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Comparing the surgical timelines of military and civilians traumatic lower limb amputations

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HIGHLIGHTS

- There are different population characteristics between civilian and military traumatic amputees.
- There was no significant difference in hospital in-patient length of stay between groups.
- An Orthoplastic approach to this injury group is crucial to optimal management.
- Daily surgical co-ordination prompts optimal operative planning and treatment.
- A weekly multidisciplinary planning meeting optimizes the treatment and timelines for these complex patients.

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ABSTRACT

The care and challenges of injured service have been well documented in the literature from a variety of specialities.

The aim of this study was to analyse the surgical timelines of military and civilian traumatic amputees and compare the surgical and resuscitative interventions.

A retrospective review of patient notes was undertaken. Military patients were identified from the Joint Theatre Trauma Registry (JTTR) in 2009. Civilian patients were identified using the hospital informatics database. Patient demographics, treatment timelines as well as surgical and critical care interventions were reviewed.

In total 71 military patients sustained traumatic amputations within this time period. This represented 11% of the total injury demographic in 2009. Excluding upper limb amputees 46 patients sustained lower extremity amputations. These were investigated further. In total 21 civilian patients were identified in a 7-year period.

Analysis revealed there was a statistically significant difference between patient age, ITU length of stay, blood products used and number of surgical procedures between military and civilian traumatic amputees. This study identified that military patients were treated for longer in critical care and required more surgical interventions for their amputations.

Despite this, their time to stump closure and length of stay were not statistically different compared to civilian patients. Such observations reflect the importance of an Orthoplastic approach, as well as daily surgical theatre co-ordination and weekly multi-disciplinary meetings in providing optimal care for these complex patients. This study reports the epidemiological observed differences between two lower limb trauma groups.

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1. Introduction

Trauma is one of the leading mechanisms causing amputation globally [1,2]. Around 5000 new cases of traumatic amputation are seen in the UK annually and the prevalence is higher as these patients often go on to live many years [3]. The incidence of traumatic amputation has recently increased the military population because of the recent conflicts in Afghanistan and Iraq [2,4–7].

The period since the intervention in Iraq in 2003 has seen a sustained level of casualties not seen since the Korean war. The UK Defence Medical Services have undertaken an extensive concurrent programme of performance improvement in order to improve treatment outcomes for soldiers [7–11]. These interventions include haemostatic dressings, pre-hospital physician-led damage control resuscitation, surgery, critical care transfer and an integrated partnership between the NHS and the military. The success of these interventions has recently been reported in a year-on-year improvement in survival [2]. As part of the continuing effort to maintain these high standards beyond those recent conflicts it is crucial to ascertain the transition of these skills to the civilian pathway. Cross-pollination of skill sets between military and civilian trauma surgeons is vital to retain long-term corporate memory.

The Queen Elizabeth Hospital Birmingham Royal Centre Defence Medicine (RCDM) is a military civilian partnership that forms the National Role 4 receiving centre for British Service Personnel. It is the only centre to directly receive Service Personnel from operational theatres and concurrently treats civilian trauma as a Level 1 trauma centre.

The aim of this work was to compare the in-patient timelines of military and civilian patients treated at the same centre. We hypothesised that there would considerable differences in the treatment timelines between these two cohorts of patients.

2. Methods

2.1. Patient selection

Military patients at the QEHB between 1st January 2009 and 31st December 2009 (inclusive) were identified through a database prospectively collated by the UK Joint Medical Command, the Joint Theatre Trauma Registry (JTTR). This period was selected at the time of conception as a complete dataset with patient follow up post discharge. Furthermore it represented, at the time of data collection during the conflict, one of the highest incidences of traumatic amputation compared to other subsequent year time points.

Civilian amputees admitted to QEHB were identified using the hospital Trust INFORMATICS database. In order to produce an adequate comparative sized cohort for direct evaluation, patients were retrospectively included over a seven year period beginning 1st November 2003 to 31st December 2010 (inclusive).

