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Train surfing and other high voltage trauma: Differences in injury-related mechanisms and operative outcomes after fasciotomy, amputation and soft-tissue coverage

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ABSTRACT

Background: In the context of scarce reports on train surfers among high voltage electric injuries, we conducted a retrospective review between January 1994 and December 2008.

Methods: After matching for inclusion criteria we reviewed patient records of 37 true high voltage injuries (12 train surfers [TS] and 25 other high voltage injuries [HV]).

Results: TS were significantly younger (TS 15.8 years vs. HV 33.3 years, $p < 0.0001$), and had a greater %TBSA (TS 49.7%TBSA vs. HV 21.5%TBSA, $p = 0.0003$) without affecting the median length-of-stay (TS 52 days vs. HV 49 days) or number of operations (TS 4 vs. HV 3). TS had different injury patterns, with a higher percentage of affected extremities (TS 72.9% vs. HV 52.0%, $p = 0.0468$) and associated injuries (TS 58% vs. HV 20%, n.s.) than HV. Both groups demonstrated comparable fasciotomy (TS 71.4% vs. HV 55.8%) and amputation rates (TS 17.1% vs. HV 15.4%). While TS required less flaps (TS 3/12 vs. HV 18/25; $p = 0.0153$), soft-tissue reconstruction revealed an overall low incidence of complication rates (one partial pedicled flap loss and two total free flap losses).

Conclusions: Train surfers have proven to be a distinct group of patients among high-voltage injuries notably as a result of a younger age, a shorter electric contact duration and higher velocity-induced trauma. With a possibly declining trend of train surfing-related accidents in an aging society, it will be interesting to see if emerging economies will face comparable phenomena, for which prevention strategies remain key.

1. Introduction

Train surfing is not restricted to the western world, and their admissions represent a non-negligible share among high voltage injuries to trauma centers worldwide [1–3]. While motivation for this conduct derives from a number of reasons, and despite the observed increased interest for high voltage electric injuries in recent publications, studies focusing on train surfers remain scarce [4–6].

High voltage electric injuries occur predominantly in young men in their thirties and account for 45.8% of work-related injuries in the US [7]. In general, electric injuries showed a 90% male predominance over the last few decades [8–20]. In train surfing-related injuries, the gender distribution was similar, but the age group concerned younger, and the mortality rate higher [1–3]. Currently there exist no reports comparing train surfing-related vs. other high voltage electric injuries.

When reviewing the literature on decompression strategies, no general recommendations exist [21]. It is therefore

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appropriate to analyze the outcomes based on affected extremities by means of decompression, amputation and associated complication rates. With a few exceptions, the majority of reports compared decompression rates stratified by patients, however, only few data on decompression to amputation ratios have become available [22].

Soft-tissue coverage after high voltage injury is challenging, and with scarce local tissue reserves available, microsurgical reconstruction provides a useful tool in tackling wound problems. Among the vulnerable structures at risk after high voltage injury, the body's vasculature is most commonly affected, resulting in progressive tissue necrosis and complicating reconstructive management. In this regard, it is difficult to find an optimal timeframe for microsurgical reconstruction: early coverage associated with incomplete debridement [23–25] vs. delayed reconstruction with risk of desiccation and infection of tissues [13,26]. Based on the observed complication rates, some authors favored either approach.

In this work, we have compared our patient collective based on its composition, evaluated decompression to amputation ratios, and reviewed outcomes in comparison to the current literature.

2. Materials and methods

After ethical board approval (Medical University of Vienna, EK No. 609/2009) we reviewed patient records from January 1994 to December 2008 and matched for high voltage electric injury ($n = 44$). Patients with flashburns ($n = 7$) were excluded.

The following parameters were analyzed: age, sex, circumstances, total burn surface area (%TBSA), type of current flow through the body, associated injuries, length-of-stay, number of operations, type of interventions (fasciotomy, amputation, defect coverage), complications (revision rate, flap losses), and mortality rate.

