
Robert Russell,1 N Hunt, 2 R Delaney 3

ABSTRACT

Introduction Review of adverse outcomes is an essential element of healthcare governance. For each operational death, the post-mortem is attended by a member of Academic Department of Military Emergency Medicine and the case is assessed by a Mortality Peer Review Panel comprised of Defence Professors and other clinical and technical experts.

Methods A search was conducted of the Joint Theatre Trauma Registry (JTR) for all UK military death reviews held from January 2002 to November 2013 and the judgement made by the Mortality Peer Review panel. Cases are awarded a ‘salvageability’ rating between S1 (salvageable) and S4 (not salvageable). Cases graded S1–3 are then assessed further for tactical, clinical or equipment factors that affected the outcome.

Results There were 621 deaths recorded on the JTTR and 517 (83.3%) were due to hostile action. The Killed in Action to Died of Wounds ratio is 6.28 : 1. Explosive mechanisms of injury were responsible for 55.65% of combat deaths and penetrating mechanisms 28.71%. An average of 10.56 injuries was recorded per casualty and the mean number of body regions affected was 3.34. The Peer Review Panel decided that 91.1% cases were not salvageable (S4); this figure is 93.9% if the deaths due to hostile action are considered separately.

Conclusions The severity of modern military trauma is overwhelming in nature and, along with trauma scoring systems, clinical peer review is an essential part of healthcare governance. The process also helps inform and direct research within clinical and force protection fields.

INTRODUCTION

Healthcare Governance is a central function within the Defence Medical Services (DMS). Assuring optimal performance of the DMS operational trauma system is an important contribution to the moral effect for troops, families and the public. In the assessment of the performance of any trauma system, a review of adverse outcomes is essential. The UK Joint Theatre Trauma Registry (JTR), maintained by the Academic Department of Military Emergency Medicine (ADMEM) at the Royal Centre for Defence Medicine (RCDM) and Defence Statistics (Health), is a prospective trauma database that collects information on all casualties admitted to UK deployed military hospitals as the result of a trauma call or who are evacuated back to the ‘Role 4’ base hospital at Queen Elizabeth Hospital, Birmingham, as a result of trauma. Consequentially, JTTR holds data on all UK military deaths resulting from operations and exercises abroad. Details are collected from clinical notes, post-mortem reports and incident reports and a member of ADMEM attends all military post-mortems to prevent the loss of potentially important medical intelligence and provides appropriate feedback to the theatre of operations as soon as possible via the Defence Professor Emergency Medicine. This clinical presence also ensures that the military and medical contexts can be clarified to the pathologists and other experts present to monitor personal and vehicle protective equipment effectiveness.

In addition to the initial evaluation, the Military Mortality Peer Review Panel meets two or three times a year to provide senior multidisciplinary review of deaths in the intervening periods. The Panel (Box 1) first met in late 2006 and reported in 2008 on 12 months from 1 April 2006 and is currently convened and chaired by the Defence Professor Emergency Medicine. This paper describes the patterns of UK Service deaths and results from the panel meetings.

Key messages

▸ All UK military deaths on operations are reviewed by a multidisciplinary panel.
▸ 55.65% were due to blast and 28.71% due to gunshot wounds.
▸ 91.1% were judged not salvage-able by the panel.

Box 1 Members of the Military Mortality Peer Review Panel

▸ Defence Professor of Anaesthetics and Critical Care
▸ Defence Professor of Surgery
▸ Defence Professor of Orthopaedics and Trauma
▸ Home Office Pathologists
▸ Senior Scientist, Dstl Porton Down
▸ Senior Consultant Critical Care, Queen Elizabeth Hospital Birmingham
▸ Senior Nursing Officer RCDM, Queen Elizabeth Hospital Birmingham
▸ Representative from Inspector General DMS

DMS, Defence Medical Services; Dstl, Defence Science and Technology Laboratories; RCDM, Royal Centre for Defence Medicine.
METHODS
A search was conducted of JTTR for all UK military deaths from January 2002 to November 2013 and the judgment made by the Mortality Peer Review panel. The panel reviews each case using a description of the mechanism of injury, evacuation timelines, injuries sustained and procedures undergone at each location. A summary including trauma scoring results is given for each case and the clinical notes, post-mortem reports and incident details are also available.

Salvageability is determined first in each case (Box 2); if a case is rated as non-survivable (S4) then further analysis is not recorded but if there are lessons identified, they are flagged up in the relevant channels. However, in other cases, discussion as to the factors affecting survival takes place. These factors are grouped into Tactical, Equipment and Clinical categories and a brief description of each factor and its impact is recorded if appropriate. This latter process replaced a further rating, which was given as to preventability until 2010 as it allowed more detail to be recorded and similar cases grouped together if necessary.

