UK specialist cardiothoracic management of thoracic injuries in military casualties sustained in the wars in Iraq and Afghanistan†

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Abstract

OBJECTIVES: Outcomes of casualties with thoracic wounding at the deployed UK military field hospital (Role 3(R3)) have been previously described. The level of cardiothoracic specialist input required on repatriation to the UK is less clear. This study aimed to assess the outcomes of casualties with thoracic injuries repatriated to the UK (Role 4 (R4)) and evaluate the impact of specialist cardiothoracic care.

METHODS: Casualties were identified through the UK Joint Theatre Trauma Registry. Casualties coded for pulmonary contusions and/or thoracotomy between March 2006 and March 2011 were identified and case-notes reviewed. Subgroup analysis was performed for patients with a documented thoracic abbreviated injury score ≥3.

RESULTS: One hundred and eighty-two UK patients were admitted to UK R4 coded to have a thoracic injury; overall mortality 4.9%. Ninety-three were classified as a thoracic AIS of ≥3; mortality 6.5%. Sixty-four were coded for pulmonary contusions and/or thoracotomy; mortality 1.6, and 66% had thoracic AIS ≥3. Improvised explosive devices injured 54 and 62% had a penetrating injury. Pulmonary contusions were present in 70%; 43% developed a chest infection. Thoracotomy/sternotomy was performed in 13 casualties in R3; 3 re-explored in R4. Oscillatory ventilation and extracorporeal membrane oxygenation was required in 1 case. Cardiothoracic surgery was involved in managing 39% (n = 24) of cases; 11 (45%) required surgical intervention and 19 (79%) had cardiothoracic outpatient follow-up.

CONCLUSION: Morbidity and mortality associated with significant thoracic injury is low at UK R4. Follow-up is required to assess long-term outcomes. Specialist cardiothoracic support and intervention was required in the management of complex thoracic trauma. Early specialist support at R4 may improve morbidity and outcomes associated with life-threatening thoracic injury.

Keywords: Trauma • Thoracotomy • Wound healing • Surgery • Emergency

INTRODUCTION

Thoracic injury sustained in combat is associated with significant morbidity and mortality. In World War I, mortality following thoracic trauma was 27% [1], and during World War II, this was reduced to 11% [2]. Mortality fell further to 2.9% during the Vietnam war [3]. In the recent conflicts in Iraq and Afghanistan, improvised explosive devices (IEDs) have become the main mechanism of devastating injuries [4, 5].

UK military personnel now wear personal protective equipment including body armour. During the world wars when body armour was not used, penetrating injury to the thorax often resulted in an unsalvageable injury at the point of injury. The improved design of body armour has led to a reduction of unsalvageable thoracic injuries [6]. Therefore, now many combat casualties survive their initial wounding to enter the medical care chain. Ballistic injury without body armour would result in severe thoracic injuries with fatal cardiorespiratory compromise [7]. The current survivable injury pattern can present more complex and challenging thoracic cases to manage due to other associated injuries [8, 9] than had been encountered in previous conflicts. Furthermore, resource utilization and allocation in managing such complex has become pertinent.

A Role 3 (R3) facility is a field hospital with a surgical capability, an intensive care unit (ICU), radiological investigations including computed tomography (CT), laboratory and blood bank facilities. The management of casualties at the point of wounding, the evacuation chain and facilities at R3 field hospitals have changed; in particular, the principles of Damage Control Resuscitation (DCR) [10, 11] and damage control surgery (DCS) as a continuum have been introduced [8, 9, 12]. Damage control philosophy has revolutionized the extent of surgical intervention at field hospitals, and may have an impact on overall long-term survival. Furthermore, early evacuation to specialist centre for definitive...
was intended that this cohort of patients would identify those referenced to the cardiothoracic departmental referral records. It is met by a strategic team based in the UK, involved in the transfer of casualties to the Royal Centre of Defence Medicine in the UK, and admitted to critical care where specialist care management is provided [17].