2.2. Treatment interventions in groups

QEHB is a Level I regional trauma centre in the West Midlands of the United Kingdom. During the conflict it provided a multidisciplinary team to treat both groups in the study. During increased kinetic activity in the conflict in Afghanistan the surgical and rehabilitation capabilities were augmented with military healthcare personnel. This was to allow for the continued provision of equal service to both groups without compromising the civilian group due to the sudden increase in incidence of military trauma. The standards of treatment were therefore stable between groups for the duration of the study period. During the period reviewed military patients, where logistically feasible, were admitted to a specific ward with other servicemen. This ward maintained a military ethos which experience had shown patients preferred. Although staffed by both civilian and military healthcare professionals the ward was lead by service personnel.

2.3. Data collection

The UK JTTR database, written and electronic notes and theatre records were retrospectively reviewed.

2.4. Exclusion criteria

Patients who had incomplete records, sustained digital amputation or partial amputation that resulted in limb salvage only, or died as a result of their wounds prior to reaching QEHB were excluded from further investigation. Afghanistan nationals treated at Role 3 Camp Bastion were not evacuated to Role 4 RCDM and were therefore excluded from investigation.

2.5. Study variables

2.5.1. Patient details

Patient variables included age and sex, dates of injury, admission and discharge, admission to intensive care, and intubation days.

2.5.2. Injury details

Variables included were Injury Severity Score (ISS), New Injury Severity Score (NISS), quantity and type of resuscitative blood products given within first 24 h of treatment, injuries sustained, GCS on admission, and amputation level.

2.5.3. Surgical details

Variables included time to closure, closure method, mobility at discharge from the QEHB and reconstructive procedures required at follow up. Surgical procedures conducted on operations were included in the number of surgical procedures for the military cohort. Mobility was assessed from the discharge physiotherapy and occupational therapy documentation within inpatient notes.

2.6. Timing of amputation

Timing of amputation was divided into immediate, (i.e. at the time of primary injury) immediate delayed (i.e. – in surgery for the first look procedure) and delayed (i.e. after first procedure) based on a previously published methodology (1). The level of amputation was recorded as below knee amputation (BKA), through knee amputation (TKA) and above knee amputation (AKA).

3. Method of closure

Method of closure was divided into standard amputation flaps (fasciocutaneous, muscle only or myocutaneous), primary closure and split skin graft (SSG). The term flap refers to the standard method for closing amputation residual limbs.

3.1. Injury severity scoring

The ISS and NISS were calculated for each patient [11,12]. Major trauma is defined as an ISS score greater than 15 [12,13].

3.2. Statistical methods

Variables were compared between the military and civilian cohorts, in order to identify differences in demographics and outcomes. Continuous variables were assessed for normality prior to the analysis using a graphical approach (histograms and QQ plots). Considerable deviations from normality were identified in all of the factors, hence a non-parametric approach was employed, with comparisons between groups made by Mann–Whitney plots. For categorical variables, Fisher's exact tests were used for between group comparisons -summary statistics were reported as medians with ranges, or percentages, as applicable.

All analyses were performed using IBM SPSS 19.0.0 (IBM Corp. Armonk, NY). Missing data were excluded on a per-analysis basis, and a p-value of less than 0.05 was deemed to be indicative of statistical significance.

4. Results

4.1. Patient details

During 2009, 71 military patients sustained a partial or complete amputation of any limb during this year period. Excluding upper limbs, 46 soldiers sustained traumatic lower limb amputations, representing 11% of the battle injury group identified in 2009. In the civilian group 21 lower extremity traumatic amputees were identified over a 7-year period (Table 1).

4.2. Age

The age of the patients significantly differed statistically between the two groups ($p < 0.001$). The median age for the military cohort was 25 years (range: 18–35), whilst the civilian cohort was 40 (range: 22–72).

4.3. Co-morbidities

In the civilian group 14 patients had co-morbidities (66%). Three had multiple co-morbidities. The most common co-morbidities were primary hypertension and drug allergies, which were reported in four patients each. Only 9 patients required medication for their co-morbidity. The largest number of medications required for co-morbidity control was 5, in a patient who had hypertension, a previous stroke and diabetes (see Table 3 – Supplemental Files).

