromedical assets.[6,22-26] This achieves a number of objectives including mounting an appropriate response, and, importantly, it dilutes the stress and demands of the aeromedical mission over a greater number of personnel.

Intelligence — mission, security and health

Aeromedical planners will be familiar with their regular aeromedical transfers. Atypical requests for assistance, such as responding to an international MCI, will require additional and more robust planning. To conduct the mission successfully, security and health intelligence is needed — both to protect the aeromedical team and to effect a more successful mission. Mission intelligence can be obtained from many sources, including embassy staff, international aeromedical contacts, and medical assessment elements (MAEs) that may be inserted into the MCI area in the immediate post-incident interval. The Internet has also become a powerful way to gain intelligence regarding MCIs and disasters. Thus, the C3 concept of command, control and communication now has computers added, to make it C4. A threat assessment should also be conducted by the mission planners. Many areas of the world are conflict zones, and

Primary triage and basic resuscitation being conducted by medical teams from USS Abraham Lincoln *and the International Organization for Migration for victims of the Indian Ocean tsunami during the third mortality-peak interval, Sultan Iskandar Muda Air Force Base, Banda Aceh, Sumatra, Indonesia, 3 Jan 2005. The two teams worked together with members of the Royal Australian Air Force to provide initial medical care to victims of tsunami-stricken coastal regions. Photo: USN 2nd Class Elizabeth A Edwards. http://www.pacom.mil/special/0412asia/ (accessed Sep 2008).*

A DC-9 crashes into a crowded market area in Goma, Democratic Republic of Congo, April 2008. Multiple bystanders are often able to assist with rescue and the carriage of survivors to hospitals. Photo: Lauren Vopni/Reuters. http://www.abc.net.au/news/stories/2008/04/16/2218146.htm?section=world (accessed Sep 2008).

aeromedical providers should not think they are immune from being drawn into any conflict. Finally, a health assessment should be formulated, with attention to environmental threats from such things as heat, humidity, vectors and wild animals.

Personnel

The aeromedical team should comprise a mix of experienced medical staff who have previously worked together as a team. The personnel should be in good health, with adequate fitness and immunisations completed. Individual and team training should have been conducted to ensure competencies are met in aircraft safety, patient care and crew resource management. All personnel should have a valid passport with appropriate visas, including a yellow fever certificate. The inclusion of a surgeon and anaesthetist in the aeromedical team has previously proven highly beneficial in responses to international MCIs.[5,6] Additional staff should also be considered, to allow crew rest and to prevent fatigue-related issues.

Equipment

Experience in previous MCI responses has shown that large amounts of oxygen, fluids, antibiotics, analgesics and resuscitation drugs should be transported. The carriage of a disaster pack containing additional stocks of these items is recommended. A dedicated burns kit with extra rolls of plastic cling wrap and scalpels for escharotomies is very useful.[5-7] Some authors have advocated obtaining resupply of depleted stocks in the area of operations;[27] however, this has never proven easy in my experience.

Immediate response — 24 hours

In an MCI, the injured often present with multisystem injuries.[28] In the first 24-hour interval, the first two peaks of mortality will have passed. International aeromedical response to an MCI will not always arrive within the first 24 hours, with more remote regions taking at least this long to reach.[29] The immediate response by an aeromedical provider in the first 24 hours should be aiming to gain intelligence (with or without MAE insertion), to adequately prepare a disaster response kit, and to achieve pre-positioning of the aeromedical personnel and aircraft closer to the MCI.

Delayed response — 72 hours

The delayed response interval is a more realistic time frame for an international aeromedical evacuation from a remote MCI. This time frame falls within the third mode of the trimodal mortality pattern, which continues up to Day 7 post-disaster. In other words, if the aeromedical team cannot achieve its mission in the first day, the time pressures are not as great. With this in mind, there should be adequate time for thorough and accurate intelligence gathering and mission planning. As more accurate situation reports appear, there may not even be a need for the mission to proceed. The more relaxed time frame will permit aeromedical planners to closely match the needs of any identified patients with an appropriate destination medical facility.