Studies have reported the early outcome of combative thoracic injury managed at deployed field hospitals [18]. In these facilities, there is no continuous specialist cardiothoracic surgical (CTS) capability and cardiothoracic management is delivered by general surgeons from different sub-speciality backgrounds after focused predeployment training in the management of cardiothoracic injury. The level of cardiothoracic specialist input required for such casualties after the initial surgery is less clear. The aim of this study was to evaluate the outcomes of British casualties with thoracic injuries who have been repatriated from an R3 field hospital setting from Iraq and Afghanistan to a UK-based R4 facility and also examine the impact of specialist cardiothoracic involvement in the management of these patients.

MATERIALS AND METHODS

This study was approved by the Royal Centre for Defence Medicine (RCDM) Academic Unit (RCDM/Res/Audit/1036/12/0146). All patients who sustained a combat-related thoracic injury and who were admitted to the UK R4 medical facility between March 2006 and March 2011 were identified from the UK Joint Theatre Trauma Registry (JTTR) using body region coding. The UK JTTR is a prospective database of casualties who trigger activation of the trauma team at reception to the deployed UK military medical facility [19]. The roles of deployed medical care describe the echelons and capabilities available for treatment as the casualty is evacuated rearward from the front line.

The JTTR was interrogated for data on patient demographics, injury severity, patterns and mechanism of injury, surgical procedure and hospital record numbers. Injury patterns were classified using the abbreviated injury score (AIS), with an AIS of ≥3 in a body region indicating serious injury [20]. The AIS is an anatomic-based, global severity scoring system that classifies injury in a body region on a six-point ordinal scale (1 minor, 2 moderate, 3 serious, 4 severe, 5 critical, 6 maximum) and scored according to the organ involved, i.e. a unilateral lung contusion in <1 lobe is considered an AIS 3 and a hilar vessel rupture is AIS 4. A subgroup analysis using just the JTTR was performed for patients who had a thoracic AIS of ≥3.

Patients coded with pulmonary contusion and/or thoracotomy in the JTTR were identified and patient details were cross-referenced to the cardiothoracic departmental referral records. It was intended that this cohort of patients would identify those casualties that sustained the greatest thoracic injuries, develop the most complications and require specialist support and management. All military personnel referred to the cardiothoracic speciality following combat-related thoracic injury were also included in this analysis. A comprehensive notes review was performed on these patients for data on chest drain management, further procedure post thoracotomy and cardiothoracic specialist input.

RESULTS

Between March 2006 and March 2011, 182 patients were identified to have sustained a thoracic injury and admitted to R4 from JTTR. Median and interquartile ranges (IQR) for age and trauma scores for this cohort are outlined in Table 1. The majority of casualties were from operational duty in Afghanistan (83%) with the remainder from the Iraq conflict. Injury mechanism, type and thoracic abbreviated injury scores are outlined in Tables 2-4 respectively. Within the total cohort, 15 (8.2%) had a thoracotomy prior to arriving at the UK R4.

Thoracic AIS score of 3 and above were recorded on 93 patients, of which 9 had a thoracotomy in R3. Further evaluation of the pattern of injury of these 93 patients showed that 50 were at risk of developing pulmonary contusions. These 50 patients were not captured on our initial JTTR review.

Of the 182 patients coded for thoracic injury and admitted to the UK R4 facility, 64 patients were coded for pulmonary contusions and/or thoracotomy between March 2006 and March 2011.

