Chemical burns – An historical comparison and review of the literature

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ABSTRACT

Chemical burns represent a small proportion of cutaneous burn with an incidence of up to 10.7%, but have been reported to account for up to 30% of all burn deaths. A review of the literature shows incidences ranging from 2.4% to 10.7%, with a substantial predominance in males. Adult patients with a burn referred to our Regional Burns Centre, over an eight-year period, were identified. 185 chemical burns were recorded (7.9%). The mean age of patient was 40 years (range 16–81 years) and male to female ratio was 6.4:1. Over three-quarters of chemical injuries occurred in the domestic or industrial setting. Acids caused 26% of all chemical burns and alkalis caused 55%. A previous study from the same centre highlights a change in the demographics of chemical burn over the last 25 years. The proportion of chemical burns has risen from 2.7% to 7.9%. Chemical burns occurring in an industrial setting, have dropped, whilst the number of domestic chemical burns has increased by over three times. This change reflects the improved industrial health and safety policy in recent years. The move from the industrial setting to the domestic has implications for future regulations.

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1. Introduction

Cutaneous chemical burns represent a small, but significant, proportion of burns with reported incidences of up to 10.7% \cite{1} and have been shown to account for up to 30% of all burn deaths \cite{2}.

A review of the literature yields several studies globally giving incidences ranging from 2.4% to 10.7% and a substantial predominance in males \cite{1,3–9} (Table 1). The majority of patients are of working age and acids are the most common causative agent. Such burns are commonly small in size, and the most common burn areas are the face and limbs \cite{5,8}. Whilst it would often be assumed that the majority of chemical burns take place in the industrial setting, some studies have reported a domestic predominance \cite{6,7,10}.

Despite the significance of this type of burn, the United Kingdom literature is restricted to case series or single case reports, with few large cohort studies. One such study from the Birmingham area was published in 1989 \cite{9} and collected chemical burn data over a period of seven years. It found an incidence of 3.1% of all burns with industry accounting for 76% of chemical burns. The aim of this study is to look again at chemical burns in the Birmingham area over a similar time study period and compare our findings with those previously published to identify any changes in the epidemiology, and the management, of chemical burns in the region.

2. Materials and methods

All adult patients with a burn referred to the Burns Centre at the University Hospitals of Birmingham NHS Foundation...
Table 1 – A review of the literature concerning large-scale cohorts of cutaneous chemical burns 1989–2011.

<table>
<thead>
<tr>
<th>Author</th>
<th>Year</th>
<th>Country</th>
<th>n</th>
<th>Mean age (range)</th>
<th>Male:female</th>
<th>Proportion of all burns</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hardwicke et al.</td>
<td>2011</td>
<td>UK</td>
<td>185</td>
<td>40 yrs (16–81 yrs)</td>
<td>6:4:1</td>
<td>7.90%</td>
</tr>
<tr>
<td>Magsoudi and Gabraely [3]</td>
<td>2008</td>
<td>Iran</td>
<td>121</td>
<td>35.3 yrs (5–80 yrs)</td>
<td>10:01</td>
<td>2.40%</td>
</tr>
<tr>
<td>Ma et al. [4]</td>
<td>2007</td>
<td>China</td>
<td>118</td>
<td>32.3 yrs (18–53 yrs)</td>
<td>8:01</td>
<td>n/a</td>
</tr>
<tr>
<td>Xie et al. [5]</td>
<td>2004</td>
<td>China</td>
<td>377</td>
<td>26 yrs (1–78 yrs)</td>
<td>3:7:1</td>
<td>8.50%</td>
</tr>
<tr>
<td>Pitkanen and Al-Qattan [7]</td>
<td>2001</td>
<td>Saudi Arabia</td>
<td>59</td>
<td>25 yrs (2–70 yrs)</td>
<td>3:01</td>
<td>n/a</td>
</tr>
<tr>
<td>Singer et al. [8]</td>
<td>1992</td>
<td>Israel</td>
<td>168</td>
<td>29.6 yrs (6–64 yrs)</td>
<td>15:8:1</td>
<td>4%</td>
</tr>
<tr>
<td>Herbert and Lawrence [9]</td>
<td>1989</td>
<td>UK</td>
<td>100</td>
<td>n/a</td>
<td>6:7:1</td>
<td>3.10%</td>
</tr>
</tbody>
</table>

n/a, data not available.

