Lessons learnt and battlefield innovations from the Middle East Area of Operations

Jeffrey C Stephenson OAM MBBS MAvMed DipAeroRet

Introduction

Unique aspects of the conflict in the Middle East Area of Operations (MEAO) have brought about a refinement in battlefield surgical techniques including the widespread use of damage control surgery (DCS). In addition, the conflict has also seen a new range of battlefield innovations, each credited with decreasing injury and mortality[1].

Management principles in battlefield trauma care

The type of surgery

Damage control surgery is used extensively in the area of operations, with careful triage required to identify those battle casualties most likely to need DCS[2]. The main principles of DCS are to rapidly stop bleeding, to remove contamination and to minimise and correct hypothermia, coagulopathy and acidosis. An additional principle is to minimise further damage by limiting the extent of surgery, and not embark on impractical and prolonged procedures. Vascular shunts are utilised to restore blood flow to ischaemic limbs. Rapid external fixation of severe fractures is attempted. In addition to these techniques, patients are also moved expeditiously, with continual reassessment en-route, through the aeromedical echelons of care. Remarkably, patients are also moved with open abdomens to prevent abdominal compartment syndrome[2].

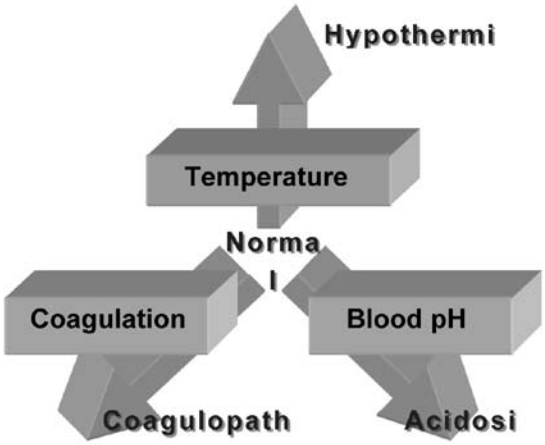

Figure 1: The resuscitation morbidity triad - morbidity and mortality rapidly increase when homeostasis of the casualty is allowed to alter from normal. Prolonged operative time increases the risk of the triad occurring. DCS decreases this risk.

Figure 2: The rocket propelled grenade (RPG) was commonly used in the early stages of the insurgency in Iraq. Source: http://forum.notebookreview.com/showthread.php?t=247963

Wounding

In the initial phases of the campaign in the MEAO most wounds were from small arms fire. With the spread of the insurgency, injuries from small arms and rocket propelled grenades (RPG) were replaced with injuries from improvised explosive devices (IED) and vehicular-borne improvised exploding devices (VBIED). These devices resulted in multi-site injuries and fragmentation wounds[3].

Energy levels

Historically, combat wounds have been described on the basis of muzzle velocity of the missile – with low velocity being defined as velocities less than 1000 to 2000 feet per second, and high velocity wounds being velocities greater than 2000 feet per second. Injuries from RPG and IED give mixed patterns of wounding, significant concussive effects and gross wound contamination - with effects not dissimilar to high velocity missile wounds. For this reason it is more appropriate to divide wounds into low energy and high energy wounds[4].

Figure 3: Roadside IED's and VBIED's are common methods of attack on coalition forces in the MEAO, inflicting serious injuries on the victims. Source: http://eldib.files.wordpress.com/2007/10/iraqiexplosion_ied.jpg

Patterns

The most commonly injured regions were upper (30%) and lower (30%) extremities, followed by head and neck injuries[5]. The pattern of injuries is unchanged when compared to previous combat wounding patterns, including the first Gulf War[6]. IED injuries involve multiple projectiles which cause multiple penetrating wounds. As the wounding patterns affect multiple body regions it has been highly beneficial to use teams from multiple disciplines.

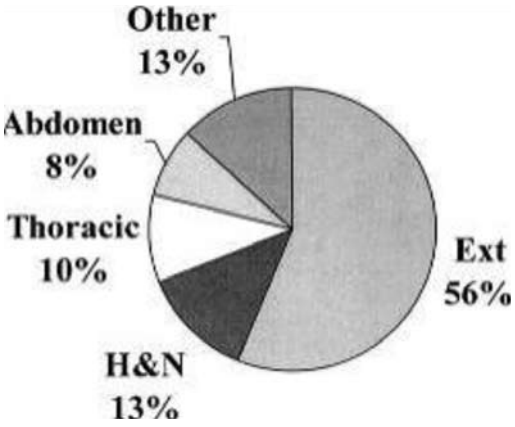

Figure 4: Injury patterns in US Forces in the MEAO. Source: 555FST Data5.