**Table 1:** Injury scores for patients in the JTTR database and contusions cohort with thoracic injury

<table>
<thead>
<tr>
<th></th>
<th>JTTR (median, IQR)</th>
<th>Contusion cohort (median, IQR) n = 64</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age</td>
<td>24 (21–28)</td>
<td>24 (6–30)</td>
</tr>
<tr>
<td>ISS</td>
<td>18.5 (10–33)</td>
<td>29 (22–49.5)</td>
</tr>
<tr>
<td>NISS</td>
<td>24 (12–24)</td>
<td>29 (22–49.5)</td>
</tr>
<tr>
<td>TRISS</td>
<td>98.34 (95.44–99.07)</td>
<td>7.84 (7.75–7.84)</td>
</tr>
<tr>
<td>RTS</td>
<td>7.84 (7.75–7.84)</td>
<td>7.85 (7.75–7.88)</td>
</tr>
</tbody>
</table>

ISS: Injury Severity Score; NISS: New Injury Severity Score; TRISS: Trauma and Injury Severity Score; RTS: Revised Trauma Score; JTTR: Joint Theatre Trauma Registry.

<table>
<thead>
<tr>
<th>Mechanism</th>
<th>JTRR number (n = 182)</th>
<th>Contusions cohort (n = 64)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aircraft incident</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Explosive—Grenade</td>
<td>6</td>
<td>1</td>
</tr>
<tr>
<td>Explosive—IED</td>
<td>83</td>
<td>35</td>
</tr>
<tr>
<td>Explosive—Mortar</td>
<td>11</td>
<td>5</td>
</tr>
<tr>
<td>Explosive—Rocket</td>
<td>4</td>
<td>3</td>
</tr>
<tr>
<td>Explosive—RPG</td>
<td>19</td>
<td>19</td>
</tr>
<tr>
<td>Explosive—mine strike</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GSW</td>
<td>49</td>
<td>19</td>
</tr>
</tbody>
</table>

IED: Improvised explosive device; RPG: Rocket propelled grenade; GSW: Gunshot wound; JTTR: Joint Theatre Trauma Registry.
Infections requiring antibiotics. Of these 45 patients, 19 (43%) developed chest injuries. Findings included blast lung injury associated with pulmonary thrombosis and oedema, pulmonary lacerations and associated pulmonary and cardiac contusions. CTS speciality was consulted on the right, left and bilaterally on 16, 15 and 14 patients, respectively. Of the 64 patients coded for pulmonary contusions or thoracotomy, 1 patient, who had a gunshot wound (GSW) to the chest with associated pulmonary lacerations and contusions.

**Table 3: Type of injury**

<table>
<thead>
<tr>
<th>Type</th>
<th>JTTR number (n = 182)</th>
<th>Contusions cohort (n = 64)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blunt</td>
<td>14</td>
<td>8</td>
</tr>
<tr>
<td>Mixed</td>
<td>36</td>
<td>13</td>
</tr>
<tr>
<td>Other</td>
<td>13</td>
<td>2</td>
</tr>
<tr>
<td>Penetrating</td>
<td>118</td>
<td>41</td>
</tr>
<tr>
<td>Thermal</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

JTTR: Joint Theatre Trauma Registry.

**Table 4: Associated severe injury in other body regions in patients with a thorax AIS of ≥3**

<table>
<thead>
<tr>
<th>Thorax AIS</th>
<th>No association injury AIS of ≥3 in other region</th>
<th>With an association injury AIS of ≥3 in 1 other region</th>
<th>With an association injury AIS of ≥3 in 2 other regions</th>
<th>With an association injury AIS of ≥3 in 3 other regions</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 (n = 45)</td>
<td>21 (46.7%)</td>
<td>17 (37.8%)</td>
<td>6 (13.3%)</td>
<td>1 (2.2%)</td>
</tr>
<tr>
<td>4 (n = 31)</td>
<td>15 (48.4%)</td>
<td>10 (32.3%)</td>
<td>4 (12.9%)</td>
<td>3 (9.7%)</td>
</tr>
<tr>
<td>5 (n = 13)</td>
<td>8 (61.5%)</td>
<td>1 (7.7%)</td>
<td>2 (15.4%)</td>
<td></td>
</tr>
<tr>
<td>6 (n = 4)</td>
<td>1 (25%)</td>
<td></td>
<td></td>
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</tbody>
</table>

AIS: abbreviated injury scale.

