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High-voltage electrical burn injuries: Functional upper extremity assessment

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ABSTRACT

High-voltage electric injuries have many manifestations, and an important complication is the damage of the central/peripheral nervous system. The purpose of this work was to assess the upper limb dysfunction in patients injured by high-voltage current. The evaluation consisted of analysis of patients' records, cutaneous-sensibility threshold, handgrip and pinch strength and a specific questionnaire about upper limb dysfunctions (DASH) in 18 subjects. All subjects were men; the average age at the time of the injury was 38 years. Of these, 72% changed job/retired after the injury. The current entrance was the hand in 94% and grounding in the lower limb in 78%. The average burned surface area (BSA) was 8.6%. The handgrip strength of the injured limb was reduced ($p < 0.05$) and so also that of the three pinch types. The relationship between the handgrip strength and the DASH was statistically significant ($p < 0.001$) as well as the relationship between the three pinch types ($p \leq 0.02$) to the injured limb. The ability to perceive cutaneous touch/pressure was decreased in the burnt hand, principally in the median nerve area. These data indicate a reduction of the hand muscular strength and sensibility, reducing the function of the upper limb in patients who received high-voltage electrical shock.

1. Introduction

Despite the preventive attempt to reduce the number of injuries involving electrical current, its incidence has been gradually increasing, reaching up to 32% of the cases referred to burn care centres [1–4]. Amongst the parameters defining the severity of electrical accident, voltage is the only one known to indicate the lesion extension [5,6]. Therefore, electrical injuries can be divided into low-voltage and high-voltage ones, that is, below or above 1000 V, respectively [1–3].

High-voltage injuries destroy the tissue exposed to the electrical current, evolving into coagulative necrosis of deeper structures [2]. Moreover, the electrical-current pathway may either produce thermal burn resulting from the Joule effect on high-resistance tissues, such as the upper and lower extremities [6,7], or cell destruction resulting from the electroporation process [8]. This type of lesion usually depends on whether the tissue involved is highly conductive (e.g., veins and nerves) and some days may be necessary until the lesion is entirely delimited [6,7]. However, in the majority of cases, both

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injury processes superpose each other in the same region, thus aggravating the tissue lesion [8].

Peripheral neurological lesions are the most debilitating sequelae from electrical shock, accounting for 10–25% of all cases and involving sensory complaints, such as paraesthesia, causalgias and reflex sympathetic dystrophy, as well as motor complaints, such as muscular weakness and atrophy, affecting mainly the upper limbs [1,5,9]. According to Ferreiro et al. [2], peripheral neurological injuries are directly related to the body part that had direct contact with the current.

The main objective of the present study was to identify and describe the dysfunction of upper limbs in individual victims of high-voltage electrical burn who were treated at the Burn Care Unit of the Clinical Hospital of Ribeirão Preto (CHRP) over the past 10 years.

2. Materials and methods

This was an observational, retrospective study. Forty-five medical records were selected, and 18 individuals who suffered high-voltage electrical injury between January 1994 and December 2004 returned for the evaluation. All patients were examined from January 2005 to January 2006.

Exclusion criteria were: individuals aged less than 18 years, who were not cognitively able to perform tests, who suffered electrical injury in the last 12 months from the moment of the evaluation, who suffered low-voltage or lighting injuries and who underwent amputation, open wounds or conditions other than those caused by the electrical shock and that could impair sensory and/or motor capacity of the upper limbs.

2.1. *Instruments and procedures*

An evaluation form was developed for gathering data on peripheral neurological function, specifically regarding the upper limbs.

Qualitative physical examination was performed bilaterally so that healthy and injured sides could be compared, including visual aspects of muscle volume and presence of deformities.

The subjects' pain was classified using both visual analogical pain scale (VAPS) and self-reported cold intolerance. The former has scores ranging from 0 to 10, where 0 means no pain and 10 means the worst pain the patient ever felt, whereas the latter has scores ranging from 0 to 3, where 3 means none or minor disturbance and 0 means hindered function [10].

Grip strength and the three types of finger pinches were evaluated using Jamar® hand dynamometer and Preston Pinch® gauge, respectively, both being positioned according to the American Society of Hand Therapists (ASHT), and the results were in kilogram force (kgf). Three measures were alternatively recorded with regards to dominant and non-dominant hands with a minimum interval of 1 min. In these tests of strength, one patient who had both upper limbs injured, the limb that had the best performance was considered the healthy limb. After the three measures, the average of the three results was considered in the study.

The general function of the upper limbs was assessed by the disabilities of the arm, shoulder and hand (DASH) standardised questionnaire, which was developed by the American Society for Surgery of the Hand, American Association for Hand Surgery and Ontario Institute for Work and Health, Canada, specially in order to evaluate impairments and activity limitations, as well as restriction for both leisure activities and work caused by the upper limb dysfunction [11]. It contains 30 items related to daily activities, with 5 response options (1: no difficulty; 2: mild difficulty; 3: moderate difficulty; 4: severe difficulty; 5: unable) totalling 100 points for full dysfunction and no points for normal function.

Semmes Weinstein monofilaments Nylon test (SORRI® Estesiometer, Brazil) [12] was used to evaluate the subjects' hand sensation based on dermatome keys corresponding to the nerves under evaluation, thus offering objective data on cutaneous pressure threshold (in g). The following sensory points were evaluated: median nerve points at first and second digital pulp; second finger palmar base; ulnar nerve points; palm of the hand at ulnar edge; fifth finger palmar base and pulp of the finger. The point corresponding to the radial nerve is located on the dorsum of the hand at the first finger's base.

All the evaluations were performed in a period from 15 months to 122 months after the accident.

The present work was approved by the Research Ethics Committee during the 209th CHRP meeting according to process number 8123/2005. All the patients were informed about the evaluation procedures and asked to sign a free, informed consent document.

2.2. *Statistical analysis*

In order to verify the correlation between the variables studied and the DASH index, the linear model of combined outcomes (random and fixed outcomes) was used for data analysis because the answers regarding the same individual were grouped, and the supposed independence between observations within the same group was not adequate [13].

For comparison of strength between the injured and the healthy limb, we used the paired Student's *t*-test. The power of the test to detect the difference between injured and healthy hand was 0.79.

3. Results

Table 1 shows the classification of patients according to gender, age, injury situation and occupation before and after the event. The relevant data of the accident are listed in Table 2.

Visual analysis of the hand showed that four patients (22%) presented ulnar claw and just one (5%) median claw. The visual aspect of the hand showed decreased muscle volume in six patients (30%).

Seven patients had VAPS scores greater than 5, indicating important hyperaesthesia without any stimulus. Three of these patients and two others had debilitating pain during the cold stimulus. Two patients reported discomfort regarding cold hyperaesthesia alone, but with no functional impairment. These different types of hyperaesthesia can be considered sensory nerve lesions that were not adequately repaired.