FIELD TRAUMA CARE IN THE 21ST CENTURY

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Abstract

The nature of trauma care on the modern battlefield is changing quickly. Leading figures in UK field trauma care spoke at a recent meeting of the Haywood Club. The challenge of modern warfare, the evolving evacuation chain and the command and governance of field trauma care were explored.

Introduction

On 9 November 2008 the Haywood Club Triservice Medical Society held a conference entitled "Field Trauma Care in the 21st Century". More than 150 defence medical professionals from all disciplines and both from the UK and NATO allies attended. The programme sought to explore some of the major issues that have confronted the DMS in the development of services for the injured in Iraq and Afghanistan. The speakers represented a wealth of experience of both clinical care and command of deployed medical assets. This article is principally based on the proceedings of that meeting.

Current operations have imposed an enduring operational burden on the Defence Medical Services unmatched since the Korean War. The system that the DMS uses to provide care to injured servicemen and others in theatre has developed markedly in that time and this trend continues. The drivers for these developments include changes in the nature of the modern battlespace and alterations in both medical and military technology. However, the sustained nature of operations since the 1991 Gulf War has itself been critical. Firstly, it has allowed a great deal of experience and corporate learning to accumulate and secondly, it has allowed processes of performance improvement that require iterative feedback, such as clinical audit, to mature. Such mechanisms cannot function when medical facilities are established and removed within a short period, as in the Falklands or Gulf Wars. Finally, and closely allied to this, it has enabled the collection of accurate, fulsome data which to date has concentrated on mortality but increasingly quality of survival is being assessed.

Field Trauma Care in the Current Operational Environment

British Forces have two sustained, medium-scale deployments, to South-Eastern Iraq and Southern Afghanistan. While these operations have significant distinctions of geography, politics, maturity and forces, from the medical perspective they share several key features. The environments are hostile. Forces are dispersed throughout the areas of operations, with no meaningful "rear area". Ground transport is often impractical either through danger, terrain or distance, meaning that air transportation of casualties is the norm. Both conflicts are asymmetrical and communications are often poor. There is a huge political (as well as ethical) imperative to preserve every casualty.

The traditional doctrinal structure of medical deployment with rearward progression of casualties from Role 1 to 4 (Figure 1) is appropriate to high intensity manoeuvre warfare but does not adequately describe the current battlespace; Figure 2 provides a schematic representation of the deployment of medical assets during OP HERRICK 4 and the differences to the traditional model are obvious. In addition, only a large force vulnerable to a considerable casualty rate justifies the deployment of a full Role 3 field hospital with several hundred beds and all surgical specialties present. The term Role 2 Enhanced (R2E) has been introduced, as seen currently at Basra Air Station and Camp Bastion, and is a field hospital with the physical infrastructure of a Role 3 facility, including CT scanner, but with a reduced capacity and limited surgical disciplines (currently general and orthopaedic surgery only).

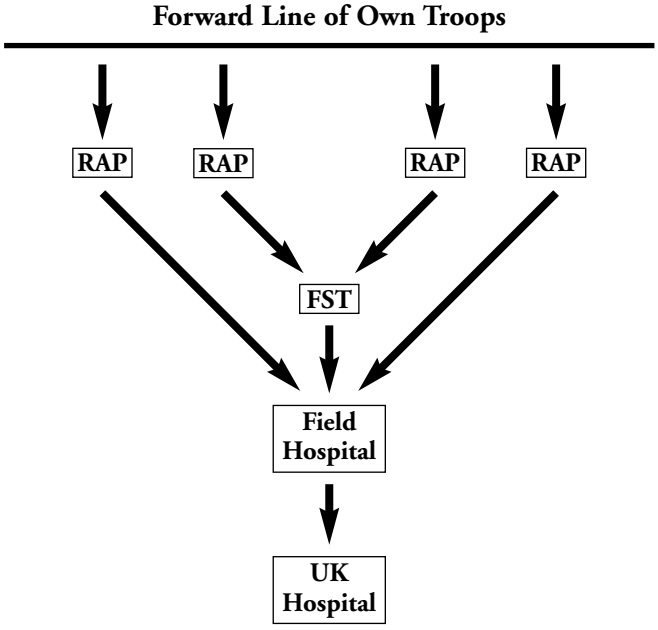

Figure 1. Traditional structure of medical evacuation chain

Following first aid from fellow soldiers including team medics, the mainstay of pre-hospital care for the injured remains the staff of the Regimental Aid Post. Table 1 shows the burden of trauma patients treated by the Aid Post at Musa Qaleh during a period of just 11 days. These cases were managed by a GDMO with 6 months experience in emergency medicine after registration and 2 CMTs.