**Table 5: Indication for primary (Role 3) thoracic surgery**

<table>
<thead>
<tr>
<th>Indication</th>
<th>Surgical approach</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bleeding</td>
<td>Right thoracotomy</td>
<td>1</td>
</tr>
<tr>
<td>Haemothorax</td>
<td>Right thoracotomy</td>
<td>1</td>
</tr>
<tr>
<td>Circulatory arrest</td>
<td>Left thoracotomy</td>
<td>3</td>
</tr>
<tr>
<td>Cross-clamp descending thoracic aorta</td>
<td>Left thoracotomy</td>
<td>1</td>
</tr>
<tr>
<td>Subclavian artery repair</td>
<td>Left thoracotomy</td>
<td>1</td>
</tr>
<tr>
<td>Circulatory arrest ± cross-clamp</td>
<td>Bilateral thoracotomy</td>
<td>3</td>
</tr>
<tr>
<td>Descending thoracic aorta</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lung resection</td>
<td>Bilateral thoracotomy</td>
<td>1</td>
</tr>
<tr>
<td>Shrapnel/fragment removal</td>
<td>Median sternotomy</td>
<td>1</td>
</tr>
<tr>
<td>Pericardial effusion</td>
<td>Median sternotomy</td>
<td>2</td>
</tr>
</tbody>
</table>

Injury mechanism, type and AIS are listed in Tables 2–4 respectively. All casualties were male and 56 (87.5%) were admitted to ICU on arrival to R4. Median (IQR) ICU and ward stay were 8.5 days (3.75–18) and 12 days (6–30), respectively. Of the patients admitted to ICU, 6 (9.4%) were readmitted following discharge to the ward. All casualties were admitted to R4 within a median of 1 day (IQR 1–2), from day of injury. Mortality among this cohort of casualties was 1.6% (n = 1/64). Of these 64 patients, 66% had a thoracic injury score of ≥3.

Pulmonary contusions were initially diagnosed in 45 patients (70%). 6 by chest radiograph and 39 via CT. Contusions were identified on the right, left and bilaterally on 16, 15 and 14 patients, respectively. Of these 45 patients, 19 (43%) developed chest infections requiring antibiotics.

**Mortality**

Overall mortality for those with a thoracic injury repatriated to the UK R4 was 4.9% (n = 9/182), and 6.5% for those with a thoracic AIS of ≥3. There were 6 fatalities in the cohort with a thoracic AIS of ≥3 (n = 6/93): 1 death on Day 0, 3 on Day 1 and 1 on Days 15 and 16 from admission to the UK R4. Of these deaths, 1 patient was known to the cardiothoracic speciality. Post-mortem findings on these patients listed multi-organ failure or hypoxic brain injury as the primary cause of death. However, 5 of the 6 within this cohort had related thoracic injuries. Findings included blast lung injury associated with pulmonary oedema, pulmonary lacerations and associated pulmonary and cardiac contusions. CTS speciality was consulted on the right, left and bilaterally on 16, 15 and 14 patients, respectively. Of these 64 patients, 19 (43%) developed chest infections requiring antibiotics.

**Thoracotomy**

A thoracotomy or sternotomy was performed on 13 (20%) casualties, all initially performed in R3. One sternotomy was performed in Germany (a R4 facility). Indication and site of approach are outlined in Table 5. Of these 14 procedures performed before UK R4, 3 (21.4%) casualties had further procedures in R4. Two thoracotomies were re-explored: bilateral thoracotomy for retrieval of intrathoracic swab known to have been present at R3 and left thoracotomy for left carotid to subclavian vein graft. A redo median sternotomy was performed to locate shrapnel and evacuate a pericardial collection. No patients had a sternotomy or thoracotomy performed for the first time in UK R4.

**Chest drain management**

Chest drains were inserted in 42 (66%) casualties for haemothorax and pneumothorax in equal proportions. Forty-one were initially inserted in prehospital or R3 on the day of injury and 1 in R4, 5 days postadmission. Chest drains were inserted on the right, left and bilaterally in 15, 13 and 13 cases, respectively. The site of insertion was unclear in 1 patient. Rib fractures were diagnosed radiologically in 20 (47%) patients.