Facts, controversies and myths

There are several inaccurate preconceptions regarding the provision of external assistance to undeveloped countries

Mission planning to conduct international aeromedical evacuation following a mass casualty incident — Operation Bali Assist II, Nov 2005. Photo: Dr Bill Griggs, Director of Trauma Services, Royal Adelaide Hospital, with permission.

following MCIs and disasters. In reality, most survivors are not rescued by these external agencies; rather, they are rescued by their fellow survivors, neighbours and local assistance teams. Foreign assistance usually does not arrive until after 24 hours — after the critical first hours have elapsed. When foreign medical assistance personnel do arrive, they are often not the best equipped to deal with local conditions and may in fact be a hindrance.[29] Aeromedical evacuation of survivors must obey the accepted caveats, which are that:

- the patient has a requirement for additional care that is unavailable in the current locality;
- the patient transport should be from a lower to a higher level of care;
- during the transfer, the care is at least equivalent to the care being provided at the originating medical facility;
- the patient consents to the aeromedical transfer; and
- the patient is likely to survive the transfer.[30]

Other myths that should be dispelled are the need for urgent burial or burning of bodies, or aerial insecticide spraying or mass immunisations. All of these tasks do not carry the urgency that is popularly ascribed to them. The real immediate need is for access to medical care, pharmaceuticals, clean water and sanitation for the survivors.[29] Finally, it should always be borne in mind that patients must be correctly assessed and prepared for aeromedical flight.[2] An excessive emphasis on haste will lead to poor patient selection and poor patient preparation.

The provision of clean drinking water to disaster survivors is a high priority. Photo: USN Photographer's Mate 1st Class Alan D Monyelle. http://www.illinoisphoto.com/main/v/Tsunami-Photos/supplies/Indonesian+kids.html (accessed Sep 2008).

Long-term considerations

Psychological care

A part of planning that is often overlooked in the aeromedical response to international MCIs is the need for provision of psychological care to the responders. To some extent, this need can be minimised by using three key planning concepts. First, the MCI should receive proper logistical planning to ensure a matched hierarchical deployment of aeromedical assets — this dilutes the psychological impact of the mission among a larger number of personnel. Second, authority gradients should not be too steep (and the military is the worst example of this), as this places excessive stress on just a few key individuals and also discourages constructive input from subordinates. Third, aeromedical teams should aim to use the same teams and the same protocols they always use.[19] Following the completion of an aeromedical MCI response, all personnel should be offered voluntary involvement in a critical incident stress management program.[31]

An aeromedical surge capability

The concept of a surge capability should be considered by aeromedical providers. Military and government providers advocate programs that permit a rapid surge in capability,[4-6,21,23-26,32,33] and military models for this have now been well tested by the US Air Force and the RAAF. The adoption of these concepts by commercial aeromedical providers will permit them to rapidly identify key additional personnel (such as trauma surgeons and anaesthetists) and procure additional (and appropriate) disaster stores.

Conclusion

Any agency that is recruited to assist with an international MCI should have a sound knowledge of the key operating concepts that apply to these unique situations. The provider should be aware of the trimodal pattern of death following MCIs and should have an appreciation of the real needs of the survivors. Personnel deployed to international MCI scenes should remain working in their regular roles. In this article I have outlined some of the more controversial aspects of MCI and disaster assistance, and aeromedical providers should analyse their activities in light of these views.

Competing interests

None identified. The views, opinions, and/or findings in this report are those of the author and should not be construed as official policy of the Royal Australian Air Force or the Australian Defence Force.

The body of a tsunami victim floats in a river. Aeromedical personnel exposed to such disaster and mass casualty incidents should be provided with psychological assistance. Photo: Kim Kyung-Hoon/Reuters. http://www.iabc.or.id/photos_aceh.htm (accessed Sep 2008).

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