The Medical Emergency Response Team

During planning for Op HERRICK 4 by 16 Close Support Medical Regiment (16 CS Med Regt), it was identified that there would be extended timelines to hospital care even with the use of helicopters. The sustained deployment of forward medical care, such as Field Surgical Teams, to all parts of the province was not possible. Given the restraints on the care that can be administered at point of wounding and at Role 1 it was decided that it would be desirable to bring critical care forward to the patient. This

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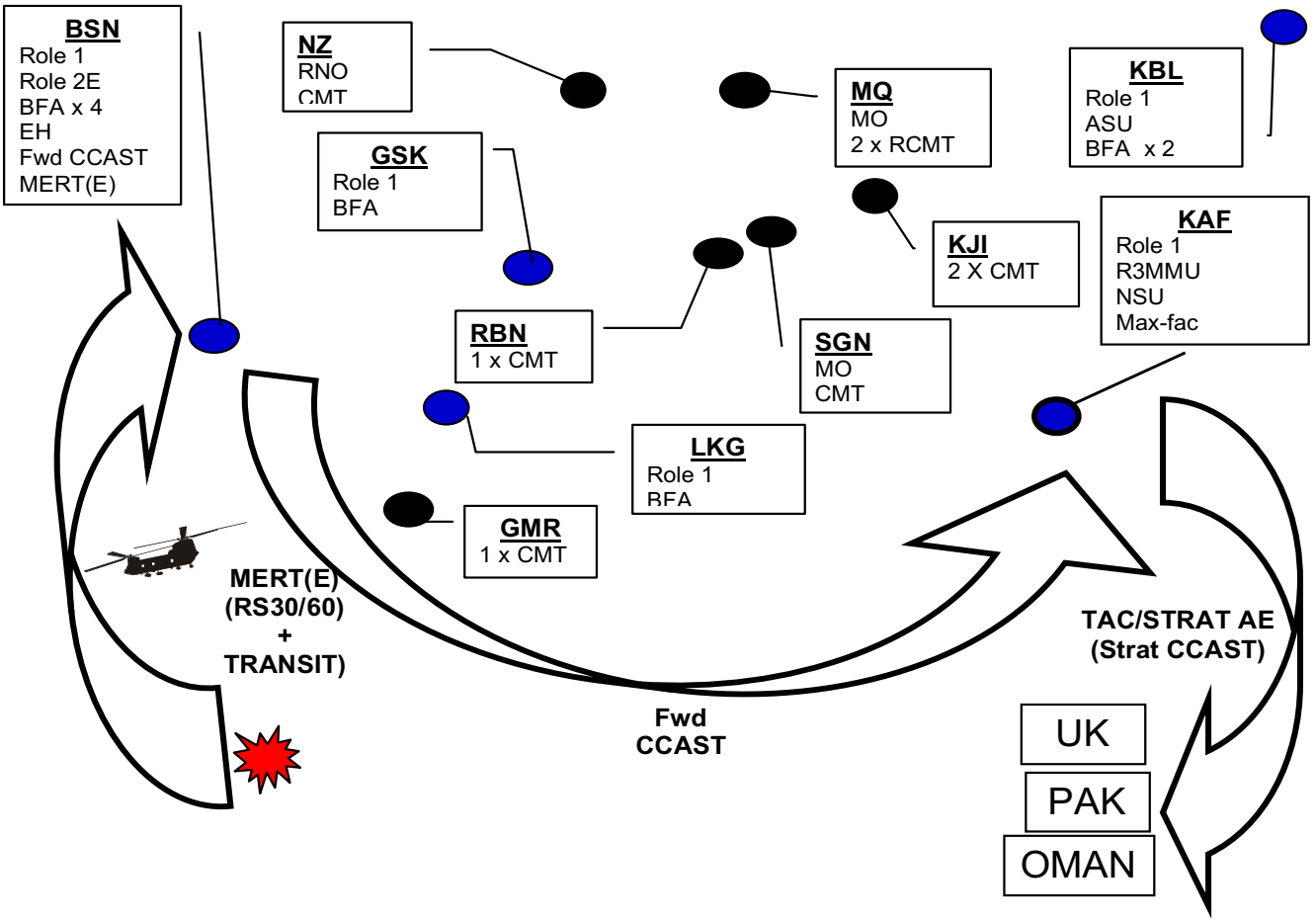

