REVIEW

Military trauma system in Afghanistan: lessons for civil systems?

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Purpose of review
This review focuses on development and maturation of the tactical evacuation and en route care capabilities of the military trauma system in Afghanistan and discusses hard learned lessons that may have enduring relevance to civilian trauma systems.

Recent findings
Implementation of an evidence based, data driven performance improvement programme in the tactical evacuation and en route care elements of the military trauma system in Afghanistan has delivered measured improvements in casualty care outcomes.

Summary
Transfer of the lessons learned in the military trauma system operating in Afghanistan to civilian trauma systems with a comparable burden of prolonged evacuation times may be realized in improved patient outcomes in these systems.

Keywords
en route care, performance improvement, tactical evacuation, trauma system

INTRODUCTION

The military trauma system fielded in Afghanistan has been adapted to the complexities of geography, patterns of injury and international multidisciplinary cooperation and collaboration. These factors distinguish it from the military trauma system that evolved in support of Operation Iraqi Freedom (OIF). The prolonged evacuation times of Afghanistan placed a greater emphasis on en route care, both from the point of injury and from forward surgical facilities to higher levels of intratheatre surgical care. Increased utilization of forward surgical facilities created a larger population of postoperative casualties requiring en route critical care. These unique challenges led to the development of a robust tactical evacuation capability. This review will focus on development and maturation of that unique element of the military trauma system in Afghanistan and discuss hard-learned lessons that may have enduring relevance to civilian trauma systems.

TRAUMA SYSTEM DEVELOPMENT

Although US and Coalition forces deployed to Afghanistan and Iraq with trauma care delivery capabilities, there was no fully organized and coordinated system-level capability. In order to deliver the advantages demonstrated in civilian trauma systems to combat casualty care in the US Central Command Theater of Operations, under the guidance of the Command Surgeon, a group of US Military trauma surgeons instituted an inclusive trauma system in support of Operations Enduring Freedom (Afghanistan) and Iraqi Freedom in 2004. The system was eventually fully integrated from the

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Curr Opin Crit Care 2013, 19:569–577
DOI:10.1097/MCC.0000000000000037

Report Documentation Page						*Form Approved* *OMB No. 0704-0188*
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.						
1. REPORT DATE **01 DEC 2013**		2. REPORT TYPE **N/A**				3. DATES COVERED **-**
4. TITLE AND SUBTITLE **Military trauma system in Afghanistan: lessons for civil systems?**						5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S) **Bailey J. A., Morrison J. J., Rasmussen T. E.,**						5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **United States Army Institute of Surgical Research, JBSA Fort Sam Houston, TX**						8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)						10. SPONSOR/MONITOR'S ACRONYM(S) 11. SPONSOR/MONITOR'S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release, distribution unlimited**						
13. SUPPLEMENTARY NOTES						
14. ABSTRACT						
15. SUBJECT TERMS						
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON	
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**UU**	**9**		

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

KEY POINTS

- The features of distance and geography led to a robust evacuation and en route care system in Afghanistan.
- Performance improvement in this system has been driven by clinical data acquisition and near real time analysis realized in improved casualty outcomes.
- Civilian trauma systems with similar challenges of distance and geography may benefit by transfer of lessons learned in war.

point of injury through discharge from acute care in the Continental United States (CONUS). The system included implementation of an embryonic Joint Theater Trauma Registry in 2005, which eventually was developed into a robust web-based application for registry of information across the entire continuum: point of injury through discharge from acute care. This registry was redesignated as the Department of Defense Trauma Registry (DoDTR) in October of 2012 in conjunction with implementation of enduring funding and support to sustain it beyond US combat operations in Afghanistan. The DoDTR supports evidence-based performance improvement in the practice of Battlefield Medicine [1]. This best practice, evidence-based performance improvement methodology has been the primary engine of advancement of combat casualty care delivered along the continuum. This has resulted in measured improvements in casualty outcomes with a case fatality rate of less than 10%, the lowest at any point in the war, despite a rising injury severity (Fig. 1) [2].