In the military cohort, only one patient had a pre-existing co-morbidity of mild asthma. Seven were known to have allergies (16%). The number of patients on medication for their co-morbidities was significantly higher in the civilian cohort than the military (47% vs. 5%, $p < 0.001$).

Table 1
Differences between military and civilian cohorts in presentation, resuscitative requirements and treatment.

Factor	Military (N = 46)	Civilian (N = 21)	p-value
Age (Years)	25 (18–35)	40 (22–72)	<0.001[a]
LOS (Days)	39 (1–79)	34 (1–124)	0.430
ITU LOS (Days)	6 (0–38)	1 (0–5)	<0.001[a]
ITU Ventilation (days)	1 (0–40)	0 (0–4)	0.034[a]
ISS	26 (4–75)	9 (4–29)	<0.001[a]
NISS	40 (8–75)	12 (4–34)	<0.001[a]
Blood products (total)	46 (0–160)	3 (0–13)	<0.001[a]
GCS	15 (3–15)	15 (3–15)	0.145
Number of surgical procedures	6 (1–19)	3 (1–9)	<0.001[a]
Time to stump closure (days)	8 (1–25)	5 (0–48)	0.325

Data displayed as: "Median (Range)", with p-values from Mann–Whitney Tests.
[a] Significant at $p < 0.05$.

4.4. Injury variables

Table 1 highlights the injury variables collected. The military cohort was found to have the more severe injuries, with significantly higher ISS, NISS, blood product usage and ITU LOS than civilians (all $p < 0.001$).

4.5. Treatment details

Table 2 shows the timing and anatomical location of traumatic amputations, which differ between the groups ($p < 0.001$). The earliest amputations for the 83% of military patients occurred immediately, with only 4% being delayed. Conversely, in the civilian cohort, amputations were most commonly delayed (52%), with only 24% being performed immediately.

4.6. Associated injuries

There were 245 associated injuries in 46 patients in the military group compared with 41 injuries in 21 individuals in the civilian group (Table 4 – supplemental files). The extremities in both groups were the body regions with the highest incidence of associated injury.

The number of injuries per patient was significantly higher in the military cohort, with a median of 5 injuries per patient (range: 1–16) compared to 1 per patient (range: 0–7) in the civilian cohort ($p < 0.001$).

4.7. Lower limb amputation

In total, 69 lower limb amputations were performed on military patients, and 21 on civilians (Table 2). Military patients were significantly more likely to have higher-level amputations than civilians ($p = 0.002$). In the military cohort, AKA made up 55% of amputations, compared to only 14% in civilians. BKA was most common the civilian cohort, with 76% of all amputations, compared to 36% in military patients.

During the hospital stay, 23% of military amputations required subsequent proximal amputation, compared to 5% in the civilian cohort. Although this difference was not statistically significant ($p = 0.107$, Table 2), this may have been a false negative error, on account of the low statistical power of the test.

4.8. Multiple amputations

There were no multiple amputees recorded in the civilian group. In the military cohort 24 patients sustained single limb amputation, 18 patients sustained double amputations and 4 patients sustained triple amputations.

4.9. Mechanism of injury

Civilian patients were most commonly injured in road traffic collision (RTC) (57%) or crush injuries, (38%), with one patient sustaining a fall and another being hit by a train. In the military group the most common cause of injury was the improvised explosive device, 96%, (IED) and rocket propelled grenade attack, 4%, (RPG).

5. Method of closure

Military patients were more frequently closed in a stepwise fashion with SSG (50%) or SSG and local flap (50%) Few of the military patients underwent primary closure (n = 3), and those who underwent flap closure as a delayed primary closure had a

Table 2
Median range of injuries in patients and level, timing and need for further amputation between groups.