Causes of death

With the use of prevention techniques, including more rigorous pre-deployment training and the use of body armour, as well as the implementation of the military trauma system, the overall fatality rate amongst wounded soldiers has decreased to 8.8%. Past conflicts have had significantly higher fatality rates with a figure of 16.5% in Vietnam[7] and fatality rates between 20 to 30% for prior conflicts in the 20th century[8]. In addition to these factors, the implementation of the current Aeromedical Evacuation System (AES) has also played a significant role[8]. Combat casualties in the MEAO are more likely to survive their wounding than those injured in the first Gulf War[8]. Deaths occurring on the battlefield were due to total body disruption, haemorrhage and severe brain injury[7]. Haemorrhage from extremity wounds accounted for one tenth of this number and would appear an obvious focal point for further reduction[7].

Figure 5: Compared to infantry forces, the occupants of lightly armoured vehicles are less frequently injured; however the injuries sustained are more severe with a mortality approaching 50%. In addition, they have an increased incidence of burns and traumatic amputations. Source: Emergency War Surgery. US Department of Defense 2004.

Some specific injuries in the MEAO

Spinal injuries

The treatment of casualties with spinal injuries is focussed on early immobilisation and prevention of secondary injury from hypoxia, haemorrhagic, septic and neurogenic shock and further mechanical disruption. Approximately 70% of all combat spinal injury patients will require surgery at some stage4.

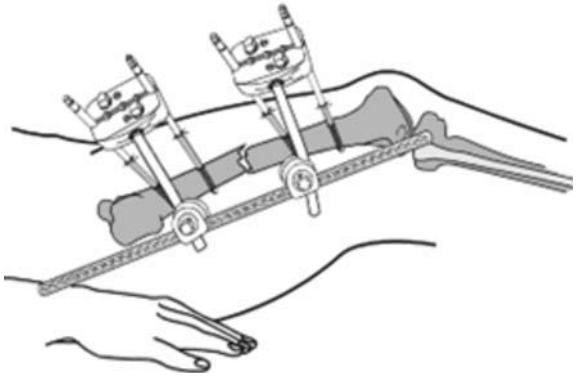

Figure 6: Intramedullary nailing of long bone fractures is contraindicated in Combat Zone hospitals. In preference, external fixateurs are applied. Broad spectrum antibiotics such as Cephazolin 1 gram given 8-hourly are continued throughout the evacuation chain. Source: Emergency War Surgery. US Department of Defense 2004.

Burn injuries

Burns account for approximately 10% of battle casualties, and nearly 20% of these will be severe burns requiring significant resuscitation[9]. Consequences of under-resuscitation include decreased tissue perfusion associated with organ failure and increased mortality rates[10]. Over-resuscitation is also problematic, with the effects being ascribed the term "resuscitation morbidity". Problems encountered from over-resuscitation include

abdominal compartment syndrome (ACS), pulmonary oedema, extremity oedema and airway obstruction[10]. These phenomena will make the aeromedical evacuation of a burns patient technically challenging, and for this reason four-person burn flight teams are utilised during AME[11].[? AeroMedical Evacuation?]. The burns AME team carries up to 800 pounds (365 kilograms) of equipment, including patient warmers, pressure cycle ventilators and bronchoscopes[11]. ACS is reported to have a threshold for occurrence if there is more than 237mL/kg infused over 12 hours (16 litres in a 70 kg man)[12].

Hypothermia

Hypothermia remains problematic in the treatment of casualties, and when combined with acidosis and haemorrhagic shock, becomes a deadly triad[2]. Prevention of hypothermia is far preferable than attempting to treat it. Novel methods utilised in the MEAO include warming fluids, direct radiation from heaters, convection blower heaters under sheets, as well as commercial products such as Bair Huggers and the Thermal Angel (which is being used by the Australian Defence Force)[2,13]. Incorporation of the dangers of hypothermia into training has resulted in a decrease in the prevalence of hypothermia amongst casualties from 7% to less than 1%7.

Figure 7: The US military using the Thermal Angel® fluid warmer (shown at arrow) in Iraq. The aim is to prevent hypothermia – which is associated with a poorer prognosis.

Source: http://www.thermalangel.com/html/areas-of-use/photos/areas-of-use-military-photos.php

Blast injuries

Patients who have sustained exposure to the supersonic pressure wave encountered in blast injuries have a variety of shearing injuries at tissue-air interfaces. This includes the tympanic membranes and the lung. AME transfer of blast-injured patients may be complicated with problems relating to expansion of trapped gasses in pneumothoraces, and the development of tension pneumothorax. Blast victims frequently require very large volumes of fluid resuscitation as well as prolonged positive pressure ventilation[14,15].

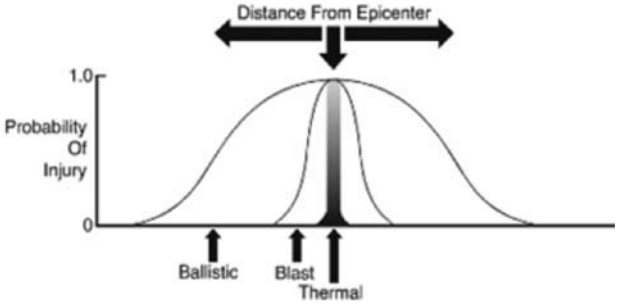

Figure 8: The mechanism of injury from explosive munitions has three patterns; thermal, blast (concussive) and ballistic. The probability of sustaining a given trauma is related to the distance the casualty was from the epicentre of the detonation. Source: Emergency War Surgery Manual. US Department of Defense 2004.