As the US Central Command Joint Theater Trauma System began to take shape, the initial focus and effort concentrated on OIF. The weekly systemwide teleconference that linked trauma teams in theatre with those at Landstuhl Regional Medical Center in Germany and Military Medical Centers in the Continental United States (Fig. 2) focused on the greater burden of injury, which in the early post-2003 period was occurring in Iraq. At that time, the discussion group was almost exclusively within the US military community of practice due to the dominance of the US in the OIF combat casualty care mission. For the first time – in 2006 – the NATO Role 3 facility at Kandahar Air Base, led by the Canadian Armed Forces, participated in the weekly teleconference and presented a casualty they had cared for who had subsequently been evacuated from Bagram Air Field in Afghanistan to Landstuhl Regional Medical Center. This inaugural, but limited first-person, combat casualty care perspective was the continuum's introduction to the complex and disparate combat casualty care environment of Afghanistan [1]. This conference provides significant direct care benefits, including transmission of important clinical data, including first-person surgeon perspectives and relay of important clinical data such as the results of microbiological culture, among others [2].

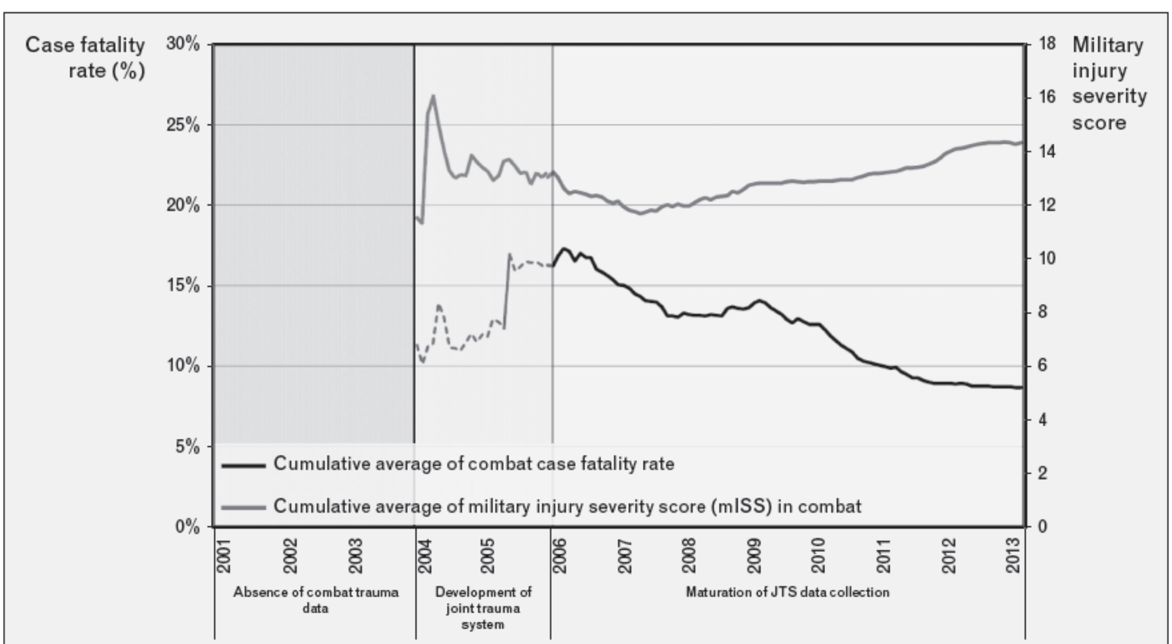


FIGURE 1. Afghanistan Combat Casualty Care mortality and ISS over 10 years. Source: Joint Trauma System.