Among the 42 patients with existing chest drains, 13 casualties required subsequent drain reinsertions; 11 inserted in R4, of which 7 were performed by the cardiothoracic speciality and 4 by the intensive care teams. Five casualties had persistent pneumothoraces and 3 had persistent haemothoraces or effusions following chest drain insertion in R3, which required subsequent chest drains in R4 and a further 3 had new drains inserted postsurgical re-exploration.

Complete new chest drain was inserted in R4 to manage pneumothorax and haemothorax in 6 patients. The remaining patients were managed conservatively with serial chest radiographs and/or CT scans for further progress assessment.

**Cardiothoracic specialist input**

Of the 64 patients coded for pulmonary contusions or thoracotomy, cardiothoracic surgery department was referred 24 (39%) of 1 patient, who had a gunshot wound (GSW) to the chest with associated pulmonary lacerations and contusions.
cases, of which 17 were seen on the day of admission to R4. An initial review was performed by a consultant in 38% of these cases and management of in-patient care was entirely consultant-led. Of these 24, 11 patients required surgical intervention, with involvement from associated specialties such as vascular and plastic surgery (Table 6). Outpatient follow-up by cardiothoracic surgery was arranged for 19 of the patients.

Extensive respiratory support with an oscillatory mode was required for one casualty. This patient continued to deteriorate and required extracorporeal membrane oxygenation support (ECMO); however, he died 15 days following admission to R4 due to worsening clinical status despite maximum support. Post-mortem examination confirmed contusions to the left upper lobe and GSW to the right perforating two lobes and changes consistent with a combination of adult respiratory distress syndrome, bronchial pneumonia and pulmonary contusions.

**DISCUSSION**

This is the first study to evaluate the management of UK casualties with thoracic injuries in an NHS (R4) setting and assess the role of specialist CT support. In the recent wars in Iraq and Afghanistan, repatriation of injured casualties to their home country for definitive medical care has been the norm. Air transfer to R4 was arranged expeditiously after optimization with initial DCR and DCS. The outcomes of these patients once repatriated are uncertain. It is important to assess the outcomes of patients who were cared for at the now RCDM and how to optimally manage their ongoing care as part of a continuous quality performance improvement (QPIS) strategy. This study was designed to complete the end-to-end analysis of thoracic wounding from the recent conflicts with the resources and level of CT specialist input available at R4.

Over the 5-year period since March 2006, the JTTR recognized 182 UK casualties with thoracic injuries, with the majority of casualties from Afghanistan. The mechanism of injury in 73% was explosive in origin, with 45% maimed by IEDs and 27% sustaining a GSW injury. The use of IEDs had been a signature warfare tool in the recent wars of Iraq and Afghanistan. However, a significant number (65%) of patients also sustained a penetrating thoracic injury. This pattern of injury is also reflected within the cohort of patients with pulmonary contusions and/or thoracotomy (n = 64) evaluated in detail in this study (Tables 2 and 3).

From the JTTR, 51% of patients had a thoracic AIS of ≥3, which is considered to be a serious thoracic injury and therefore at risk of developing pulmonary contusions. However, only 64 patients were coded for this injury. This reflects the potential of undercoding in JTTR by the trauma nurse coordinators when assessing and coding initial confirmed injuries. Hence, retrospective analysis of the registry could underestimate the burden of chest injury. Of the 64 patients coded for pulmonary contusions or thoracotomy, 88% needed ICU admission on arrival to R4 and required a prolonged intensive care stay. The readmission rate of these patients was high at 9.4%. This emphasizes the importance of clinicians to understand pulmonary injuries, which are common, and should require greater attention at R4 during the chain of recovery.