	Military	Civilian	Statistical diff.
Level of Amputation	**(N = 69[b])**	**(N = 21)**	Fishers Exact Test P = 0.002[a]
Above Knee Amputation	38 (55%)	3 (14%)	Exact Test p = 0.002[a]
Through Knee Amputation	6 (9%)	2 (10%)	
Below Knee Amputation	25 (36%)	16 (76%)	
Total number of Amputations	69	21	
Timing of Earliest Amputation	**(N = 46)**	**(N = 21)**	Fishers Exact Test p < 0.001[a]
Immediate	38 (83%)	5 (24%)	
Immediate Delayed	6 (13%)	5 (24%)	
Delayed	2 (4%)	11 (52%)	
Further Amputation	**(N = 69[b])**	**(N = 21)**	
No Further Amputation	53 (77%)	20 (95%)	Fishers Exact Test
Higher Amputation	16 (235)	1 (5%)	p = 0.107
Mobility at Discharge	**(N = 42)**	**(N = 18)**	
Dependent	1 (2%)	1 (6%)	
Dependent in wheelchair	1 (2%)	0 (0%)	
In bed	0 (0%)	1 (6%)	
Independent in wheelchair	39 (93%)	14 (78%)	
Independent with crutches	1 (2%)	2 (11%)	

[a] Significant at p < 0.05 or Number of cases with percentage bracketed.; with p values from Fishers Exact test where appropriate.
[b] Refers to number of limbs amputated rather than number of patients. Data displayed as: "Median (Range)", with p-values from Mann–Whitney Tests.

fasciocutaneous amputation flap (n = 4) or myocutaneous amputation flap (n = 5). In the civilian group the tendency was for standard amputation flap closure rather than SSG (n = 14 and n = 6 respectively); the flaps were again either fasciocutaneous (n = 5) or myocutaneous. (n = 9). There was one civilian mortality in which flap closure was not achieved.

5.1. Time to closure

There was no statistically significant difference in the time to stump closure between the two groups. The military patients required a median of 8 days to achieve closure (range: 1–25) compared to 5 days (range: 0–48) in the civilian cohort (p = 0.325, Table 1).

5.2. Mobility on discharge

The rates of independent mobility did not differ significantly between military and civilian patients (95% vs. 89%, p = 0.576, Table 2).

5.3. Discharge destination

All military patients subsequently underwent rehabilitation at Headley Court. One civilian was directly discharged to a rehabilitation centre in the civilian cohort; all other patients were discharged home.

5.4. Mortality

Two military and one civilian patient died from their injuries whilst in hospital. In the military cohort, one patient had care withdrawn once the significance of his head injury became clear. The second patient underwent a total of 19 procedures overall on the body before developing multi-organ failure secondary to sepsis. The civilian patient died of wounds whilst in hospital.

6. Discussion

The management of traumatic amputations should be undertaken in specialist trauma centres that can provide a dedicated orthoplastic team [14–17]. The QEHB provides a unique centre of experience for treating this injury group. The variability between military and civilian trauma has given clinicians at this centre an irreplaceable breadth of clinical experience. Ensuring the dissemination of this experience throughout wider civilian clinical practice is critical to ensuring long-term retention of corporate knowledge.

The incidence of traumatic amputations is relatively low in the UK population (5–7%) [3]. In 2009 the incidence amongst soldiers was much higher. 71 military amputees were admitted to QEHB in that year. The same year also had the highest incidence of injuries per month in the conflict. This time frame therefore represented the highest yield of cases to examine, reflecting a key point on the learning curve for military and civilian surgeons. Our hypothesis was that the greater ISS/NISS, as well as time in ITU, in the military group would be reflected in a longer LOS and time to stump closure compared to civilians.

Quantifying the outcomes from trauma and the amount of cross-pollination of knowledge between these groups is nevertheless challenging.

As expected the timelines illustrate the well-reported differences between these groups. There is a significant difference in kinetic energy between IED blast and RTC [7,18–20]. This explains the expected difference in ISS and NISS scores. Furthermore the difference in age between groups reflects the previously reported epidemiology for civilian trauma. The greater ISS and NISS also explain the greater number of blood products used in resuscitation. It also highlights changes in delivery of care by military medics, particularly the early use of blood products, control of haemorrhage and consultant-delivered treatment. These are all confounding factors that were expected to have a significant effect on their injury timeline.