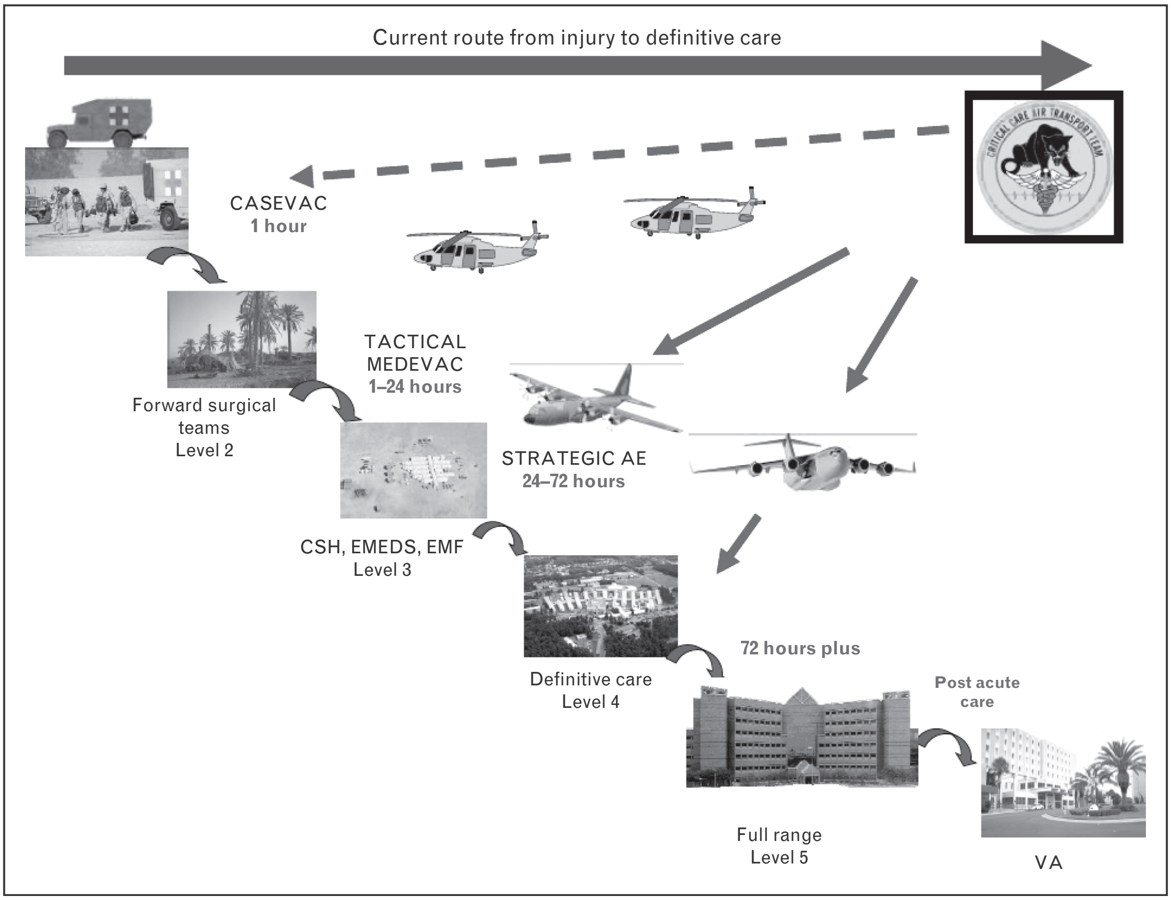


FIGURE 2. Continuum of care. Adapted from [1].

The battle space of Afghanistan is characterized by great distance and mountainous geography, which combined prolonged evacuation times from the point of injury. It was recognized that earlier – in fact prehospital – initiation of life-saving intervention and resuscitation (including blood products) might help to mitigate the adverse effects of time and distance on battlefield survival [3▪▪]. In addition, in contrast to Iraq, where Level 3 facilities were more numerous and proximate to the point of injury, casualties were evacuated to Level 3 from Level 2 facilities nearly twice as frequently in Afghanistan. This greatly increased the utilization of forward surgical facilities in Afghanistan, placing a heretofore unseen burden on the tactical transfer of postoperative and critically injured patients.

The system adaptations to meet these challenges included the UK Medical Emergency Response Team (MERT), the En Route Critical Care Providers and the Tactical Critical Care Evacuation Teams (TCCET). In addition, to improve evacuation coverage, the US 'PEDRO' Pararescue Teams (a personnel recovery and combat search and rescue capability) were included in both the point of injury and intratheatre, interfacility evacuation mission [1,3▪▪]. The tactical evacuation and en route care capability that developed and matured in Afghanistan is perhaps its most significant distinction. In that complex mission, the focus has been placed on time to capability, as opposed to time to location [4▪].