Infection

Broad spectrum antibiotic coverage is started as soon as possible for the battle casualty, usually being commenced at an Echelon II or III facility (Forward Surgical Team or Combat Support Hospital). The antibiotics are continued for 48 to 72 hours and then ceased unless there has been an infection identified, or there is an abdominal viscus injury, whereupon the antibiotic is continued for 7 to 14 days[4]. There have been reports of late infectious complications with unusual organisms such as *Acinetobacter*[14].

Combat casualties – the advances

The aeromedical evacuation system operating from the MEAO is part of a wider sophisticated system that is being developed over time. Areas that are currently the focus of military research include[7]:

- Personal protective equipment
- Body armour extensions
- Kevlar helmet revisions
- Haemostasis
- Battlefield torniquets
- Haemostatic dressings
- Recombinant factor VIIa
- Hypotensive resuscitation
- Haemostatic resuscitation
- Patient data – collection, tracking and transfer.

Body armour

There is no doubt that body armour has decreased the incidence of injury from penetrating wounds to the abdomen and torso. There is evidence to support this when comparisons are made between coalition forces wearing body armour, and Iraqi forces who do not wear the same protection[5]. The combination of body armour and "up-armouring" of vehicles has limited the number of torso injuries[5]. Whilst this has led to greater numbers of survivors, there has also been a parallel increase in the number of survivors with multiple extremity injuries.

Vehicle armour

Increased vehicle armour or "up-armouring" of vehicles occurred in response to observed injury patterns implicating poor protection from vehicle panels. Unfortunately in response to the increase in vehicle armour, insurgents elevated the position of their IED's and attacked the sides of vehicles with roadside bombs[3].

Figure 9: The six Australian Light Armoured Vehicles (ASLAV) previously operating in Baghdad were fitted with the latest form of Kevlar spall protective liners. Source:http://www.smh.com.au/articles/2004/10/25/1098667689954.html

Tourniquets and dressings

In response to the observations of medics in the battlefield, and after analyses of causes of death, there has been an introduction of new haemostatic dressings and tourniquets. Combined with this is the pre-deployment training of all combat personnel in the use of these items for self and "buddy" aid. Examples of these devices are the Combat Application Tourniquet™ and the HemCon™ Bandage[16,17]. Battlefield research confirms that these devices are proving effective in the control of haemorrhage[18].

Figures 10 & 11: The Combat Application TourniquetTM (CAT) – is carried by combat troops and used as buddy first aid – comprising the first echelon of medical care in the MEAO. Shown folded up on the left and in use above.

TRAC2ES

In 2001 the US Air Force commenced use of a new system called the Transportation Command Regulating and C^2 (Command and Control) Evacuation System (TRAC2ES)[19]. This is a patient tracking system utilised by the DoD [Department of Defense], allowing planners to decide which patients should be transported on the available aircraft. It also determines which AME teams and equipment should be utilised and where the casualty should be moved19. TRAC^{2}ES is run by the Global Patient Movement Requirements Center (GPMRC) which is an organisational element of US Transport Command (USTRANSCOM)[20].

Joint Patient Tracking System (JPTS)

With large numbers of combat troops in theatre at any one time, there arose a need to develop a readily accessible, real time tracking system permitting multiple providers, including aeromedical staff, access to injury status. In effect the JPTS is a real-time, web-based patient medical record system that is accessible to health staff who log on using an access code[7]. Another novel proposal is to place memory bus devices (thumb drives) into a soldier's dog tags – thus permitting transfer of a large amount of data with the casualty[2,7].

Joint Theatre Trauma Registry (JTTR)

To assist in research and development, the US Army Institute of Surgical Research commenced a trauma registry called the Joint Theatre Trauma Registry[2]. This database now contains over 7,500 soldier injury records[7]. Analysis of this data will influence the course of combat trauma in the next few decades.

Conclusion

Unique medical and surgical innovations during the conflict in the MEAO have translated into significant advances in patient care. The innovations range from more sophisticated immediate first aid through to the refinement of advanced resuscitative techniques such as damage control surgery. The conflict has also heralded a new age in data communication, with instant transfer of patient information and en route patient tracking systems now accepted as standard practice.

Disclaimer

The views, opinions, and/or findings in this report are those of the author and should not be construed as an official policy of the Royal Australian Air Force or the Australian Defence Force.

Author's affiliation: Department of Defence

Author's contact: Squadron Leader (RAAFSR), Director of Medical Services, Senior Medical Officer, 3 Combat Support Hospital, RAAF Richmond, NSW, 2755 Australia

Email: Jeff.Stephenson@defence.gov.au

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