Figure 2. Medical Concept of Operations at the start of Op HERRICK 4. Box titles represent location names. The geographical complexity, the bypass of forward medical assets in favour of direct evacuation to hospital and the dependence on air assets should be noted. MO=Medical Officer RNO = Regimental Nursing Officer; CMT=Combat Medical Technician; BFA=Battlefield Ambulance Station; MERT(E)=Medical Evacuation Retrieval Team(Enhanced); NSU=Neurosurgical unit; CCAST=Critical Care Air Support Team; EH=Environmental Health

Date/Time	Casualties
Day 1/1500	1 x T1 casualty, GSW left lower limb 2 x T2 casualties
Day 2/0655	1 x UK soldier dead on arrival
Day 5/1800	1 x UK soldier dead on arrival 1 x UK T1 casualty, open head injury
Day 6/1230	1 x T1 thoracoabdominal wound 9 x T2/T3 casualties, soft tissue fragmentation injuries (FI)
Day 7/1800	5 ANP casualties: 1 x FI to neck 1x T2 (became T1) head/neck and chest FI 3 x T2/T3 casualties, soft tissue FI
Day 10/2000	1 x UK T1, neck FI 1 x ANP T2, right lower limb FI 4 x T3 casualties

Table 1. Casualty load at one aid post in a forward operating base over a ten day period during Op HERRICK 4.

service was provided by 16CS Med Regt cadre clinicians with an interest in forward critical care joining the Medical Emergency Response Team (MERT). The philosophy of the 16 CS Med Regt MERT is set out in Box 1.

The HERRICK 4 MERT was a joint, physician-led team consisting of 5 personnel:

- Consultant Anaesthetist / Emergency Medicine
- Emergency Department RGN
- ODP
- Paramedic
- Interpreter

MERT(E) Philosophy – Op HERRICK 4

- Agile enhanced medical response that can replace or complement forward echelons of medical support
  - Tactically aware
  - Trained (and experienced) response to the critically injured
  - Deployable by any means
- Based on a civilian HEMS model
  - Clinical excellence despite environmental austerity
  - Rapid delivery of the casualty to **the most appropriate location**
  - Requirement for critical care skills

Box 1. This philosophy guided the constitution and employment of the enhanced MERT first employed during Op HERRICK 4

This team was able to deploy by any means, but usually did so by helicopter accompanied by a force protection element. There was no staged response according to the expected severity or number of casualties. This mix of personnel was intended to project a skill set that would provide informed and credible decision making, embedding the doctrine of mission command in medical activity. Competent critical care was to be provided, with experienced personnel employing organ support techniques with the intention of preventing, rather than reacting to, physiological deterioration. At the same time, this crew mix would act as an enabler of medical support, for example by employing MIMMS methodology on the ground, assisting in medical planning and providing a conduit for information between the forward areas and the hospital or medical command. The employment of this model has continued in subsequent HERRICK deployments.

120 MERT missions were flown during HERRICK 4 and 5 evacuating 207 casualties Initially, the time taken to retrieve casualties was longer than was desirable. This improved after improvements in communications and procedures. Figures 3 and 4 detail the type of injury and triage categories on these missions. Figure 5 demonstrates the 20 Advanced Life Support interventions performed (22% of missions). Five unexpected survivors were subsequently identified by TRISS methodology; this is discussed further in the section on governance.