SYSTEM DEVELOPMENT AND MATURATION

The evolution of TCCC into a robust, evidence-based and widely disseminated paradigm of care – coupled with improvements in combat injury prevention – has resulted in a greater proportion of wounded personnel requiring Medical Evacuation (MEDEVAC) to a Medical Treatment Facility (MTF) [5]. This phase of care is referred to as en route care and often comprises the longest prehospital stage of a patient's journey in Afghanistan. This is partly not only due to the eccentric distribution of combat operations but also due to the maturation of MTFs into fixed positions with hard-standing infrastructure and sophisticated logistical support. Although the outcomes achieved by such facilities are unparalleled in modern warfare, they are contingent upon a patient surviving to admission, highlighting the importance of en route care [5,6▪▪].

En route care in Afghanistan is designed to be part of a continuum of care that incorporates the delivery of Damage Control Resuscitation. This includes techniques such as permissive hypotension, avoidance of synthetic fluids, and early blood product use [7]. Critical to an effective trauma system is the 'Intelligent Tasking' of prehospital MEDEVAC assets, a process common to both civilian and military trauma systems [8].

INTELLIGENT TASKING

This is the process whereby medical information from units on the ground requesting MEDEVAC assistance is integrated with the tactical picture of the battle space in order to dispatch the most appropriate asset. In Afghanistan, this is achieved through regionalized Patient Evacuation Co-ordination Cells (PECC) [9].

The process begins with a '9-liner' from the requesting unit that details medical information pertaining to casualty number, injury type as well as important operational constraints such as ongoing hostile activity and helicopter landing site (HLS) details. The PECC has an overview of the regional tactical situation and takes the information from the '9-liner' and synthesizes an appropriate MEDEVAC tasking.

The staff within the PECC consist of personnel from Medical Operations (generally a nursing background) and Aviation Operations. Although there are certainly recurring patterns of injury – e.g. traumatic amputation following Improvised Explosive Device injury – that can be protocolized, specific medical advice can be obtained from a physician if required. For example, it may be appropriate to divert a flight to a neurosurgery capable facility in the instance of a severe head injury or away from a facility that has no available critical care facilities.

One of the busiest PECCs is in South West Afghanistan and is responsible for the coordination of MEDEVAC missions from several nations, including the US and UK (Table 1) [9,10▪▪]. It is also in this region that the use of multinational assets has permitted the comparison of MEDEVAC platforms, enabling the refinement of tasking procedure as part of the Trauma System Performance Improvement process.

EVIDENCE-BASED PERFORMANCE IMPROVEMENT FOR TACTICAL EVACUATION AND EN ROUTE CARE

Beginning in 2005, with the inception of the US CENTCOM Joint Theater System, a team of trauma nurse coordinators and noncommissioned officers – lead by a Trauma Nurse Program Manager and directed by a senior US Military Trauma Surgeon – has deployed to theatre. This JTTS team initially focused its efforts on facility-based theatre care and performance improvement. In conjunction with the June 2009 US Secretary of Defense Mandate of a 60-min standard for evacuation time from point of injury to surgical care, two trauma nurse coordinators and a noncommissioned officer were added to the JTTS team. This 'MEDEVAC' element of the JTTS team was initially focused on coordinating reports for evacuation times and addressing clinical adversity attributed to out-of-standards (>60 min point of injury to surgical care) missions.

Evaluation of the clinical impact of the out-of-standards missions required that JTTS had ready access to evacuation patient care records. It became clear, early on, that documentation of en route care (both from point of injury evacuations and from the intratheatre inter-facility transfers) was suboptimal and that the team had little, if any, access to the documentation that existed. In order to deliver an evidence-based, best practice capability to the tactical evacuation community, the efforts of the JTTS MEDEVAC team became focused on improvement in documentation and capture, aggregation and analysis of all relevant evacuation and en route care clinical data. As the team applied itself to improving evacuation and en route care documentation and to capture of these records, increasingly – in addition to the facility records – patient point of injury evacuation and transfer records were also abstracted into the DoDTR. The return on this investment was a maturing performance improvement assessment tool that, in its early application, has been used to measure the impact of clinical adaptations in en route care, both from the point of injury and in the transfer mission [1]. This includes recent assessments of the association between resuscitative teams and mortality outcomes, which has led to a reevaluation of the role of forward advanced life-saving intervention and damage control resuscitation in the US military [3▪▪].

