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A correlation analysis of metacarpal & phalangeal injury pattern from improvised explosive devices amongst armed force personnel

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ABSTRACT

Injuries to the hand during military combat operations, particularly from improvised explosive devices (IEDs) have a significant impact on form, function, mental health and future employment but remain underreported amidst the life and limb-threatening emergencies that garner more attention. An understanding the patterns of hand injuries encountered from IEDs is crucial to optimizing reconstruction and rehabilitation. The aim of this study was to re-evaluate hand injury sustained from IED in order to understand the clinical burden for reconstruction and direct the focus for future hand protection. We identified 484 hand injuries in 380 patients sustained as a result of IEDs among military personnel service in Afghanistan between 2006 and 2013. 53% of all surviving military personnel injured by IEDs sustain injuries to the hand. Analysis of the 103 patients who sustained injury to the metacarpal, phalanges or digital amputation revealed that the middle and ring fingers are most commonly injured. Amputation to the ring finger is strongly associated with injury to the adjacent fingers and amputations to the middle, ring and little fingers concurrently is a commonly observed pattern. The proximal phalanges of the middle and ring fingers had a strong correlation for fracture together. These findings disprove the conventional belief in an ulnar focus of injury and support the quest for a development of combat hand protection that addresses the injury pattern seen.

Introduction

Traumatic injuries to the hand among military personnel are life changing injuries. The Improvised Explosive Device has been responsible for many of these injuries in recent conflict zones [1]. Acceptable functional outcomes rely on prompt identification and surgical reconstruction. However, they tend to be underreported, as they typically occur in the context of polytrauma when clinical priorities lie elsewhere.

Previous research into blast related injuries has focused on the head and neck, lower limbs and pelvis [2–5]. Historically, lower extremity injury was seen with greater frequency than upper extremity injury [6–10]. Nevertheless, more recently, evidence highlights the burden of upper extremity injury [6]. A retrospective search of injuries from the Iraq conflict between 2004 and 2005 indicates that 24.5% and 28.7% of injuries are seen in the elbow, forearm, hand, wrist and phalanges respectively. Although extensive research programs have focused on utilizing targeted muscle re-innervation or vascularized composite allotransplantion to reconstruct significant upper extremity injuries, little is known about the overall epidemiology or injury pattern beyond a case-by-case basis [11,12]. Although the implications from firework and shotgun related injuries has been documented [3,16,18–25,30], the burden of injury from high energy IED blast to the hand has yet to be reviewed [13]. This is important to elucidate potential areas for ballistic protection or tissue salvage [5,7–10,13–19,36]. Moreover,

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lessons from military patterns of injury can be useful in civilian settings, as IED injuries are common among civilians in conflict zones. Terrorist attacks or industrial explosions can also produce similar patterns of injury [20–24].

While traditional teaching and experience have stressed an ulnar focus of injury, the analysis points towards a propensity for injury to the 3rd and 4th fingers with unique patterns of amputation pertaining to each hand. Therefore there is a significant difference between the perceived clinical experience and the physical injury burden, that will ultimately affect the design of any future body armor. Thus, the aim of this work was to re-evaluate the patterns of hand injury observed following IED explosions among military service personnel repatriated to the Royal Centre for Defense Medicine (RCDM) in Birmingham, the unit receiving all UK military casualties from Afghanistan, with a view to predicting the clinical burden of injury from future conflicts and to highlight where the focus of hand protection should be.

Methods

Patient selection

The Joint Theatre Trauma Registry (JTTR) is an application used by deployed tri- service trauma coordinators to collect battlefield injury demographics, care and outcomes for military and civilian injured personnel. The data collection allows comprehensive searches of the anatomical location of injury, care and outcomes of patients. The JTTR was searched for all UK military personnel sustaining upper limb injuries logged between September 2006 and April 2013.

Inclusion criteria

All upper extremity trauma to surviving UK military personnel occurring as a result of an improvised explosive device (IED) while deployed in Afghanistan were included in our analyses.