Deployment of the MERT puts valuable assets at risk. In addition, the inclusion of a consultant anaesthetist or emergency physician, while not unprecedented is a change to previous practice where a general practitioner (who may or may not have significant pre-hospital experience), usually based at the airhead with the aircraft rather than at the hospital, was deployed. This change may have wider implications, whether for manning or lines of responsibility. Other observations included the poor quality of communications from the scene rearwards and the good quality of the work of CMTs. The delivery of critical care on aircraft is possible (as CCAST MEDEVAC has shown previously) but diagnoses have to be made on the basis of an incomplete pattern of information. Thus a mixture of knowledge, experience and intuition is needed. However, the presence of a critical care physician has other benefits in allowing the other team members to concentrate on their own roles and to act as a natural focus of clinical governance.

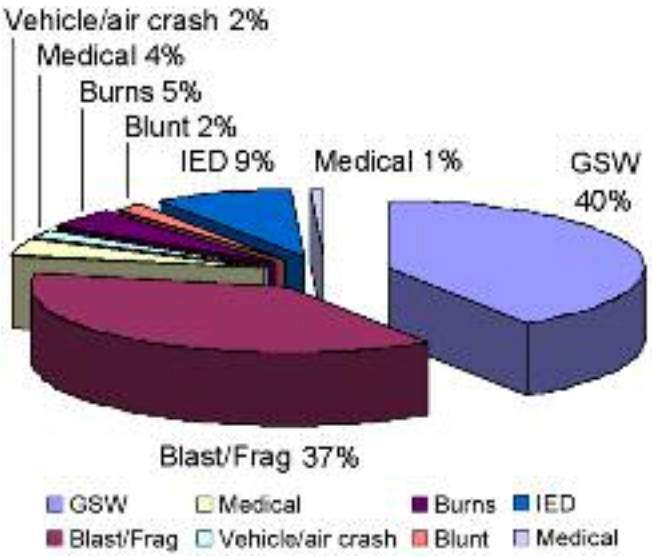

Figure 3. Breakdown of 207 casualties flown by MERT during Op HERRICK 4 and 5 by mechanism of injury.

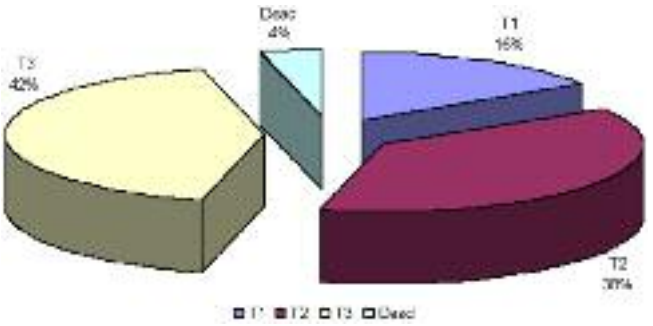

Figure 4. Triage category of patients flown by MERT during Op HERRICK 4 and 5.

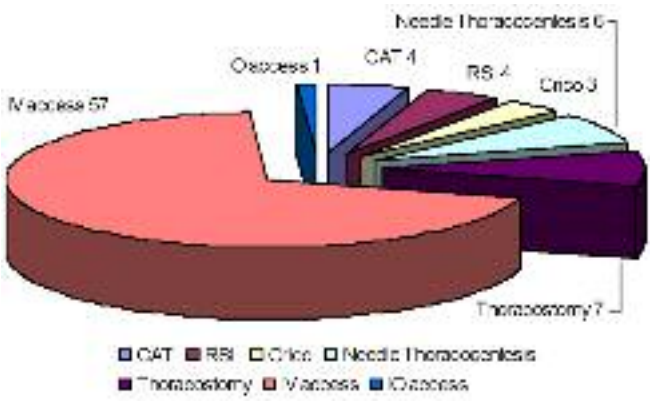

Figure 5. Critical care interventions by MERT during Op Herrick 4 and 5.