CROSS-PLATFORM MEDEVAC PERFORMANCE IMPROVEMENT

The use of the Performance Improvement process to refine and validate system performance is best demonstrated by the experience in South West Afghanistan. The MEDEVAC mission in this region is supported by three major assets: US Air Force PEDRO, US Army DUSTOFF and the UK MERT. As each asset has different clinical and military capability (Table 1), characterization of clinical

Table 1. Forward aeromedical evacuation platforms operating in Southern Afghanistan

Tactical call sign	DUSTOFF	PEDRO	MERT
Service Organization	US Army	US Air Force	UK Royal Air Force
Red Cross Symbol	Yes	No	No
Combat Search and Rescue	No	Yes	No
Helicopter			
Air frame	UH 60 Blackhawk	HH 60 Pavehawk	CH 47 Chinook
Cruising speed	173 mph	183 mph	196 mph
Armaments	None	2 miniguns	2 miniguns and 1 M60
Patient litters	3 or 6	2 or 3	8 or 9
Medical crew			
Physician	0	0	1
Nurse	0	0	1
Paramedic	0	2	2
EMT B	2	0	0
En route intervention			
Active warming	Yes	Yes	Yes
Intravenous access	Yes	Yes	Yes
Intraosseous access	Yes	Yes	Yes
Needle chest decomp.	Yes	Yes	Yes
Cricothyroidotomy	Yes	Yes	Yes
Supraglottic devices	Yes	Yes	Yes
Chest tube placement	No	Yes	Yes
Blood products	No	Yes	Yes
RSI	No	Yes	Yes
ACLS	No	Yes	Yes
TXA administration	No	Yes	Yes
Video laryngoscopy	No	Yes	Yes

ACLS, advanced cardiac life support; EMT-B, emergency medical technician-basic; RSI, rapid sequence intubation; TXA, tranexamic acid. Adapted from [3■■,10■■].

performance was especially important both to inform the tasking procedure in the shorter term and also for longer-term military medical planning.

The PEDRO platform is crewed by paramedics trained to high proficiency in military skills capable of delivering rapid sequence intubation (RSI), blood products and tranexamic acid. DUSTOFF crews are typically emergency medical technician basic-level flight medics who can deliver an extension of basic field care such as basic airway manoeuvres and tourniquet application. The MERT asset is flown on a large CH-47 Chinook airframe and consists of a four-member clinical team headed by a physician and including a nurse and two paramedics. This team is capable of delivering a sophisticated level of care, including RSI, resuscitative thoracotomy and blood product administration [3■■,10■■,11■■]. It should be noted that DUSTOFF is a designated medical asset and protected under the Law of Armed Conflict, as identified by a Red Cross. Consequently, it can only carry defensive weapons (i.e. small arms), whereas PEDRO and MERT possess an offensive capability, making them ineligible for the Red Cross.

The first large multinational MEDEVAC outcome study was performed by Morrison *et al.* [11■■] and involved the sharing of US and UK registry data. They compared patients retrieved by MERT ($n = 1093$) with a combined group ($n = 628$) of PEDRO and DUSTOFF patients, stratified into three ISS bins (1–15, 16–50 and 51–75). They observed a reduction in mortality in the middle ISS group when patients were retrieved by the MERT group (12.2 vs. 18.2%; $P = 0.035$).

This work was extended by Apodaca *et al.* [10■■], who used the US DoDTR to evaluate 543 casualties evacuated using the UK MERT platform and compared their outcomes with 326 evacuated by PEDRO. The JTS report found that, in the higher ISS category (20–29), mortality was lower in MERT-retrieved patients than in the PEDRO (4.8 vs. 16.2% respectively; $P = 0.021$). This analysis also demonstrated a