Exclusion criteria

All non-survivors were excluded from the search as were other injured personnel that included local civilians, police, civilian contractors and non-UK military personnel. Injuries without the anatomical side of injury (right or left) were disregarded from in-depth analysis of left versus right, but were included in the overall numerical burden of injury.

Correlation analysis

All surviving patients who sustained upper extremity injuries from IEDs were subject to further analysis. Fractures and amputations were plotted on the side of the body and particular digit injured. This data was then subject to an injury specific as well as a combined injury correlation analysis in order to investigate associations between fingers during injury. Anatomically, the hand was divided into three ulnar fingers and 2 radial fingers for comparison of ulnar versus radial injury pattern.

In the correlation analysis, the thumb was referred to as 'Finger 1' to aid in investigation between digits.

Statistical analysis

For the analysis of correlation of injuries between fingers, binary variables were produced for each finger identifying whether or not an injury had occurred for each patient. Spearman's correlation coefficients (Rho) were then produced between each pair of fingers, in order to quantify the degree of association between them. The injuries were then divided into different types (amputation/fracture), and the analysis repeated. In these cases, only those patients with at least one injury of the stated type were considered.

Comparisons of the number of injuries across the fingers, and between the hands were performed using related samples non-parametric tests, namely Wilcoxon's test and the Freidman test, in order to account for the paired nature of the data, and the fact that the number of injuries followed a skewed distribution. All analyses

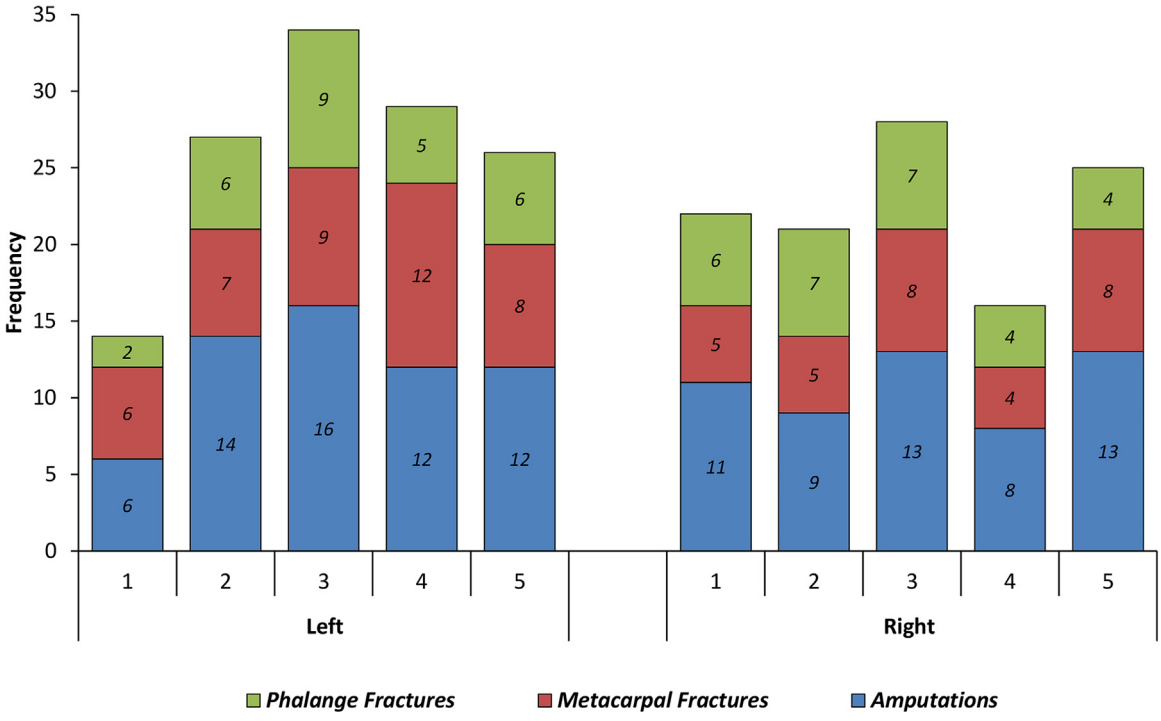

Fig. 1. Stacked bar graph of finger injury incidence by injuries.