For cases reported in this paper prior to the start of the review panel process in 2006, an initial sifting process of all deaths from 2002 was undertaken by the Defence Professor Emergency Medicine. Cases that were clearly S4 (eg. decapitation, whole body disruption) were recorded on JTTR as such and only those in which salvage was thought possible or where there was doubt as to the grading were brought to the panel.

RESULTS
JTTR holds the records of 621 deaths dating from 2002. The Army accounted for 500 (80.5%), Royal Marines 70 (11.3%), Royal Air Force 43 (6.9%) and Royal Navy 8 (1.3%); 611/621 (98.4%) were male personnel. The age range was 18–80 years with a mean of 26.7 years. The definitions and distributions of casualty categories are shown in Figure 1 and Box 3. The ratio of killed to died overall was 6.48:1, but if hostile action (HA) only is included, the ratio is 6.28:1.

Cases are shown by year and theatre of operation and then by Operation and rolement (Table 1). The mechanisms of injury for the 620 cases for which it has been determined at the time of writing are demonstrated in Figure 2. Explosive mechanisms produced 345 (55.65%) and penetrating 178 (28.71%).

Box 2 Definitions of salvageability

**Salvageability:** ‘If these injuries had occurred 5 minutes from a Major Trauma Centre what is the likelihood that surgical intervention would be attempted for given injuries and the predicted influence on survival’:

- **S1: Salvageable:** intervention would likely have influenced survival (probability of survival >95%).
- **S2: Potentially salvageable:** intervention would have been attempted and may have influenced survival (probability of survival 5%–95%).
- **S3: Possibly salvageable:** intervention would have been attempted but with a high probability of mortality (probability of death >95%).
- **S4: Non-salvageable:** intervention would not have led to survival.

Box 3 Casualty category definitions

- **KIA (Killed in Action):** personnel killed instantly or dying before reaching a UK or a coalition ally medical treatment facility as a result of hostile action.
- **DOW (Died of Wounds):** personnel who die as a result of injuries inflicted by hostile action after reaching a UK or coalition ally medical treatment facility.
- **KNEA (Killed by Non-Enemy Action):** personnel killed instantly or before reaching a UK or a coalition ally medical treatment facility as a result of non-hostile activity.
- **DNEA (Died from Non-Enemy Action):** personnel who die as a result of injuries caused by non-hostile activity after reaching a UK or coalition ally medical treatment facility.

Injury scoring

Injury Severity Scores (ISS)\(^9\) ranged between 4 and 75 with a median score of 75 and an IQR of 57–75; 21 did not have a score recorded. Three cases had an ISS below 15, 164 were in the range 16–59 and 454 had a score of 60–75, which has been defined as ‘un-survivable trauma’. The New Injury Severity Score\(^{10}\) showed similar results but with an IQR of 75–75.

The Triage Revised Injury Severity Score (TRISS)\(^{11}\) and A Severity Characterisation of Trauma (ASCOT)\(^{12}\) values could be calculated for 559 deaths as physiological data were missing in the other 62 cases. For TRISS, eight had a probability of survival >50%, this being the cut-off between ‘expected’ and ‘unexpected deaths’ whereas ASCOT, which uses a calculated <50% percentage chance of death as a similar cut-off, had 16 in this category.

The total number of recorded injuries ranged from 1 to 57 with an average of 10.56 per casualty. The Abbreviated Injury Scale (AIS)\(^{13}\) body regions injured per casualty ranged between 1 and 9 (all) with the mean number of regions injured being 3.34 and the median 3 (IQR 2–5) (Table 2 and Figure 3).

Salvageability

Overall, 617 cases had a recorded salvageability judgement by the Peer Review Panel (Table 3), two cases are awaiting consideration and two cases do not have enough information on injuries.

Figure 1 Casualty category distributions. DNEA, died from non-enemy action; DOW, died of wounds; HA, hostile action; KIA, killed in action; KNEA, killed by non-enemy action; NHA, non-hostile action.
and medical treatment to form a considered opinion and both occurred outside the usual UK DMS medical chain.

One of the three ‘definitely salvageable’ casualties died as tactical issues prevented medical aid reaching him. In both the other cases, treatment issues were thought to play a part (poor application of tourniquets, failure to call a trauma team, possible over-administration of opiates and poor handling of massive transfusion and hypothermia). The factors affecting the S2 cases were tactical in nine, military equipment in one and treatment in four (tourniquet application, incorrect drain site and development of complications). In one S3 case, a single aspect of treatment (tourniquet application) could have been improved but it would be unlikely to have produced a different outcome. In total, 24 cases were affected by tactical considerations and in the remaining 10 it was considered that everything possible had been done and that while survival was possible, it would be extremely unlikely in even the best circumstances (percentage chance of survival < 5%).

