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Lethal triad in severe burns☆

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ABSTRACT

Introduction: Hypothermia, acidaemia and coagulopathy in trauma is associated with significant mortality. This study aimed to identify the incidence of the lethal triad in major burns, and describe demographics and outcomes.

Methods: Patients admitted during a 71 month period with a total body surface area burn (TBSA) $\geq$ 30% were identified. A structured review of a prospective database was conducted. The lethal triad was defined as a combination of coagulopathy (International normalised ratio > 1.2), hypothermia (temperature $\leq$ 35.5 °C) and acidaemia (pH $\leq$ 7.25).

Results: Fifteen of 117 patients fulfilled the criteria for the lethal triad on admission. Lethal triad patients had a higher median (IQR) abbreviated burn severity index (ABSI) (12 (9–13) vs. 8.5 (6–10), $p = 0.001$), mean (SD) TBSA burn (59.2% (18.7) vs. 47.9% (18.1), $p = 0.027$), mean (SD) age (46 (22.6) vs. 33 (28.3) years, $p = 0.033$), and had a higher incidence of inhalational injury ($p < 0.0001$) and full-thickness burns ($p = 0.021$). Both groups received similar volumes of fluid ($p > 0.05$).

The lethal triad was associated with increased mortality (66.7% vs. 13.7%, $p < 0.0001$). With logistic regression analysis and adjustment for ABSI, the lethal triad was not shown to be a predictor of mortality ($p > 0.05$).

Conclusion: Burn patients with the lethal triad have a high mortality rate which reflects the severity of the injury sustained.

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1. Introduction

The combination of hypothermia, acidaemia and coagulopathy, or the 'lethal triad', is a well-known entity within the trauma population and is associated with significant mortality [1,2]. Development of the lethal triad is not only related to the severity of injuries but can also be exacerbated by resuscitative interventions [1,2]. In an attempt to mitigate the impact of

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Abbreviations: DCR, damage control resuscitation; ABSI, abbreviated burn severity index; TBSA, total body surface area; INR, international normalised ratio.

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resuscitation and surgical interventions the concept of damage control resuscitation (DCR) has emerged as a standard of care in trauma management [3,4]. DCR involves damage control surgery, haemostatic resuscitation and permissive hypotension, and has been associated with improved survival in trauma patients with severe haemorrhage [5,6].

Burns are characterised by a similar direct endothelial injury, acute phase response and release of pro-inflammatory cytokines, which is accompanied by hypovolaemia, impaired myocardial contractility and cellular hypoperfusion [7]. In burns the presence of either hypothermia, hyperlactaemia or coagulopathy in isolation, are associated with increased mortality [7–10]. An early lethal triad could have significant implications given the increasing propensity for early total burn wound excision and allo/auto-grafting [9,11,12]. To the best of our knowledge, this is the first study to investigate the lethal triad in patients with severe burns.

The aim of this study was to assess the incidence and clinical impact of the lethal triad in patients with severe burns. The impact of fluid resuscitation and all components of the abbreviated burn severity index (ABSI) were also evaluated [13].

2. Methods

2.1. Study setting

St. Andrew's Burn Centre is a supra regional burn service looking after burn patients of all ages and severities, serving 9.8 million people within the United Kingdom.

All patients admitted to St. Andrew's Burn Centre are assessed by a multidisciplinary team in a dedicated admission room. In this admission room patients can be accurately assessed, resuscitated, and emergent interventions can be undertaken.

2.2. Patient selection and design

Patients of all ages admitted to a regional burn centre with a total body surface area burn (TBSA) of 30% or more between January 2006 and December 2011 were identified.

Exclusion criteria were: associated major trauma (head, chest, abdomen, pelvis injuries or long bone fractures); admission more than 12 h after the burn; suspected cyanide poisoning (enclosed fire with reduced conscious level, inhalational injury and hyperlactaemia); pre-existing bleeding diathesis or prior anticoagulants administration; any blood product or factor concentrate administration; non-thermal injuries or medical skin loss; temperature, arterial blood gas and coagulation test not completed on admission; any missing data entries.

2.3. Data collection and statistical analysis

The prospectively completed Metavision electronic patient record was utilised to identify patients. A structured review was conducted using a predetermined template to collect data on demographics, interventions and admission investigations. All data collected was anonymised.

In accordance with local practice and previous publications [14], moderate hypothermia was defined as a temperature of less than or equal to 35.5 °C. A trauma patient with a pH of less than or equal to 7.25 have been shown to be at increased risk of massive transfusion, and hence was used to define acidaemia [15]. A coagulopathy was defined as an admission International normalised ratio (INR) greater than 1.2. This value represents our local laboratory's definition of coagulopathy and are in keeping with recent definitions of acute burn induced coagulopathy and acute traumatic coagulopathy [7,16]. Burn patients had to fulfil all the above criteria to possess the lethal triad.

Data was analysed for any association between the lethal triad with all components of the ABSI and fluid administration. Continuous Gaussian or skewed data were presented as mean (SD) and median (IQR) respectively. The groups were compared using the means of continuous variables and a permutation test version of a two-sample t-test. Discrete data was analysed using Fisher's exact tests. Logistic regression modelling was used to evaluate the prognostic value of the lethal triad. Analysis of data was performed using Microsoft Excel 2010 (Microsoft, USA) and program R (R Foundation for Statistical Computing, Austria). A p value < 0.05 was considered statistically significant.

3. Results

Two hundred and five patients were admitted during the 71 month period. Sixty did not fit the inclusion criteria and 28 had data missing, leaving a total of 117 patients for analysis. The 28 patients with missing data had a similar male:female ratio (1.6:1), median (IQR) age 39.5 (24.75–60.25) and ABSI 10 (7–12).

The majority of patients were admitted following a secondary transfer from other institutions, and the mean time from burn to arrival at the burn centre was 360 min. The majority of patients were male (64%) with significant burns, mean TBSA burn and median ABSI of 49.3% and 9 respectively.

Fifteen of the 117 (12.8%) patients analysed fulfilled the definition for the lethal triad on admission (Table 1). Lethal triad patients suffered from more significant burns with a higher ABSI (Fig. 1, $p = 0.001$), TBSA burn ($p = 0.027$), and incidence of inhalational injury ($p < 0.0001$) and full-thickness burns ($p = 0.021$). Lethal triad patients tended to be older, with a mean (SD) age of 46 (22.6) compared to 33 (28.3) years respectively ($p = 0.033$).

Despite receiving similar median (IQR) volumes of fluid ($p > 0.05$), the lethal triad group were significantly under-resuscitated according to their calculated volumes from the Parkland formula ($p = 0.009$).

All components of the lethal triad were each individually associated with increased mortality (Table 2). However, only the presence of an early coagulopathy and admission pH were found to be independent predictors of mortality ($p < 0.05$). Admission temperature was a poor predictor of mortality, with an area under the curve (AUC) and Scaled Brier score of 0.673 and 3.1 respectively.

The lethal triad was associated with an increased mortality (66.7% vs. 13.7%, $p < 0.0001$). Fig. 2 depicts the receiver operator curves for binary logistic models according to the presence of the lethal triad and adjusted for all components of the ABSI (age, gender, full thickness burn, inhalational injury and

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