In response to these events, DMSD instituted the "Objective Analysis of Forward Deployed Medical Emergency Response Team" in October 2006. This process consisted of a clinical audit of operational activity, a review of the literature, a modified DELPHI study and stakeholder meetings. The literature review revealed a paucity of directly applicable evidence. Such studies as do exist tend to compare helicopter transport of the injured with road transport, rather than comparing different clinical skill sets. Most were from an American urban setting whereas operational activity has more in common with the rural experience found in Australasian literature. Only a single level one study [1] that addressed the question of the impact of including a physician with critical care skills in an aeromedical prehospital team and reported a 35% lower mortality in a blunt trauma population when a physician was present. This difference was ascribed to "physician judgement". The full review is published in the recent JR Army Med Corps Combat Casualty Care supplement [2]. The MERT-E is in current use in Afghanistan and evidence on its efficacy is still being gathered.

Forward Deployment of Surgical Assets

Forward Surgical Teams (FSTs) can be used to ameliorate the problem of extended evacuation times to the Field Hospital. However, there is an obvious play-off between the necessity to remain light with a small logistic footprint and desire to maximise the treatment capacity and capability of the unit. Civilian studies have clearly demonstrated that survival is better in hospitals that are fully resourced and specialised for the treatment of the injured (i.e. trauma centres) [3] and that patients do not suffer where they bypass nearby hospitals in order to be taken to a trauma centre [4]. The employment of forward surgery by the armed forces can therefore only be justified by the distinct features of military trauma care, i.e. the nature of military trauma and the delays in evacuation that occur.

There are three inter-related considerations that must dictate the design and employment of forward surgical units:

1. The treatment capacity, both in terms of numbers but also in terms of the type of treatment, particularly critical care.
2. The acceptable delay to treatment.
3. The deployability and logistical footprint of the unit.

Israeli data from the recent conflict in Lebanon indicate the vast majority (85%) of military deaths occur within minutes of wounding. A further 10% die within the hour. Of those dying later, a high proportion are killed by CNS injury. Only those who can survive to reach the FST could benefit and some of the later deaths would be unsalvageable. It is the 10% who die within an hour but have survived the first few minutes who could benefit. Within this cohort of potentially salvageable deaths we can now consider what injuries (abdominal, thoracic, head and limb) injuries may occur that can be effectively treated by early surgery.

A 1987 review of Israeli experience showed that 80% of abdominal injuries could tolerate delay of surgery by 6 to 8 hours [5]. Those who could not had high energy injuries, were shocked or had 3 or more organs injured. Resource-intensive critical care is integral to the process of damage control surgery

(DCS) that these patients would require. Military trauma care occurs in sub-optimal conditions where it may not be possible to reproduce civilian results from DCS. The lighter a forward surgical unit is, the less likely it will be that it can provide the necessary quality of critical care. Life threatening chest injuries that may be salvageable by early surgery consists of damage to the heart, the great vessels and the lungs. All of these require rapid, definitive surgical repair. However, the optimum management of these injuries requires the same critical care input as abdominal DCS.

Surgery for ballistic head injuries is primarily aimed at preventing infection rather than relieving raised intracranial pressure, as in blunt head trauma. Optimal surgery requires prior CT scanning. Surgery for this indication can be delayed for 6 or more hours and early surgery (within minutes) is unlikely to generate additional survivors.

Treatment of limb injuries is intended to save either life or limb. Exsanguinating haemorrhage should be controlled by pressure, tourniquets and/or novel haemostatics. If these fail then the patient is unlikely to survive to surgery. A role for early surgery in the salvage of junctional injuries may exist. Limb-threatening vascular injuries exist in 2-3% of casualties. Early repair is advisable but may be complicated by accompanying fracture and/or shock and requires a specialist surgeon and equipment. A role for the early use of vascular shunts may exist to salvage limbs from later amputation.

Thus there may be 2-5% of all deaths that are salvageable by receiving early surgery (less than 1 hour, certainly less than 2). However, this depends upon the surgical unit having the necessary resources to provide high quality critical care. Thus the "tent in the desert" model of forward surgery is unlikely to save lives relative to evacuation to a field hospital even with a delay of several hours.

