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Corrosive attacks in the UK – Psychosocial perspectives and decontamination strategies

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ABSTRACT

Acid attacks, or vitriolage, are defined as violent assaults involving the deliberate throwing of an acid or similarly corrosive substance with the intention to "maim, disfigure, torture or kill" [1]. The Acid Survivors Trust International suggest a prevalence of 1500 attacks reported worldwide per annum, although this is likely to be an underestimate by 40% [2]. The UK is thought to have one of the highest of rates of recorded corrosive attacks, with an increase from 228 attacks in 2012 to 601 in 2016. Most were reported by the London Metropolitan police force followed by Northumbria, Cambridgeshire, Hertfordshire, Greater Manchester and Humberside [[2]]. The chemical agents involved include acids, alkalis, oxidising and reducing agents, alkylating and chelating agents and solvents. They cause injury by producing a chemical interaction which can lead to extensive tissue destruction and extreme pain. Herein, we present a review on the changing epidemiology of corrosive attacks in the UK and currently employed management strategies.

1. Socio-cultural and historical perspective of vitriolage

Acid attacks are not a new phenomenon in the United Kingdom, with attacks reported as early as the 1880s. Media at that time stereotyped these as a women's crime whereby female perpetrators, motivated by jealousy and vengeance, threw oil of vitriol (sulphuric acid) over perceived rivals or cuckolding lovers [1]. In reality, evidence suggests attacks were undertaken by both men and women most often to resolve disputes. These attacks seem to have almost exclusively involved throwing the substance at the face and neck, although it has been commented that the fashion for hats in this era protected victims and lessened the severity of the injury [3].

Outside the UK, the prevalence of acid attacks has always been high in developing countries noted to have a patriarchal society, wherein victims are predominantly women attacked due to a perceived insult to a man's power or status [4]. These societies have been suggested to often be of low socio-economic status without access to higher education, with lax substance management laws and potentially corrupt or unsupportive law enforcement agencies [2]. In the UK, the Poisons Act 1972 regulates the sale and possession of dangerous or corrosive substances so that some can only be purchased by procuring a home office licence. Some substances however, are only classed as reportable meaning that they can be purchased freely with the onus on the seller to report suspicious sales [6]. Amendments to the Act were made in 2018 to introduce increased control of substances; creation

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of a new offence of "carrying a corrosive substance in public" is hoped to halt the escalating incidence of these attacks [7].

2. Why do people use corrosives to cause injury?

Research into the motivation behind such attacks is sparse; victims have been noted to be reluctant to disclose details perhaps due to fear of repercussions or shame [8]. However, many of the recent UK corrosive attacks are largely attributed to gang activity [9] and so the psychological profiling of those attracted to gangs may be helpful in understanding the motivations behind such attacks. Gangs tend to be city-based [10,11]; members are more likely to be involved in criminal activity and violent offences, value social status and material wealth, and are more likely to defer responsibility for their actions to their victims [2]. Gang members are also more likely to be male, engage in sensation-seeking behaviour, feel alienated from family or community, have experienced abuse or neglect, and have low educational attainment [12–14]. Given these factors, we can understand why acid may be chosen as a tool by these groups. A meta-analysis of studies into acid attacks suggest they are rarely fatal; the attackers' intention therefore is more likely to be to visibly shame or humiliate their victim [1], highlighted in that attacks are typically aimed at the face, with variable splashes onto the neck and upper trunk [4]. A person's face is the fundamental basis for human recognition and so the act of disfiguring someone's face may be considered to be erasing or disfiguring their identity [15]. This may be particularly relevant in cultures where appearance is a significant factor in marriage potential or social status [5] and may be seen as exerting control or power over another. Given the emphasis placed on social status in gang culture [11], this may be a pertinent factor. Furthermore, in-group glorification and previous experiences of violence by gang members may serve to dehumanise the victim and create a sense of moral disengagement, leading the individual to justify their behaviour [16,17].

Throwing acid and other corrosive substances may be seen as preferable to physical assault or stabbing as it involves considerably less physical strength on the part of the perpetrator and does not require close contact with the victim meaning it can be thrown from a moving vehicle or through a window. While this can allow a potentially quicker escape from the scene, it also means that the perpetrator does not have to observe the consequences of their actions which may heighten moral disengagement and reduce the perpetrator's sense of moral responsibility [18], particularly if the physical harm was secondary to robbery or other activity. In addition, acid may also be viewed as easier and cheaper to obtain than firearms [19], making it appealing and more accessible to younger, less affluent individuals such as those who may be involved in gangs.