**DISCUSSION**

The Peer Review Panel is an important part of providing assurance to the Chain of Command that the DMS Trauma system is functioning optimally and that Healthcare Governance of the system is in place in that continuous adjustments and improvements are made. As well as immediate feedback to theatre following a post-mortem, comments are passed to clinicians through the Deployed Medical Director (DMD) and at the weekly Joint Theatre Clinical Conference. Feedback can also be passed from the DMD to the Medical Regiment and thus to the Combat Medical Technicians who dealt with the casualty at the point of wounding. This also allows everyone involved in a casualty’s care the opportunity to raise questions and receive answers about what happened. Where there has been deviation from standardised procedures, explanations are sought that may result in identification of a training gap and appropriate measures taken.

### Table 1  Cases by year, theatre, Operation and roulement

<table>
<thead>
<tr>
<th>Year</th>
<th>Iraq</th>
<th>Afghanistan</th>
<th>Other</th>
<th>Total</th>
</tr>
</thead>
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<td>3</td>
<td>3</td>
<td></td>
<td>6</td>
</tr>
<tr>
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<td>1</td>
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<tr>
<td>2006</td>
<td>29</td>
<td>39</td>
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<td>69</td>
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<tr>
<td>2007</td>
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<td>42</td>
<td></td>
<td>89</td>
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<tr>
<td>2008</td>
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<td>2010</td>
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<td>2011</td>
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<tr>
<td>2012</td>
<td>42</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>2013 (to November)</td>
<td>8</td>
<td>1</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>174</td>
<td>444 (71.50%)</td>
<td>3 (&lt;0.01)%</td>
<td>621</td>
</tr>
</tbody>
</table>

### Table 2  Number of injuries by body region and Anatomic Injury Scores (AIS)

<table>
<thead>
<tr>
<th>Body region</th>
<th>Number of cases with highest AIS in region</th>
<th>Number of cases with injury in region</th>
<th>Maximum (mean) number of injuries</th>
<th>Number of cases with a maximum given AIS in each region</th>
</tr>
</thead>
</table>
|                       | 249                                        | 321                                  | 18 (3.32)                       | AIS 6 (Fatal) 220 14 19 0 2 4  
|                       | 2                                           | 208                                  | 8 (1.94)                        | AIS 5 (Critical) 0 18 14 10 86 80  
|                       | 43                                          | 155                                  | 7 (2.03)                        | AIS 4 (Severe) 22 58 18 3 37 6  
|                       | 18                                          | 179                                  | 11 (1.98)                       | AIS 3 (Serious) 47 21 13 14 85 0  
|                       | 99                                          | 273                                  | 19 (3.78)                       | AIS 2 (Moderate) 108 58 91 62 22 7  
|                       | 39                                          | 342                                  | 15 (3.97)                       | AIS 1 (Minor) 14 76 86 45 47 11  
| Upper extremity       | 3                                           | 242                                  | 12 (2.13)                       |  
| Pelvis and legs       | 53                                          | 348                                  | 12 (3.55)                       |  
| External              | 27                                          | 75                                   | 5 (1.22)                        |  

**Figure 2**  Mechanism of injury.
Further benefits derived from the in-depth review of military operational mortality have been the increased linkages between clinical personnel and those working for other Defence agencies. The review has been used to determine emerging injuries and treatment patterns, determine potential areas of clinical research and inform the on-going development of personal and vehicular protective systems and equipment.

There is a potential overlap in the definitions of Killed in Action (KIA) and Died of Wounds (DOW) that are duplicated for Killed by Non-Enemy Action and Died from Non-Enemy Action. Depending on circumstances, a casualty who arrives at hospital in cardiac arrest may receive blood and undergo surgery before resuscitation attempts are ceased and death pronounced. The convention that has been applied in these cases is that if there have been any signs of life at any time after arrival at the hospital then DOW is used, otherwise KIA is the designation. There are 32 cases who received blood in the emergency department and/or theatre but as they did not regain a cardiac output at any stage, are still classified as KIA. In one case, nine units of packed red blood cells and five units of fresh frozen plasma were given. This case and 28 others were S4 when reviewed. The two S2 and five S3 cases all had prolonged evacuation periods as a result of tactical issues. The S4 cases potentially represent failure to recognise futility. In the resource-rich environment of Bastion Role 3, this may not have further ramifications if there are no other casualties requiring immediate treatment. However, as the Armed Forces move to contingency operations, resources will be much more limited. While the final decision to stop resuscitative efforts should always rest with the clinicians at the trolley-side, a further study of these cases will be undertaken to determine if lessons can be drawn and if there is any potential for ‘rules of thumb’ to be developed.