Trust, between 28/02/2003 and 27/02/2011, were identified from the British Isles Burn Injury Database (BIBID). All paediatric patients with burn referred to the neighboring Birmingham Children’s Hospital NHS Foundation Trust, in this time frame, were also identified in the same manner. A data collection proforma was completed for each patient at time of assessment, and data transferred to a Microsoft® Excel® spreadsheet (Microsoft® Corporation, Redmond, WA) for analysis. A subgroup of adult patients who sustained chemical burn was selected for further analysis. Inclusion criteria for this subgroup were: (1) burn secondary to chemical exposure; (2) isolated chemical burn with no associated thermal or explosive component; (3) patients aged 16 or over; (4) completed BIBID proforma within the specified date range. A detailed case note review was performed for a cohort of these patients assessed between 1/1/2009 and 31/12/2010, focusing on interventions and outcomes. Statistical analyses were undertaken using GraphPad Prism®, version 4.00 (GraphPad Software, San Diego, USA). Data were compared using a Student’s t-test, a one-way ANOVA, with a Bonferroni post-test (parametric methods), and the Mann–Whitney U-test (non-parametric methods). Results were expressed as a mean. Statistical significance was considered at a probability of p < 0.05.

3. Results

A total of 4386 patients were referred to both the adult burns centre at the University Hospitals of Birmingham NHS Foundation Trust and the paediatric burns unit at Birmingham Children’s Hospital NHS Foundation Trust. This included 2054 paediatric patients and 2332 adult patients, equating to an average of 559 referrals per year for burns of all causation. From the adult cohort during this period, a total of 185 chemical burns were recorded (7.9%), a mean of 23 per year. Chemical burns, as a percentage of total burn referrals, on a month-by-month basis were significantly less common in the month of July (p < 0.05), whilst total burn referrals were more common in the summer months (May–August), than the winter (Fig. 1).

The mean age of patient was 40 years (range 16–81 years) and male to female ratio was 6.4:1 (160 males vs. 25 females). There was no significant difference between the genders in respect to age (mean age male = 41 years, mean age female = 37 years, p > 0.05), percentage of total body surface area affected (TBSA; male = 2.0%, female = 1.7%, p > 0.05), and length of stay in hospital (LOS; male = 3.5 days, female = 2.5 days; p > 0.05).

Incident locality was recorded in 73% of cases. Over three-quarters of chemical injuries, when recorded, occurred in the domestic (42%) or industrial setting (34%) (Fig. 2). During the study period, 225 burns of all causation occurred in the industrial setting (9.5%). In total, one-third of all chemical burns occurred in industry. The chemical was identified in 83% of cases. In broad terms, acids caused 26% of all chemical burns (including two percent attributable to hydrofluoric acid), and alkalis caused 55% (including 26% due to cement) (Fig. 3).

Of the cohort of cement burns, 40% of these occurred in the domestic setting, compared to 25% at work. Alcohol and/or drug misuse was cited as a contributing factor in 4.3% of all chemical burns.

A delay in presentation was common, with the mean time to assessment being 36.1 h. Although acid burns did present sooner (29.6 h), this was not significantly different to alkali burns (40.9 h; p = 0.41). Cement burns, when viewed in isolation, did present significantly later than all other chemical burns (57.7 h; p = 0.032) (Fig. 4).
The percentage of the total body surface area (TBSA) affected ranged from 0% to 22%. Percentage TBSA was recorded in 90.9% of cases. Burns were classed as superficial erythema alone, with no skin loss (i.e. zero percent TBSA) in 11 cases. The mean percentage TBSA was 1.9%, and although women presented with smaller burns (1.7% TBSA) than men (2.0% TBSA), this was not significant ($p = 0.6$). Although chemical burns with associated thermal injury or explosive component to the causation were excluded from the final analysis, they were associated with a significantly larger percentage TBSA (6.3% TBSA; $p < 0.001$). The anatomical distribution showed a predilection for the peripheries (Fig. 5). Hands were more commonly affected than feet in the female cohort, and vice versa in males.