3. Current decontamination strategies

The main determinants of the degree of injury are concentration of the agent, site and duration of exposure. Without prompt intervention, victims may have irreversible visual impairment and disfigurement [20]. Whilst spare in its documentation in the literature, acid appears to be the most commonly used agent in the UK, followed by alkalis including bleach [4]. Conversely, alkali appears to be the agent of choice to assault in the United States [21].

Traditionally, treatment for chemical burns of the skin and eyes involves removing the compound from body contact (e.g. brushing from the skin [22] or removing clothing) followed by copious flowing water irrigation to dilute the chemical [23–25]. This strategy is taught worldwide, is promoted in a number of life support courses and is endorsed by the British Burn Association in their recent 'Report, Remove, Rinse' advertising campaign. Whilst sound in its objectives, this management strategy is already dated [26,27] following the availability of specific decontamination solutions.

pH monitoring of the burn site is the only measure of adequate decontamination [26] and irrigation may be performed for up to 2 h [23] to return skin pH to between 5.5 and 9 (safe limits), thereby risking profound hypothermia from the cold lavage fluid [23]. Research has illustrated that up to certain chemicals require seventeen-times more water than more conventional neutralising solutions to normalise pH [28]. Furthermore, as water is hypotonic, it may propagate further penetration of chemicals into tissues [27,29,30]. Irrigation with isotonic or hypertonic crystalloid solutions and not hypotonic water is preferred, the hypothesis being to draw out the damaging agent (osmosis) rather than causing absorption of hypotonic water, increasing intracellular distance and perpetuating the environment for the injurious chemical [27,29,30]. A number of commercial products are now marketed specifically for the prehospital decontamination of chemical burns with an increasingly supportive evidence base, including Diphoterine® and Hexafluorine®.

4. Diphoterine® and Hexafluorine®

Diphoterine® is a commercially available amphoteric, hypertonic, chelating solution used to decontaminate and irrigate chemical splashes [31,32], with a higher buffering capacity to free ions than saline or Hartmann's solution. It is available in several sizes, dependent on the volume of chemical splash: 50/500 mL eyewash, 100/200 mL spray canister and 5 L canister. Initially developed as a readily accessible eyewash for those based in an industrial environment, it has been shown to be effective at neutralizing acid and base splashes to the eyes and skin and is water soluble [31,32]. It has low toxicity and does not irritate the skin or eyes [31–36], with comparable safety to saline irrigation [35,36].

The evidence supporting the use of Diphoterine® in clinical practice is variable in its quality [37–40]; however, the results from *in vitro*, *in vivo* animal and *in vivo* human studies are compelling. Alkali injuries to the eye are potentially catastrophic, as liquefactive necrosis rapidly allows penetration of the chemical through the cornea and into the anterior chamber of the eye. Irrigation of the eye with Diphoterine following ammonia treatment dramatically neutralizes the base, preserving cytological architecture, reducing stromal oedema [41] and normalising anterior chamber pH with as

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little as 5 min of irrigation compared to saline treated controls [42,43]. Diphoterine® also modulates inflammation and pain [36] through effects on neurotransmitters [44]. Circulating levels of substance P, which plays regulatory roles in inflammation and pain modulation, were lower when skin burns were treated with Diphoterine®, while beta-endorphin levels increased following Diphoterine® irrigation of cutaneous chemical burns [44]. Taken together, this suggests that inflammation is abated and that pain is improved following Diphoterine® treatment [36].

This agent is not brand new; the first case report of Diphoterine® use in the management of skin and eye corrosive burns was reported during the 1990s [45]. Most experience has been gained from the industrial sector, but the increasing prevalence of chemical attacks both in the UK and abroad has prompted the use of chelating solutions in treating these injuries. As seen in *in vitro* and *in vivo* animal studies, Diphoterine® treatment shortens corneal re-epithelialisation time following alkali injury compared to saline [46]. Cutaneous decontamination of acids and alkali spills see significantly better outcomes in those treated with the solution than those treated with water, with a significant reduction in the number exhibiting blistering and other clinical stigmata of a chemical burn [31], ultimately resulting in less time off work and less treatment costs [47]. Even delayed application of Diphoterine® significantly altered cutaneous wound pH compared to saline but did not alter the need for surgery or time to healing [48].

At present, there are no documented cases in the literature of hydrofluoric acid (HF) being used to assault. It is, however available for industrial use, as well as in commercially available products including rust remover and alloy wheel cleaner. For this reason, we feel that an awareness of Hexafluorine®, an amphoteric solution specifically developed for the decontamination of HF [49] is important amongst the pre-hospital, emergency and plastic surgery community. As well as the irrigation effect, the hypertonic Hexafluorine® limits tissue penetration [50], and neutralises/chelates the free hydrogen and fluoride ions responsible for tissue damage. A number of case studies have commented on the role of HF decontamination using this amphoteric wash in clinical practice and industry. These demonstrate good results when applied acutely to skin [30,51] and eye [30] burns, but also show success with delayed application to large volume HF burns [52].