To attempt to address these concerns new designs of light hospital units are being developed. The 10 Bedded Close Support Hospital (CSH) design is intended to provide a small capacity hospital with full facilities for the provision of DCS and critical care for a small number of patients. It will have a modular design, being a deployable component of, and the skeleton for the establishment of, a full field hospital. This arrangement will mirror the Casualty Clearing Stations deployed in WW2, with their heavy and light components. Such units will be critically dependent on the maintenance of a "back door" for the evacuation of patients to R2E or R3 and on resupply. Failure of either of these will rapidly degrade the Lighter Hospital's ability to maintain modern standards of trauma care, and could leave the unit as little more than the abandoned "tent in the desert" it should replace. Very light surgical units such as Role 2 Light Manoeuvre (R2LM) may still be required where nothing else can be provided due to operational constraints, such as in airborne or Special Forces operations or to fill the void as result of rapid advance of a brigade in contact. This temporary Medical Surgical Facility would need to be established until the CSH could be brought forward into the new Brigade Area of Operations.

Clinical Governance of Field Trauma Care

One of the biggest developments in the UK's military trauma system has been the need and the opportunity to develop a robust framework of clinical governance for operational trauma care. This allows the chain of command to assess the quality of the care provided by the DMS and allows clinicians to participate in an iterative process of performance improvement.

The clinical governance framework is based around the Major Trauma Audit for Clinical Effectiveness (MACE), part of the Joint Theatre Trauma Registry (JTTR). The MACE has been developing since 1997. The JTTR is now based at RCDM and staffed by trained Trauma Nurse Coordinators (TNCs). However, it is only since 2007 that it has enjoyed an established cadre of staff to administer it; previously it had been conducted by clinicians on their own collective initiative.

Data for the MACE is gathered by TNCs who fulfil the scribe role in the trauma team on operations. Detailed audit forms are filled out on all patients for whom the trauma team is activated and all injured coalition personnel who are evacuated out of theatre. These forms are submitted to the JTTR. The data set allows calculation of all the trauma statistics listed in Box 2.

- Abbreviated Injury Score (AIS)
  - o Civilian 1998 standard
  - o US Military 2005 Standard
- Injury Severity Score (ISS)
- New ISS (NISS)
- A Severity Characterization of Trauma (ASCOT)
- Standardised Mortality Ratio (SMR)
- E-value

Box 2. Trauma Scoring systems routinely calculated from JTTR data

The MACE/JTTR is now the central component of a sophisticated system of trauma governance. The components of this system are:

- Developing and maintaining practice standards
- Monitoring system performance coupled with clinical feedback
- Individual, collective and organisational learning
- Patient focused trauma system development
- Risk awareness and amelioration

Sixty Performance Indicators have been specified by a committee that includes the relevant DCAs and Defence Professors. Relevant data is included in the MACE entry for each casualty. Deviations from the standard of care generate critical event reports; failure over time to meet performance indicators will lead to analysis of root causes. In both cases (i.e. the individual and the sustained failure) appropriate remedial action will be taken.

The outcomes data from the MACE are synthesised with other mechanisms of system monitoring. In particular a member of JTTR staff attends the autopsy following each UK death. Unexpected survivors and deaths are identified from the database using TRISS methodology. These are then subjected to a process of peer review. In the review of deaths a distinction is drawn between deaths that are salvageable ie amenable to effective treatment within current practice and those that are preventable, defined as practically treatable within the tactical situation at the time.

There have been 22 unexpected survivors during the period covered by Telic 8-10 and Herrick 4-6. 2 potentially survivable deaths occurred during this time, one through drowning and one through loss of a limb in a minefield. At peer review these were found to be salvageable but not preventable in the tactical situations that existed. Overall there were 76 UK servicemen killed on operations in the year to 31 Mar 07, 75% of which were due to hostile action (48 killed in action and 9 died of wounds). Analysis of this group reveals the mechanisms of injury seen in Table 2. There was one fatal tension pneumothorax (2% of all deaths) – this is comparable to US figures.

