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Identification of factors predicting scar outcome after burn in adults: A prospective case–control study

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ABSTRACT

This study examined influences on scarring after burn in a prospective study using a defined outcome measure: scar height measured by a modified Vancouver Scar Scale (mVSS). A prospective case–control study was conducted among 616 adult subjects who sustained a burn in Western Australia. Patient factors influencing scar outcome including gender, Fitzpatrick skin type and selected co-morbidities were explored, as well as injury and clinical factors. A logistic regression model for raised scar after burn was developed which achieved an overall correct prediction rate of 81.1%; 74.8% for those with raised scar and 86.0% for those without raised scar. From this study, injury and clinical predictors for raised scar after adjustment for other variables are: increasing %TBSA, greater burn depth as indicated by level of surgical intervention, wound complications and prolonged hospital stay. Intrinsic patient predictors for raised scar in patients with comparable injuries are: young age (≤30 years), female gender and Fitzpatrick skin types 4–6. The strength of association statistics (odds ratios and 95% confidence intervals) reported will be of practical benefit for clinical decision-making and counselling of patients, and plausible biological explanations for the findings support the validity of the results.

1. Introduction

Scarring is a consequence of the biological process of wound repair and continues to be the key unmet challenge after burn [1]. Raised scars caused by excessive dermal fibrosis are classified as hypertrophic when they remain within the margin of the original wound [2] and may have a serious impact on a patient's quality of life [3]. Hypertrophic scars are the most common complication of burn, and while it is difficult to generate precise estimates of prevalence, reported rates in adults or children hospitalised for burn vary between 32 and

Abbreviations: CI, confidence interval; OR, odds ratio; POSAS, Patient and Observer Scar Assessment Scale; SH, scar height; SSG, split-thickness skin graft; %TBSA, % total body surface area of burn; Th, T helper cell; TLR, toll-like receptor.

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72% [4]. Despite the heavy burden of burn-related scarring, few robust prospective studies with adequate sample size have reported strength of association statistics for factors associated with risk of poor scar outcome. Risk stratification and the identification of individuals at high risk of poor scar outcome are critical to guide clinical decision-making and to reduce the health burden due to scarring after burn.

Predictors of severe scarring after burn identified in previous prospective studies include total body surface area burned (%TBSA) [5,6], burn depth [5–7], multiple operations [5–7], self-reported race [6] and skin pigmentation (Fitzpatrick skin type) [7]. Retrospective audits of medical records have reported that age at time of injury [8,9], gender [9], darker skin [8,10,11], anatomical site of burn [8,9], time to healing [9,10,12], burn depth [9], meshed skin graft [9], multiple surgical procedures [9] and bacterial colonisation [13] are associated with hypertrophic scarring after burn.

The results of these previous studies are inconsistent for some factors. This study aims to replicate the examination of some of these influences on scarring after burn in a prospective study using a defined outcome measure. This study specifically includes the exploration of hypotheses related to intrinsic patient factors impacting scar outcome: age, gender, Fitzpatrick skin type (skin pigmentation) [14] and selected co-morbidities (asthma, eczema, diabetes Type 1 or Type 2) which may influence on wound healing.

A prospective case–control study was conducted among 616 adult subjects who sustained a burn in Western Australia and were treated at Royal Perth Hospital or Fiona Stanley Hospital, Western Australia. The primary outcome measure for the study was the scar height sub-score (SH) of the subject's worst scar according to the modified Vancouver Scar Scale (mVSS) [15]. Scar height (SH) specifically relates to the bulk of the scar above the level of normal skin. We developed an epidemiological model for raised scarring after burn and report strength of association statistics (odds ratios [OR] and 95% confidence intervals) for factors associated with raised scarring which will assist individualized patient management.

2. Methods

2.1. Subjects

This case–control study commenced at the Royal Perth Hospital Burns Unit (Western Australia) in May 2010 and was completed in July 2015. In January 2015 the Burns Unit relocated to Fiona Stanley Hospital. The research was conducted in accordance with Section 3.2 of the National Statement on Ethical Conduct in Human Research 2007 (National Health & Medical Research Council, Australia) with approval by the Royal Perth Hospital Human Research Ethics Committee (EC number 2009/114) and authorization from the Fiona Stanley Hospital (Project Number 2014-105).

Subjects were eligible for recruitment if they sustained an acute burn with hospital admission, outpatient treatment or hypertrophic scar treatment at Royal Perth Hospital or Fiona Stanley Hospital Burns Unit and were 16 years of age or over at the time of their burn. All subjects were recruited in the outpatient clinic. Subjects were excluded from the study for the following reasons: unable to provide written informed consent, a history of more than one hospital admission for acute burn, acute burn treated outside Western Australia, previous history of keloid scarring, or burn scar diagnosed as a keloid scar. A keloid scar is defined as a raised dermal lesion that extends beyond the boundaries of the original wound, enlarges progressively over time and may be accompanied by symptoms of pain and pruritus.

2.2. Patient treatment algorithm

The clinical treatment pathway for patients with burn in the care of the Burns Service of Western Australia is described in Fig. 1.

2.3. Explanatory variables

Clinical data is collected systematically from all burns patients treated in the burns units of Royal Perth Hospital or Fiona Stanley Hospital in the BMDS (Burns Minimum Data Set) and/or the (BIMS) Burns Information Management System. Data on the following variables was extracted for each subject at time of recruitment: age (at time of injury), gender, external cause of burn (scald, contact, flame, sunburn or radiation, chemical, friction, electrical), co-morbidities (asthma, eczema, diabetes), anatomical site of injury (head/neck, chest, abdomen/groin, back/buttocks, arm, hand, leg, foot, genitalia), % total body surface area of burn (%TBSA), length of hospital stay (days), surgery level (proxy variable for wound depth [see Fig. 1]: conservative; ReCell®; split-thickness skin graft (SSG) ±ReCell®; Integra® Dermal Regeneration Template+SSG+ReCell®), wound complications (Yes/No: skin graft loss or over-granulation or wound infection), multiple surgical procedures (Yes/No), healed within 14 days (Yes/No). In the case of missing data in the database, patient clinical records (hard copy) were reviewed. The Fitzpatrick skin type Classification Scale [14] (Fig. 2) was conducted by patient questionnaire separately at the time of recruitment.

2.4. Primary outcome measure

Patients with acute burn were followed up for 12 months after injury with scar assessments conducted according to a modified Vancouver Scar Scale (mVSS) [15] at 3, 6 and 12 months. The primary outcome measure was the mVSS scar height (SH) sub-score of the subject's 'worst' scar (scar area with the highest total mVSS score) closest to 12 months after injury. The anatomical site of this scar was also recorded. In some cases scar assessments were discontinued prior to 12 months due to 'excellent' scar outcome in the clinical judgement of a consultant plastic surgeon (assigned SH=0 mm). When the latest scar assessment was performed earlier than 6 months after injury, the subject's medical record was reviewed and if 'excellent' scar outcome was not reported a new appointment for scar assessment was made. Subjects who did not attend the new appointment were assigned the value of the latest existing scar assessment in the database. Cut-off scores based on the SH created three ordered categories for univariate analysis (Fig. 3): normal flat appearance (SH=0 mm); scar evident but not raised (SH>0–1 mm);

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