5. The psychological sequelae of acid attacks

A search of the literature failed to identify any research exploring the psychological consequences of acid attacks in a UK population, although an open letter from a survivor of an acid attack highlights the complexities of living with such as injury [53]. Research in other countries has identified difficulties with anxiety and depression [54], social exclusion and isolation [55]. To understand the psychological sequelae in the UK, it may be helpful to look at the wider literature into the impact of facial burns or trauma alongside other forms of physical assault in Western cultures. Research exploring psychological consequences of burn injuries or facial trauma has identified increased prevalence of mental health issues such post-traumatic stress disorder, poor body image, alcoholism, depression, poor life satisfaction, sleep disturbance, stigmatization and social exclusion in the injured person [56–59], with high levels of distress also reported by their family members [60]. These factors have in turn been suggested to increase the likelihood of post-trauma criminality, unemployment and marital difficulties [60]. Victims of physical assault are also at increased risk psychological distress and mental health conditions, with research indicating greater substance misuse, anxiety and mood disorders, post-traumatic stress disorder, impaired quality of life and more suicide attempts [61,62], particularly in those subjected to gender-based violence [61].

6. Psychological support

Given the sparse literature base concerning the psychological impact and management of victims of acid attacks in the UK, guidance and evidence relating to the support of burn-injured patients must be drawn upon. Effective psychological support should begin early during admission, and the National Burn Care Standards stress that patients with a burn injury should be assessed for psychological distress on admission by an appropriately trained clinical psychologist or psychiatrist and supported as required during their inpatient stay and following discharge. The National Burn Care Standards also advise additional sources of support, such as support groups and structured reintegration into education or employment as required.

6.1. *Post-traumatic stress disorder*

For patients where acute traumatic stress or post-traumatic stress disorder symptomatology is the main presenting problem, NICE guidance [63] recommends that trauma-focused cognitive behavioural therapy (CBT) or Eye Movement Desensitisation and Reprocessing (EMDR) therapy be offered to those presenting with symptoms within three months of the event. Trauma focused CBT aims to facilitate the processing of trauma memories through reliving and retelling memories of the event. EMDR also seeks to facilitate the processing of trauma memories, but by triggering eye movements associated with memory processing neural mechanisms with the aim of restarting the brain's natural memory processing ability.

6.2. *Grief and adjustment*

Grief reactions are common in the presence of perceived loss, and in most cases, resolve with time. However sometimes grief processing can be delayed, particularly where the loss is complicated by emotions such as shame, or if the person finds it difficult to access and process the loss. This may be the case for individuals without a secure support network or who experience emotional dysregulation due to mental health issues or emotional processing issues. In these circumstances, therapy may be appropriate to facilitate the grieving process and seeks to help the person complete four key tasks: 1) accept the reality of the loss, 2) process the pain of the loss, 3) adjust to life without the loss, and 4) find an enduring connection with the loss in the context of continuing with life [64].

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6.3. *Visible difference*

Where the primary concern involves the person's dissatisfaction with their changed appearance due to scarring, therapy may in the first instance focus on processing the grief and emotional reactions associated with the appearance change. Therapeutic approaches relevant to visible difference may also involve social communication skills training, building self-confidence, or addressing unhelpful thought processes in relation to the appearance change. Therapeutic models used to support appearance related concerns including CBT (addressing unhelpful thoughts and beliefs about appearance), social skills training, and Acceptance and Commitment therapy (learning how to live with a changed appearance in the pursuit of other values) [65,66].

6.4. *Pain*

Some individuals experience persistent pain or sensation change as a result of their injury. In this instance the goals of therapy may be to develop psychologically derived pain management strategies or, when all other options are exhausted and pain persists, to help the person learn to tolerate their pain in the pursuit of achieving an acceptable quality of life. Traditional pain management strategies include distraction (employing alternative activity to minimise attention on pain stimuli), guided imagery (developing visual concepts in the mind's eye to reduce pain, i.e. imagining cool water pouring on burning pain), CBT (changing unhelpful thoughts about the pain) and relaxation (physically relaxing muscle groups to reduce pain stimuli and pain-related anxiety). While these techniques often do not completely remove pain, they can have the added benefit of causing the individual to perceive greater control of their pain thereby reducing any distress it causes. Alternatively, acceptance-based approaches aim to help the person explore the cost of pursuing pain management strategies and develop willingness to tolerate the pain so that they can live in accordance with their values.