ECMO was available and had been used in one patient within the cohort coded for pulmonary contusions (n = 64). Although the mortality within this cohort is low (1.6%), of the total 182 patients admitted to R4, overall mortality was 4.9%, 6 deaths within the group identified as a thoracic AIS of ≥3 and had a high clinical risk of pulmonary contusions (n = 50). Of these 6, 5 had thoracic related injuries and did not have cardiothoracic speciality consult. Post-mortem examination confirmed multi-organ failure and hypoxic brain injury as associated causes of death; however, they had significant associated thoracic injuries. The thoracic injury may certainly not be the underlying precipitating cause of their deaths, rather the overwhelming complexity and severity of the other associated injuries. However, it is prudent not to overlook associated thoracic injury despite other devastating injury and establish a multidisciplinary and specialist approach with CTS consult, in the management of these complex patients to optimize management and avoid a likely decline within a particular physiological system. The nature of injuries and cause of death of those patients with a thoracic AIS of <3 was beyond the scope of this study, and therefore, we cannot comment any further on the differences seen between the groups.

Pulmonary contusions were confirmed radiologically and treated for in 70% of patients within the cohort coded for this. Of these patients, 43% developed chest infections. Incidence of pneumonia following trauma may vary from 2 to 33% [21, 22]. Furthermore, the risk of pneumonia following trauma is further complicated by the risk of ventilator-associated pneumonia [23], with the risk of pneumonia directly proportional to the length of ventilatory support [21, 24]. Moreover, patients who have sustained injuries in the frontline, particularly through IED blasts, are at an increased risk of contamination with rare and resistant bacterial species, i.e. *Acinetobacter*. The median injury severity score within this cohort was high at 24. It is known that severe pulmonary contusions are associated with high injuries scores and this in turn increases the risk of complications, adult respiratory distress and infections. Therefore, the combination of these high-risk factors associated with this cohort of patients may explain the high incidence of chest infections observed in this study.

Thoracotomy was performed in 8.2% (n = 15) of patients admitted to R4. One patient who had a thoracotomy was not coded as such and hence was not evaluated in detail. Thirteen were performed in R3 as part of the DCR and DCS principles and 1 was performed in R4 (Germany). On arrival to R4, 14 of the 15 patients had specialist cardiothoracic input regarding further management and required further procedures in 3 cases. Thoracotomy performed in an R3 setting as part of DCR and DCS is a major undertaking for the clinician and more so for the patient. There were no mortalities within this subgroup and is another reflection of the aggressive early surgical intervention at R3, where DCS has shown to be extremely effective [25]. Cardiothoracic surgeons supervised predeployment training of non-CT surgeons, being deployed on
military operations. This training has been incorporated into DCR and DCS principles, which have facilitated the results reported in this study. This care is then integrated into a trauma system allowing access to CT specialist care within 48 h.

Although the number of repeat surgical interventions was small, these patients required regular specialist management with regard to potential complications. These patients have multiple chest drains in situ and appropriate chest drain management is pivotal in making progress in patients with complex thoracic injuries related to blunt and/or penetrating trauma.

The management of these patients from admission to R4 requires a multidisciplinary team approach, and we feel that specialty support is vital in making a positive direction in treatment. As evident in this study, those with a thoracic AIS of ≥3 have the potential to develop life-threatening complications. Specialist consultant-led cardiothoracic support was provided in the management of 39% of cases within the pulmonary contusions cohort. These patients are at risk of and have the potential to require further surgical intervention and early involvement in these cases may improve outcomes. This study has shown that there is potential for increased consultation with specialist CT advice in these patients. Of 182 patients admitted to R4, 93 cases had a thoracic AIS of ≥3 and cardiothoracic surgery was involved with 24 of these cases. This could be as a result of the geographical limitation imposed prior to June 2011; cardiothoracic surgery and the military ward was split over two sites. After June 2011, all specialties have been located on a single site. As a consequence of this QPIS this need has been identified and required resources defined. This would include overall management of complex thoracic injuries, the daily advice and management of chest drains, fluid resuscitation and critical care support. This, as part of a multidisciplinary team approach, should pay particular attention to the daily management of the complex injured military casualty and the clinical requirements of associated injuries. It is anticipated that this QPIS would also improve concurrent civilian trauma care.