This study has found three key differences between the groups that are areas for future investigation. Firstly military casualties spent longer in critical care than civilians [7]. Additionally they were subsequently cared for on a fully functioning surgical acute care ward with dedicated nursing and military medical officer support. This dynamic well co-ordinated team between civilian and military nursing and allied healthcare professionals may potentially act as a platform to facilitate more timely surgical intervention. Civilian patients awaiting further debridement were treated on a standard level I ward based environment. Greater utilisation of critical care principles, such a dedicated staffing and supplementary clinicians, within a level 1 ward based environment in civilian traumatic amputees may contribute to shorter lengths of stay, earlier wound closure and earlier rehabilitation. Evidence is divided on the direct ability of ICU/HDU to reduce LOS [21], however it may contribute to optimisation of patients for theatre and wound closure. This will require further quantification [22]. Although not reflected in the data, such differences echo the key principles of military management, namely a dedicated orthoplastic multidisciplinary team, daily surgical planning and weekly MDT meetings.

Secondly, military patients required more operations than civilians. Their injuries also sometimes required immediate amputation. This reflects the nature of their injury, contaminated with a progressive necrosis from blast [7,23,24]. They also required further revision, with a more proximal amputation and debridement, in 23% of cases. Such serial debridement highlights the level of contamination and the adoption of evidence based orthoplastic principles for their wound care [16,17]. The civilian wounds were relatively clean by comparison and thus required fewer debridements. Civilian patients were often closed with myofasciocutaneous amputation flaps whilst the lack of viable tissue in soldiers meant a phased SSG approach was more suitable [14]. This reflects a situational difference in method of closure whilst adopting similar surgical principles. These figures show that although the approaches to the wounds of both groups were the same, their time to closure was not different. This begs the question of whether, along with significant wound contamination, a secondary reason for this could be logistical in terms of civilian patient access to theatre.

This finding may also reflect errors in the analysis of retrospective data, a pitfall of retrospective analysis. However it could also reflect the intense treatment regimens adopted for military patients. This is multifactorial and difficult to quantify. During this period Defence Medical Service surgeons augmented the orthoplastic department in order to deal with the increase in military trauma [7]. This permanent uplift allowed for more dynamic allocation of manpower to both services. The implementation of extra theatre lists and regular thrice-daily planning meetings allowed for prompt co-ordination of operations. Furthermore the in-depth weekly Multi-Disciplinary Team meeting (MDT) allowed for direct communication between all surgical, critical care and rehabilitation staff. This created a co-ordinated pathway for this patient group with a unified aim [19]. Although treatment is tailored to the patient, the co-ordination of them as a group clearly has had some impact. The relative funding, geographical and social problems of our civilian patients means that group co-ordination is more challenging.

The data illustrates that there is no difference in LOS between groups, despite the opposing forces of higher ISS and early discharge availability to Headley Court in the military. The two groups therefore have different discharge parameters. The military is clinically driven whilst civilian discharge is dependent upon many external factors and frequently related to social circumstances. Civilian discharge depends on interplay between the patient, home, mobility, family support, rehab and other social factors. Improved co-ordination of such factors in civilian practice would likely lead to an accelerated discharge.

From our study, only one civilian was directly discharged to a rehabilitation unit. In comparison all soldiers were directly discharged to a dedicated rehabilitation facility for a planned period of further therapy and rehabilitation. The effect of this on streamlining their clinical pathway cannot be underestimated, both logistically for care co-ordination and psychologically for the patient.

The influence, of a dedicated rehabilitation pathway, on inpatient treatment was two fold. As military patients were destined for a dedicated rehab centre they could be potentially discharged earlier with a relatively lower level of independent mobility. Conversely civilians have a much more convoluted route to rehabilitation. Therefore, the importance of discharge mobility is potentially greater in civilians.