Formal burn resuscitation was performed in one case (22% TBSA), seven patients were admitted to a high-dependency unit (HDU) bed for observation (3.4%) and overall, just over two-thirds of patients required overnight admission (66.4%). The average LOS was 3.4 days (range 0–28 days), with no significant difference between the genders ($p > 0.05$). With respect to the excluded chemical burns with associated thermal injury or explosive component, the length of stay was significantly longer (7.9 days; $p = 0.0018$).

The further detailed analysis of 72 patient case notes for chemical burns revealed that nine patients had associated thermal injury or explosive component to the causation, and were excluded, and 12 sets of notes were unavailable, leaving 51 case notes for the final analysis. Tangential excision of the chemical burn was performed in 17.6% of cases. A split-thickness skin graft (SSG) was used for reconstruction in eight cases, one case of a hand burn was reconstructed with Matriderm® dermal regeneration template (Eurosurgical, Guildford, UK) plus SSG, and one case required regrafting.

4. Discussion

This is the second largest review of cutaneous chemical burns in the worldwide literature. A previous study performed within the Birmingham area [9] provides a historical context for the present study and highlights a significant change in the demographics of chemical burns injury in the region over the last 25 years (Table 2).

The total number of burns of all causation, per year, has increased by 120%, from the 1980s to the 2000s. Adult chemical burn incidence has more than doubled, and are becoming proportionally more common in women, and affecting a wider age group. The proportion of chemical burns, when compared to burns of all causation has risen from 2.7% to 7.9%. Chemical burns occurring in an industrial setting, has dropped by one half, whilst the number of domestic chemical burns has increased by over three times. Industrial burns of all causation have dropped by over 50% during this period. The incidence of...
acid burns has remained static, whilst the number of alkali burns has increased by 50%. Cement burns now account for about one quarter of all chemical burns, whereas in the 1980s, they accounted for one in sixteen chemical burns: a significant number of cement burns now occur in the residential setting.

Chemical burns are getting smaller in size with only seven percent currently being of greater than five percent TBSA, compared to 31% from the 1980s. The number of overnight admissions has remained at 66% in both cohorts, but the length of admission has decreased in the contemporary group, with only one percent of admissions being greater than 14 days, compared to nine percent from the former study. The rate of surgical intervention has halved in the recent study, probably reflecting the smaller size of these burns. Anatomical distribution of chemical burns remains consistent, affecting the extremities. In the present study, the greater involvement of the right hand may represent hand dominance.

The key findings of this study show that the number of injuries occurring in industry has markedly dropped, most likely in part due to the Health and Safety at Work Act (1974) and the Care of Substances Harmful to Health (COSHH) regulations (2002) in the UK [11,12], whilst the number of domestic chemical injuries has significantly increased. There was an observed proportional increase in the percentage of industrial burns caused by chemicals which may reflect the overall reduction in industrial burns as a whole, again due to current legislation. There has also been a recent decline in industrial activity in the West Midlands area. Historically, Birmingham is the birthplace of the manufacturing process and by the turn of the 19th Century, it was known as the “City of a 1000 trades” [13,14]. This recent move from manufacture to the service industries, combined with improved health and safety legislation may contribute to this relative reduction in industrial injury.

This movement from the industrial setting to the domestic setting is probably a combination of lack of regulations governing domestic application of chemicals, the wide range of chemicals available to the layperson, and the increase in the Do-It-Yourself (DIY) culture in the UK in recent years [15]. The concurrent change in employment demographics, and the aging population, over the last 25 years may account for the increase in chemical burns in females and the wider age range affected [16,17].

In summary, chemical burns in the West Midlands, including Birmingham, are becoming smaller and the rate of surgical intervention has decreased, over the last 25 years. The move from the industrial setting to the domestic has implications for future regulation of chemicals capable of causing cutaneous burns, especially those from cement, and may guide future public health campaigns focused on the avoidance of chemical burn and the need for suitable protective clothing and training in their use.

Conflict of interest statement

The authors have no conflict of interest.
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REFERENCES