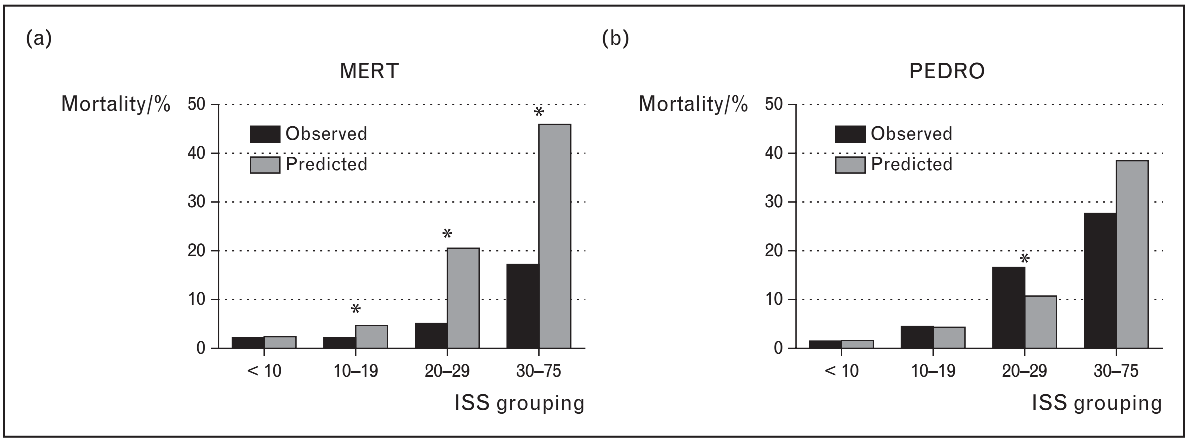


FIGURE 3. Observed vs. predicted mortality outcomes, using TRISS methodology, in the MERT and PEDRO MEDEVAC platforms. *Statistically significant if $Z \geq 1.96$ or $Z \leq$ 1.96. Adapted from [10▪▪].

significant difference in observed survival when MERT and PERDO data were evaluated by TRISS methodology (Fig. 3).

However, despite these reports, it is unclear whether improved outcomes relate to en route resuscitation or a phenomenon of the tasking procedure. In order to answer this question, Apodaca *et al.* [12▪] used the Shock Index (SI = HR/SBP) as a metric of haemodynamic stability to compare the retrieval with admission value per MEDEVAC provider. Patients were grouped into three ISS strata (1–9, 10–25 and 26+) and SI compared. An improvement in SI was noted across all strata for the MERT group, with PEDRO retrievals associated with deterioration in the higher ISS group (ISS >26) (Fig. 4).

In aggregate, these performance improvement studies have helped to inform upon system performance by validating outcomes and enabling the refinement of the MEDEVAC tasking process. Specifically, these studies have helped to identify a sub-group of critically injured patients who benefit from early, sophisticated clinical care.

Such analyses have important implications for civilian systems, not only the clinical aspect but also the organizational component and rigorous performance improvement. The military experience from Afghanistan would suggest that, in the setting of extended prehospital timelines, a higher clinical capability en route improves outcome in critical casualties. However, for this to be effective, the tasking component has to be able to rapidly make a determination as to the clinical needs of the patient, factoring in important nonclinical, system-specific components.

Early data from analysis of the intratheatre interfacility tactical transfer of critical care patients have demonstrated a similar survival advantage for the more seriously injured casualties with an advanced care provider in attendance (Fig. 5). These data support the investment that the US has made in fielding this tactical critical care capability. It is noteworthy that the US Air Force aeromedical evacuation system was transformed in the decade prior to the wars in Afghanistan and Iraq by the development of the Critical Care Aeromedical Transfer Team (CCATT). This capability was developed to provide a more robust and extended capability in support of the global evacuation mission [13,14▪].

TRANSFER OF SYSTEM LESSONS LEARNED TO CIVILIAN PRACTICE

The paradigm shift in this practice evolution was led away from the notion of time to location in favour of the concept of time to capability. In that paradigm, greater emphasis has been placed on delivery of the right care to the right patient at the right time as opposed to the singular principle of delivery of the patient to a location. Adaption of lessons learned in the development and maturation of the military trauma system that supports the International Security Assistance Force (ISAF) operation has particular relevance to civilian settings with vast and austere rural locations.

These are the settings wherein the impact of distance and geography on evacuation times may be mitigated by earlier delivery of life-saving care and resuscitation to the patient. Although the concept of advanced prehospital care is familiar to European trauma systems, it is relatively underdeveloped in the US [15–18]. Cross-fertilization of military concepts to civilian practice is already underway, for example, the US military fields prehospital medical care in South Texas area P, a region with similar geography to Afghanistan (Fig. 6) [19▪▪].