The early identification of a regionally dedicated rehabilitation unit for all these patients is crucial. As is a focussed co-ordination of their inpatient care that is directed towards this goal of rehabilitation. These are two areas for potential regional/national improvement highlighted by military patient timelines [25]. This could potentially reduce the hospital LOS in proportion to their lower ISS & NISS.

6.1. Limitations

There are several key limitations to the cross analysis of these two groups. The key limitation is the comparison of a sample of one year to continuous data. Despite the potential availability of further data, the sample we used had prior validation in peer reviewed research that underpinned its quality to undergo further analysis. Nevertheless, a case matched continuous dataset may have given more valuable conclusions.

Our study utilised terminology for timing of amputation utilised in previously published methods from a national trauma databank study of traumatic amputations. This is different from published terminology from the Lower Extremity Assessment Project. This may represent a limitation in the analysis of our data group.

Although this the first study to attempt to compare outcomes between these two groups there are unavoidable discrepancies in data reporting when using retrospective data. In addition there was a lack of standardised functional independence measurement between the groups. Such discrepancies will have increased any beta errors in statistical analysis. The small incidence of traumatic amputation within the civilian cohort and different mechanisms of injury make it difficult to construct matched cohorts.

6.2. Statistical limitations

The small sample size, particularly in the civilian cohort, meant that the analyses had low statistical power. As a result of this, the analyses could only detect large differences between the groups; hence false negative errors may have occurred. For this reason, non-significant differences need to be interpreted with caution, especially where moderate differences were observed between groups (e.g. the rates of limbs requiring additional levels of amputation).

Also, since multiple hypothesis tests were performed throughout the investigation, there is a chance that false positive results may have occurred in some cases. However, the majority of the results that were significant returned p-values <0.001. An adjusted P value threshold of $P < 0.003$ was therefore used. Hence, even after accounting for the effect of multiple comparisons (e.g. using Bonferroni correction), these differences would remain statistically significant, meaning that false positives are unlikely in these cases.

7. Conclusion

This retrospective timeline comparison has identified potentially three areas for future cross-pollination between military and civilian trauma practices. Although the data itself is unable to directly show causality or translation of healthcare practice between groups, it supports clinical observational evidence [7].

Firstly the use of dedicated orthoplastics teams allows for the maintenance and improvement of ‘corporate knowledge’ and the management of these critical injuries. The continuity of care from dedicated orthoplastic teams allowed for daily surgical planning with MDT teams to co-ordinate care and prioritise the civilian and military surgical caseload. This finding is reflected in published national clinical guidance on the management of open extremity fractures [15–17].

The importance of daily surgical co-ordination between military and civilian caseload cannot be under estimated, particularly in the integration of a truly multi-disciplinary team. Furthermore the weekly MDT encouraged clinicians to reach out to experts to solve unique problems in this patient cohort. This fostered further inter-disciplinary collaboration.

Lastly the weekly ward based MDT that liaised between all interested parties, rehabilitation at Headley Court, physiotherapy and social services, meant that surgical and social priorities could be deconflicted. Such a 360-degree approach to the care of this patient group explains the differences in outcomes. Adjusting and adopting these principles in civilian centres nationally may aid in transferring corporate knowledge to the home front.

Ultimately we have a responsibility to record the lessons learnt from treating soldiers with combat injuries and to transfer them to the treatment of civilian amputees.

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Author contribution

Robert Staruch wrote the first draft and edited all subsequent copies of the text.

Phillipa Jackson edited and wrote portions of the final draft.

Guang Yim collected substantial reconstructive data for the project.

James Hodson provided statistical analysis.

Mark Foster provided direction on study concept and helped on data collection.

Tania Cubison provided information and experience on surgical reconstruction which contributed substantially to the final draft of the paper.

Steven Jeffery provided direction and edited the final draft.

Conflict of interest statement

No Conflict of interests.

Guarantor

Steven Jeffery is the guarantor of the paper & work.

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Appendix A. Supplementary data

Supplementary data related to this article can be found at http://dx.doi.org/10.1016/j.amsu.2016.02.008.

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