Monitoring of system performance is pointless without a mechanism for clinical feedback. This is achieved through the weekly Joint Theatre Clinical Case Conference, a teleconference chaired by the Professor of Military Emergency Medicine and including clinicians and medical commanders from both theatres, CCAST and members of RCDM staff. There is clinical feedback on patients who have reached the UK, exchange of information on patients being evacuated and discussion of equipment, training and policy issues arising from recent cases and JTTR analysis. This process drives a continual modification of current practice.

Standardised Mortality Ratios (SMRs) for recent operations can be calculated from the MACE data:

- SMR Kosovo 1999 1.5
- SMR Iraq 2003 1.5
- SMR Iraq 2006-7 1.1
- SMR Afghanistan 2006-7 0.9

Why has this improvement occurred? There appears to be 4 main factors. Trauma scoring systems have been refined, and this may confound the observed improvement but only to a small degree. There has been a learning effect as the DMS has been on operations for well over a decade. Technological enhancements in trauma care have played a role. Crucially, though, the DMS has implemented an increasingly sophisticated trauma system (now with end-to-end oversight of patient care) during this period.

Region	Percentage involvement
Head	42%
Thorax	40%
Neck	24%
Abdomen	16%
Limbs	16%
"Whole body"	14%
Face	2%
External	2%

Table 2 Percentage involvement by body region for Hostile Action injuries with an Abbreviated Injury Score of 3 or more. Overall, 67% of Hostile Action injuries were due to blast and 33% due to gunshot wounds.

Command of Field Trauma Care Providers

Figure 2 gives some idea of the complexity of the command challenge of mounting and sustaining a coordinated trauma system in the field. Significant risks and weaknesses were identified prior to the deployment of the UK Medical Group (Med Gp) on Op HERRICK 4 and some of these are listed alongside the mitigation put in place in Table 3. However, the situation in Helmand Province developed rapidly and the fighting was the most intense seen for at least a generation, with three Med Gp personnel wounded in action. The five bases originally planned became 11, leading to commitment of the medical tactical reserve, which could not then be reconstituted. The Population at Risk grew as non-medical command structures became the gatekeepers to the evacuation chain. Large numbers of Afghan patients who were not eligible for repatriation to the UK necessitated careful management of bed occupancy. The challenges for command at this stage highlighted several important areas:

- Ensure coherence of your plan with others – discuss up, down and sideways
- Engage with clinical staff
- Maximize the potential of your clinical skills and place medical personnel on the battlefield where they can have the earliest positive clinical effect. This represents the dilemma of deliberately putting individuals in harm's way versus enhancing the Force's Moral Component
- Decisiveness:
  - General Colin Powell's P@40 to 70 – where P is the probability of success and only 40-70% of the information required to ensure success is available. Once information is in the 40 – 70 range, go with your instinct as procrastinating in the name of reducing risk may actually increase it.
- The Healthcare Governance Board – clinicians and commanders together –made risks borne by clinicians visible.
  - Commanders need to formally underwrite the risks carried by their subordinates.
- It is vital to walk the ground and (be seen) to get one's hands dirty.

The Conference concluded with the 4th Hugh Owen-Thomas Memorial lecture given by Col Donald Jenkins USAF, who was instrumental in the establishment of the US military trauma system. The contents of his speech are beyond the scope of this article but good accounts of this process are available in the literature [6].

Risk	Mitigation
Insufficient clinical capability within Iraq model IRT	MERT(E)
Low light levels	FLIR equipped Blackhawk helicopter made available
Temperature	Acclimatisation & hypothermia mitigation put in place
No CT at R2E Camp Bastion	Use allied facilities and manage risk
Lack of neurosurgical cover	Fwd CCAST (rapid evacuation with neurointensive care) & use of Other Nation facilities
Ability to treat Afghan civilians	Deconfliction from local or NGO provision, to provide only culturally and technically appropriate medicine
Failure to establish practice, process and continuity through clinical roulement	Clinical staff deployed for 3+ months

Table 3. Examples of risks and weaknesses in Op HERRICK 4 Medical Plan and actions taken to ameliorate these.

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