Expanded assimilation of these practices into areas such as the rural US could provide the same

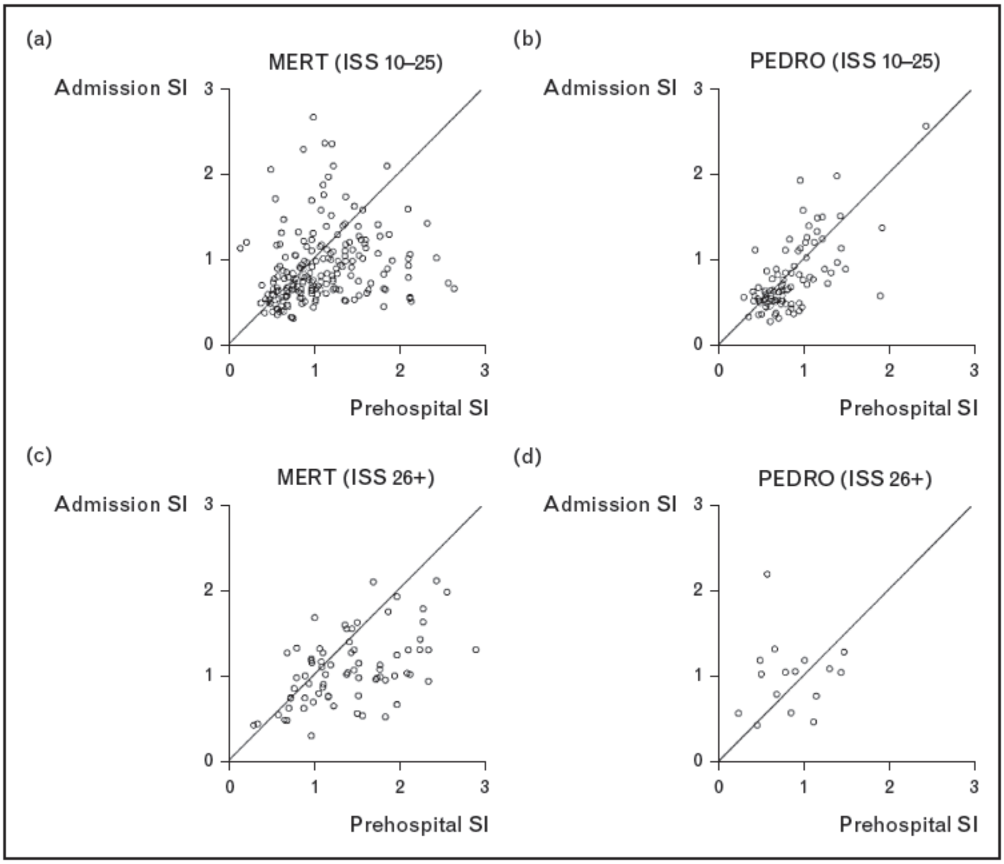


FIGURE 4. Scatter graphs of prehospital SI plotted against admission shock index for MERT and PEDRO platforms for two ISS groupings. The diagonal line is the line of no change, with points plotted below indicating an improvement in haemodynamic stability. (a) MERT, ISS 10 25, $P<0.001$; (b) PEDRO, ISS 10 25, $P=0.013$; (c) MERT, ISS 26+, $P=0.001$; (d) PEDRO, ISS 26+, $P=0.440$. Adapted from [12▪].

potential survival advantage to severely injured, but survivable, patients. Prepositioning or predesignation of 'forward' civilian facilities in which damage control surgery could be projected could provide a means for earlier life-saving surgical intervention in patients unlikely to survive a prolonged evacuation, such as those with survivable, but significant, uncontrolled torso haemorrhage. In order to provide meaningful assessment and refinements to such a system, important clinical information must be aggregated into a population registry. As such, documentation, registration and concurrent data analysis will provide the civilian-relevant engine for advancements in 'forward' trauma care that may be realized in improved patient outcomes.