Comparison with the experience of American Forces described by Eastridge et al is interesting but no firm conclusions can be drawn as there has been no cross-review or communication on this subject between the reviewers and parameters may have differed. The KIA to DOW ratios of HA casualties are very similar (UK 6.28 vs US 6.87) but the UK review panel rated 93.5% (416 cases) of HA casualties non-salvageable compared with the US figure of 75.7% rated non-survivable. There are many potential explanations for this difference not least a different application of the cut-off between KIA and DOW as described above. The KIA to DOW ratio has in the past been suggested as a measurement of trauma system performance but ‘inevitable’ deaths surviving to reach hospital before dying make it a poorer tool than identifying unexpected outcomes.8

The results of this paper point to the overwhelming severity and nature of military trauma described in other studies14 15 especially given the proportion of injuries caused by improvised explosive devices. Data from the Vietnam War and previous modern conflicts showed a preponderance of single life-threatening injuries.16 In the battlefield environment, any AIS score 4 or greater is potentially fatal.17 In this study, 371 cases had AIS 4+ injuries to more than one body region, the highest being six regions, and 80 had AIS 6 injuries to two or more regions (highest 4). Of those killed by an AIS 4+ injury to a single body region, the head (72 cases) and thorax (46) were most often involved.

A further finding is the necessity to apply a clinical dimension to the review process as well as using the different trauma scoring methods especially when considering individual cases. As was observed when analysing survivors over 18 months between 2006 and 2008,4 there is not necessarily agreement between the methods themselves or between them and experienced clinical opinion. In total, 17 cases were identified by ASCOT and/or TRISS as ‘expected survivors’ (one TRISS only, eight ASCOT only and eight by both). Of these, clinical review

![Figure 3](image)

**Figure 3** Distribution of number of Abbreviated Injury Scale body regions injured.

<table>
<thead>
<tr>
<th>Year</th>
<th>S1 Definite</th>
<th>S2 Potential (&gt;-5%, &lt;95%)</th>
<th>S3 Possible (&lt;5%)</th>
<th>S4 (Not salvageable)</th>
<th>Outstanding/not rated</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2002</td>
<td>–</td>
<td>–</td>
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<tr>
<td>2003</td>
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<td>2008</td>
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<td>2009</td>
<td>1</td>
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<td>14</td>
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<tr>
<td>2011</td>
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<td>2</td>
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<td>–</td>
<td>7</td>
<td>2</td>
<td>9</td>
</tr>
<tr>
<td>Total</td>
<td>3 (0.5%)</td>
<td>13 (2.1%)</td>
<td>35 (5.6%)</td>
<td>556 (91.1%)</td>
<td>4 (0.6%)</td>
<td>621</td>
</tr>
</tbody>
</table>

Summary

The UK military deployed to Afghanistan and Iraq have operated in an environment where the risk of mortality from combat wounds has been high. Effective treatment at the point of injury and immediate evacuation to definitive care have been vital aspects of survival. The US Joint Trauma System evaluates trauma care by the TRISS method, a retrospective model that incorporates the Abbreviated Injury Scale and the Injury Severity Score to calculate the probability of survival to discharge. This is used to identify potential learning points.

In this article, we report on deaths in DMS that were not expected to be survivors (EDS; defined as a probability of survival of less than 0.0001). The study involved 107 casualties who died in the UK Role 4 from 2002 to 2011 and included all 104 members of the joint trauma registry. Mortality Peer Review was conducted, and the impact of unexpected survivors on the death rate was assessed.

Results

The overall death rate was 91.1% for the study period. Operationally, 50% of deaths were classified as unexpected survivors (EDS) and 50% were classified as expected deaths (ED). Three-quarters of the casualties were killed at the point of wounding and were declared KIA or killed in action. The distribution of casualties was as follows: 10 S4, 3 S3, 1 S2, and 2 S1. Three further cases had an ISS of <15 thus not reaching the threshold for ‘major trauma’. Of the 104 DMS members of the joint trauma registry, 91(95%) had attended a mortality meeting, with 83 members (89%) having attended the sub-group meeting for unexpected survivors. The mortality meeting was composed of 9 core members, with 6 having attended all or most mortality meetings.

Conclusion

The use of unexpected survivors and peer review has improved trauma care in the UK Country UK Role 4. Trauma scoring systems are useful tools, clinical peer review is an essential part of the robust healthcare governance process that is in place to identify potential lessons and give feedback.

Competing interests

None.

Provenance and peer review
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REFERENCES

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