Limitations
Despite the advantage of some data being collected prospectively, this study has the inherent limitation associated with a retrospective review. In some cases, the complete sets of clinical notes were not available for review, and hence, data were extracted from associated online clinical documentation. Coding for clinical conditions remains inaccurate and unreliable. Within the JTTR, 27% of patients that could be coded for a pulmonary contusion on clinical grounds were not. Therefore, extraction of data based purely on coding would be inaccurate. However, this study was looking at only those that were coded for pulmonary contusions and/or thoracotomy. Review of patients with thoracic injury on the JTTR was an additional aspect of this study.

Future work
Although this study provides insight into the outcomes of patients with thoracic injuries admitted to R4, there are yet no data to establish long-term outcomes and in particular cardiorespiratory functional recovery. A study proposal to examine this has been approved. Prospective data collection to this end will shed further insight into the long-term outcome of these severely injured patients. In addition, similar outcomes of patients with injuries to other body regions are lacking. Therefore, further work is required to establish the true end-to-end outcomes of combat-related injuries; individual prospective data collection will assist towards this. Furthermore, the high incidence of chest infections among patients with pulmonary contusions has prompted a dedicated service provided by a military respiratory specialist, and this work may translate into civilian trauma practice.

CONCLUSION
Patients repatriated to their home base facility are associated with low mortality and morbidity. Current coding of these injuries within the JTTR is suboptimal and needs to be addressed in order to better track patients with significant intrathoracic injury. Although the overall extent of intensive care support and length of stay is long, this reflects the complexity of the injuries. Appropriate specialist UK (Role 4) resource utilization is needed to provide the maximum support to those patients with complex battlefield injuries within a multidisciplinary context.

Conflict of interest: none declared.

REFERENCES
APPENDIX. CONFERENCE DISCUSSION

Dr M. Dusmet (London, UK): This is a very nice paper and to most of us this is quite an unusual subject. I found it intensely stimulating and your results are absolutely outstanding.

So my questions are really more to satisfy my curiosity, and I hope the audience’s curiosity, than anything else. I actually trained in general surgery in Switzerland before becoming a thoracic surgeon, and Switzerland has very liberal use of helicopters to evacuate. And yet at every trauma lecture we went to we were always told how the military outperforms us in terms of transit times. I was wondering if you could give us a better idea of what the average evacuation time was from point of injury to R3, do you know that?

Dr Senanayake: I’m afraid I can’t give you a specific answer because we don’t have that data.

Dr Dusmet: Do you know how long the patients actually stayed in R3 on average?

Dr Senanayake: Yes, the median length of stay was one day. So patients were transferred out of R3 into R4 within 48 hours.

Dr Dusmet: And what was the sort of range?

Dr Senanayake: It was 24 to 48 hours.

Dr Dusmet: Okay. Do you have any idea of the time lapse between the time of injury and the time getting to R4?

Dr Senanayake: The time lapse?

Dr Dusmet: Yes. Injury to R4, admission to Birmingham.

Dr Senanayake: It’s usually within 48 hours.

Dr Dusmet: And that includes a 12-hour flight, right?

Dr Senanayake: That’s right.

Dr Dusmet: That is simply amazing. My memory of trauma scores is a little bit rusty, as I’m sure is the case with many others; could you give us an example of what a chest, a thoracic AIS (acute injury score) of 2, 4 and 6 would represent in terms of type of injury, just to refresh our memories.

Dr Senanayake: So 1 is classified as minor, 2 is moderate, 3 is serious.

Dr Dusmet: But what would be a moderate chest injury?

Dr Senanayake: A moderate chest injury is something that is mainly superficial with no external evidence of penetrating injury or a ballistic pattern of injury.

Dr Dusmet: And what would a 4 be, for example?

Dr Senanayake: Anything that’s upward from a rib fracture to a penetrating wound.