The treatment regimen consisted of a standard intensive care work-up (central lines, hemodynamic and respiratory support, etc.). Initial fluid management started with 2 ml/kg BW × %TBSA/24 h crystalloid, then adaptation according to changes in hematocrit, serum lactate and orientated on urinary output of 1 ml/kg BW/h. Elevation of urinary pH in case of myoglobinuria was achieved with diuretics as needed.

Diagnostic trauma work-up on admission included otolaryngology and ophthalmology consults, ultrasound, as well as CT scans in all stabilized patients. Blood laboratory parameters inclusive of myoglobin and serum creatin kinase were initially repeated every 6 h and then daily after 24 h.

Surgical decision for decompression within 24 h was considered in circular deep partial or full thickness burns, zones of other related injury, and all entry-/exit points. The operative plan was primarily guided on clinical symptoms and signs (tense extremity, paresthesia/numbness, pulselessness) and extremities were decompressed by fasciotomy, which included a carpal tunnel release in the upper extremities. Early elevated serum levels of myoglobin or creatin kinase supported this operative approach. Wounds were afterwards covered by temporary polyurethane dressings (Epigard®, Biovision GmbH, Germany). Early debridement was performed if tissue injury and patient stability allowed doing so. If extent of injury required, early amputations were performed in affected parts of necrotic extremities. Coverage of burn wounds was performed according to burn depth and extent of injury [27]. Wounds were disinfected and dressed daily. In case of planning a microsurgical reconstruction, most patients received preoperatively a contrast CT-angiography in order to assess recipient vessels. Skin grafts were used to permanently cover full-thickness defects on adequate wound beds not requiring additional soft tissue coverage. Indications for free flaps included exposed vital structures (bone, tendon, nerve, etc.) and lack of local soft tissue resources.

Data was analyzed with the Student's *t*-test for parametric and with the Mann–Whitney test for non-parametric data (GraphPad Prism 4, La Jolla, CA, USA). P below 0.05 was considered statistically significant. Parametric data is presented in mean ± SD, and non-parametric data in median [minimum–maximum], if not otherwise stated.

3. Results

After matching for inclusion criteria, we reviewed 37 records of patients: train surfing-related (TS) and other high voltage injuries (HV) accounted for 12 and 25 admissions, respectively. All but one patient were male, with the one female belonging to the TS group. Two of the HV accidents occurred during leisure time, all of the other were associated to work-related causes.

Train surfers were significantly younger (TS 15.8 ± 2.3 years vs. HV 33.3 ± 11.4 years, $p < 0.0001$) and had a significantly greater total burn surface area (TS 49.7 ± 17.0%TBSA vs. HV 21.5 ± 16.1%TBSA, $p = 0.0003$). No statistical significant differences for length-of-stay (median [min–max]: TS 52 [19–265] days vs. HV 49 [4–85] days) or number of operations (TS 4 [1–10] vs. HV 3 [1–7] operations during the primary hospital stay) were noted.

Injury patterns showed a predominantly vertical current flow in both groups (TS $n = 10$ vs. HV $n = 18$). On the one hand, a horizontal current passing through the upper extremities was only noted in other high voltage injuries ($n = 7$). On the other hand, a horizontal current flow through the lower extremities, with either side being the entry or exit point, occurred in two train surfers exclusively (Fig. 1).

As depicted in Table 1 other associated injuries occurred in 58% of train surfers and 20% of other high voltage injuries (TS median 1 [0–4] vs. HV 0 [0–2] injuries per patient), demonstrating a trend for train surfers having more associated injuries ($p = 0.0522$).

Train surfers' extremities were significantly more often affected (burns, entry/exit points) than those of other high voltage injuries (TS 72.9 ± 29.1% vs. HV 52.0 ± 28.8%/$p = 0.0468$). The overall fasciotomy rate was 62.1% (TS 71.4% vs. HV 55.8%).

Macroamputations were necessary in 16.1% of affected extremities (TS 17.1% vs. HV 15.4%), of which train surfers only required in the lower extremities (6/6 macroamputations). In other high voltage injuries and in accordance to the way of electric current through the body, we noted an equal distribution of macroamputations ($n = 14$) to the upper (7/14)