7. Conclusion

Chemical decontamination of corrosive injury with chelating agents such as Diphoterine® and Hexafluorine® needs to have a more widespread role in the pre-hospital and hospital environments, together with increased education about their existence and availability. Non-availability of these agents or delay in their use can be temporised by more standard guidelines and teaching as regards to dilution/irrigation but we should acknowledge that isotonic crystalloid may be better than water. Therefore, we advocate the decontamination strategy outlined in Fig. 1, which aims to guide decision making for those treating chemically injured patients.

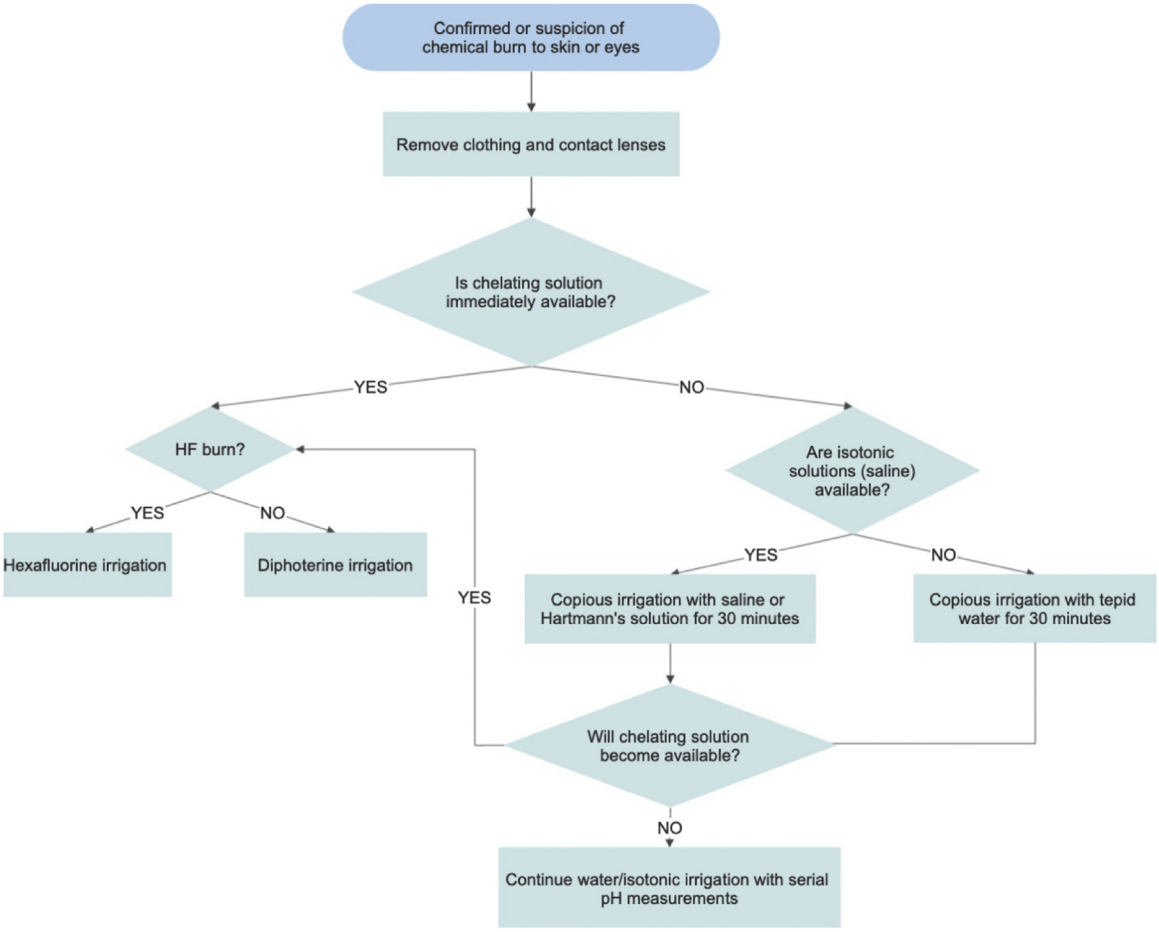

Fig. 1 – An algorithm for emergency decontamination of chemical injuries to the skin and eye.

Furthermore, there is a clear absence of research into the psychological consequences and management of those subjected to acid attack violence, perhaps due to the relatively small number of patients presenting with these injuries, reluctance to participate in research, or the fact that the increase in prevalence was unanticipated and research projects take time to initiate and complete. Future research should continue to explore the psychological consequence of acid attacks and associated surgical reconstruction, as well as the efficacy of differing therapeutic models with this population.

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Declarations of interest

None.

Conflicts of interest

We, the authors, have no conflicts of interest to declare.

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