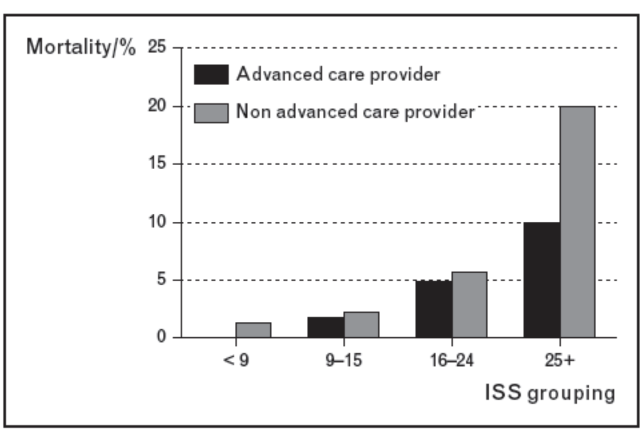
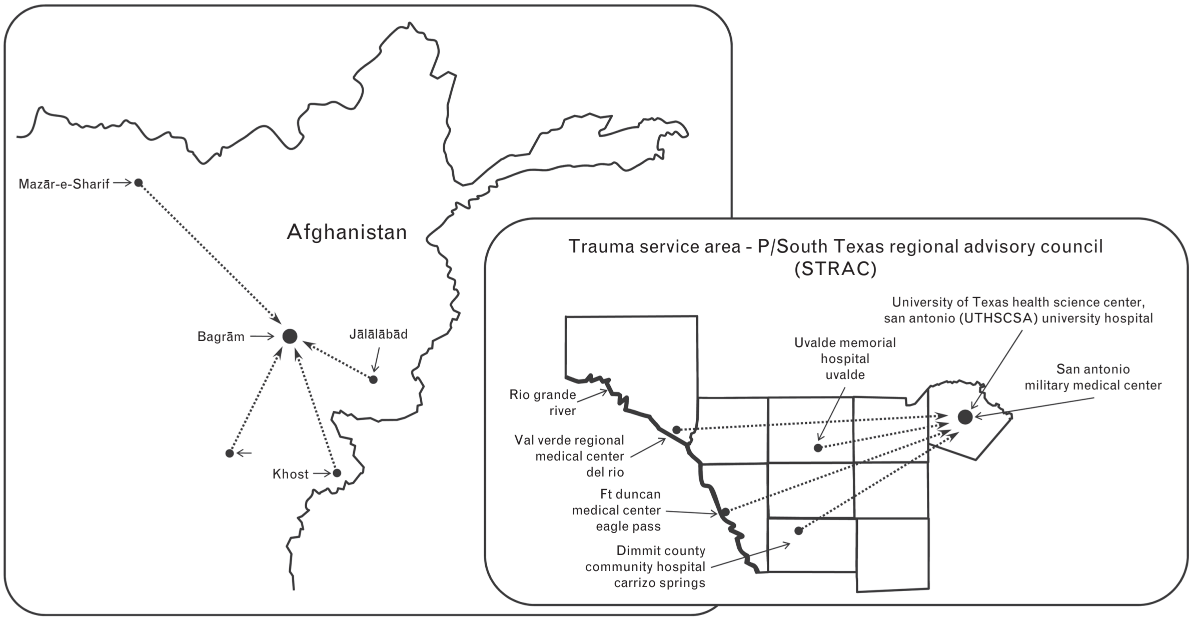


FIGURE 5. Trend toward survival with unadjusted mortality rate comparison between advanced and nonadvanced care providers per ISS grouping; $n=778$. Source: Joint Trauma System.

CONCLUSION

The trauma system in Afghanistan has evolved from primitive beginnings into a mature inclusive trauma system, driven by comprehensive registry outcomes data. This has enabled the challenges of a dispersed and austere battle space to be met with the delivery of forward damage control resuscitation by scalable clinical assets, reducing the time to capability and improving outcome. Transfer of this development from military to civilian trauma systems would provide an enduring benefit to the injured from lessons learned in war.

Military-civilian translation pre-hospital trauma research: "The del rio model 2013"



Distance comparison

Afghanistan					Texas				
Mazār-e Sharif	to	Bagrām	<=	170 miles	Del Rio	to	San Antonio	=	150 miles
Khost	to	Bagrām	<=	120 miles	Eagle Pass	to	San Antonio	=	125 miles
Ghazni	to	Bagrām	<=	90 miles	Carrizo	to	San Antonio	=	90 miles
Jālālābād	to	Bagrām	<=	75 miles	Uvalde	to	San Antonio	=	80 miles

FIGURE 6. A geographical comparison of South Texas Area P compared with Afghanistan and the similar distance between medical facilities. Source: South Texas Regional Advisory Council.

Acknowledgements

We are grateful to the US JTS for providing data for figures.

Conflicts of interest

There are no conflicts of interest.

No funding has been received for this work.

The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense.

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