Dr Dusmet: And is it something that’s thought to be unsustainable?

Dr Senanayake: Untreatable.

Dr Dusmet: There were two patients that had a thoracotomy to cross-clamp the aorta; did either one of those survive?

Dr Senanayake: Out of those patients, all of them survived. The ones that are not highlighted in my presentation are the ones. Within the overall cohort of 182 patients, there was one patient within that group that we were not aware of but who was transferred to Role 4 and died within 24 hours. And that may not be directly related to the thoracic injuries; as you saw, there are severe injuries related to other body regions. Post mortem examination has confirmed this to be hypoxic brain injury. So we can’t really relate the thoracic injury to their death; however, everyone within that table survived.

Dr Dusmet: And you have a 42% incidence of pneumonia. How many patients had injuries that we would consider significant comorbidities that would predispose to pneumonia, such as quadriplegia? Were there any quadriplegics in your series?

Dr Senanayake: There were no quadriplegics.

Dr Dusmet: Paraplegics?

Dr Senanayake: No.

Dr Dusmet: Major lower limb amputations?

Dr Senanayake: I don’t have that data on me. But what I could say is the pattern of injury that these patients sustain is quite severe and there is severe exposure to a dirty wound and that’s a risk factor by itself. A proportion of these patients spent a lengthy time on an intensive care unit and that exposes them to ventilator-associated pneumonia. Their mobility is reduced. And even though they may not have thoracic injuries that go on to cause pulmonary contusions and infection, the other associated injuries put them in a high-risk category for developing chest infections.

Dr Dusmet: And finally, if I may ask one last question, how do you get penetrating trauma of the chest if you’re wearing body armour?

Dr Senanayake: That is mainly junctional and, as I mentioned at the onset, from axillary, clavicular or from lower down. And if they’re walking and the mine explodes below them, the penetrating injury is from below the body armour. So whereas previously this would injure their chest directly and they wouldn’t survive, due to the junctional pattern of these injuries they do survive.

Dr Dusmet: And has body armour been redesigned because of that?

Dr Senanayake: I think I’m restricted to talking more about body armour due to the military, but progress is always underway within the military.

Dr T. Graham (Birmingham, UK): If you don’t mind, can I clarify a response back to Mr Dusmet in relation to we would call the patient journey.

The military have developed a fantastic system. The MERT helicopter, when it’s called out and lands, has a 2-minute time to collect the casualty from the battlefield and then take off again, because the helicopter becomes a hot target. And one of the tactics, in Afghanistan particularly, is to maim or wound soldiers with the aim of attracting a helicopter in.

And then the other important thing about patient transfer is that in the air travel back from Afghanistan via Germany into the UK, they have a medical team on board, so there is active medical care progressing during that 10- to 12-hour flight. And if the patients deteriorate, as one did, they will put down in Germany and then undertake active surgery.

And the third important thing related to the care of the patients is that there is an MDT approach and we have online access to the military hospital in Afghanistan, and we will often participate in the active management of these patients before they leave the field hospital setting. All these things contribute to a smooth and rapid transfer of the patients through the system.

Dr P. Sardari Nia (Maastricht, Netherlands): This is an excellent study. I think it is also historiographically important that we have this data.

I have a question, also out of curiosity. The registry is from 2006 to 2011. Now we know that the wars began much earlier. Were no data available, or why is the study restricted only to the time frame of 2006 to 2011?

Dr Senanayake: As you see, we identified that although the data is prospectively collected by the military, the robustness of the data is limited. And that’s one of the limitations of this study. So we thought going before 2006 would be limiting it further. As from 2006 onwards, the collection of data has been better, according to the military, and even despite that we have identified limitations.

Dr Sardari Nia: And is there any management difference? Because it would be interesting to see if there is a management difference between the time frame of this study and the previous management of thoracic injuries and to compare them.

Dr Senanayake: I agree. Unfortunately, I can’t comment on that because we don’t have the data prior to 2006.