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Case Report

Treatment in the healing of burns with a cold plasma source

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Abstract: A cold plasma produced with helium gas was applied to two second-degree burns produced with boiling oil. These burns were located on a thigh and a shin of a 59-years-old male person. After the first treatment as benefit the patient neither presented itching nor pain and, after the second treatment, the patient presented new tissue. This result opens the possibilities of the application of a cold plasma source to health burns.

Keywords: Thermal burns, skin burns, cold plasma, helium plasma

Introduction

Thermal burns have always been injuries caused by accidents, being of greater incidence in children and older adults. Surface burns or grade 1 burns are usually treated conservatively because the skin has a potential for reepithelialization, contrary to burns from grade 2 to grade 4 burns, which some of them have mixed patterns, or dermal lesions are deep. These pose an aesthetic and functional risk for the patient and end up compromising their life if they are extensive [1, 2]. There is an urgent medical need not satisfied with new treatments for wounds and burns infections caused by different types of bacteria [3, 4]. Among the results of research carried out in academic, clinical and industrial settings it can be mentioned: ultrasound [5], Laser [6] antimicrobial [7], negative pressure [8], micrografting [9], Colistin [10], etc.

Plasma medicine is an interdisciplinary field based on the exploit of non-thermal atmospheric-pressure plasma (cold plasma) [11, 12], which has been investigated and developed by research groups, institutions, and laboratories worldwide. The plasma medicine potential has been applied in bacteria inactivation [13] and *in vitro* cancer treatment [14-16], likewise, in the living tissues [17, 18] without causing damage due to the plasma temperature is below 40°C. The cold plasma produced at atmospheric pressure consists of charged particles, reactive species of both oxygen and nitrogen, and free radicals.

The cold plasmas of helium and/or argon have been tested in a preclinical environment in studies carried out at the Plasma Physics Laboratory of the National Institute of Nuclear Research [19]. They were applied in an experimental bio-model (laboratory mice of strain Balb/c), which were wounded with a length of ~1 cm and a depth of ~0.5 cm by a scalpel. Over the wound were applied three treatments using an argon plasma and subsequently three treatments with helium plasma, achieving accelerate healing process with the natural one [19]. This is because plasma is a potent generator of RNS/ROS species promoters of sterilization and tissue regenerators [19, 20]. By means combining these plasmas are activated the coagulation proteins and promoted the activation and formation of the platelet of the fibrin filaments [21].

Investigations related to the application of cold plasma in humans are being carried out in an

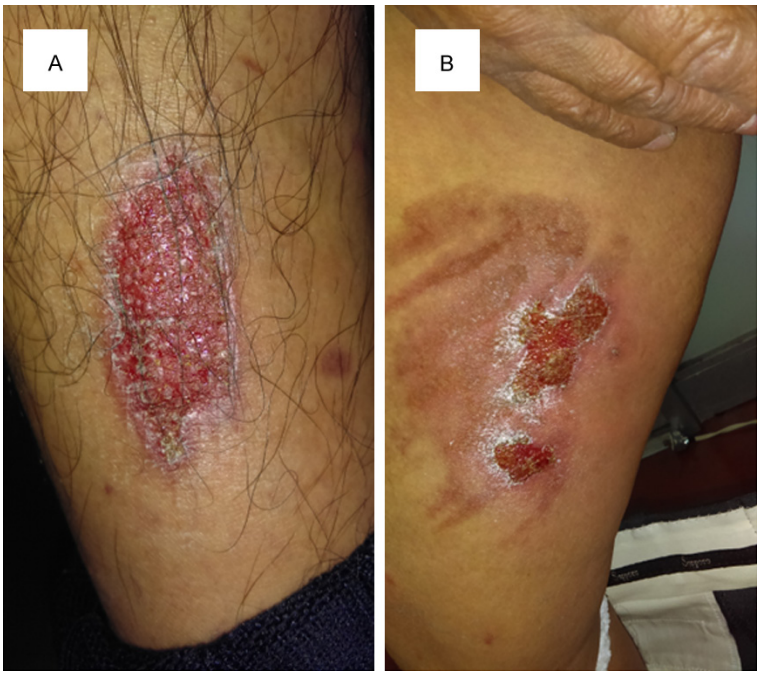

Figure 1. Burns on (A) shin and (B) thigh.

incipient way [22, 23]. In this sense, we present in this paper a case report of a person who suffered skin burns produced by boiling oil on the inner part of a thigh and the lower part of a shin. The objective of the application of cold plasma was to take advantage of the bactericidal effect of this, as well as the rapid generation of the epithelium and the anti-inflammatory process.

Materials and methods

For the helium plasma application, the parameters reported in previous work with laboratory animals by García-Alcantara [19] were considered. So, the RF generator was 13.56 MHz coupled to a capacitor-inductor-capacitor circuit, the power applied to the plasma needle reactor was 10 W, in the treatments a 0.025 Ls^{-1} of helium was used, and the time-period in each session lasted 180 seconds, the distance between the needle-type reactor and the wound was 5 mm. Only two treatments were applied in one day with separation on four hours, and a surgical cleaning was performed before each treatment.

The here reported case was conducted according to the Helsinki II Declaration and the International Standard on Clinical Investigation of Medical Devices in Human Subjects. The protocol was approved by the ethics in research and research in health committees from the ISSEMYM medical center. Also, the written informed consent of the patient for the application of the treatment, the use, and publication of the information and photographs obtained.

Results and discussion

59-year-old male reports that is a man clinically healthy and suffers by burns produced three days before. These burns were caused by boiling oil and are shown in (**Figure 1A**) over a shin with a 15 cm^2 of damage area and (**Figure 1B**) a thigh with a total damaged area of 79 cm^2, and of this, the area covered by the crust is of 9 cm^2. In these figures, you can see a slight epithelization.

The burned patient reports that he has severe pain; also that it is observed in both wounds a reddish color with blisters and inflammation. For this reason, both can be classified as burn wounds of the second degree. Besides, the patient reports that as treatment was applied the ointment with Nitrofurazone for three days.

Subsequently, the patient came back to the hospital, and it was decided to apply the treatment using a helium cold plasma by means of a needle-type reactor with the patient informed consent. A first treatment was applied with a duration of three minutes in each one of the wounds, and with the objective of eliminating the exudates fluid in the wound, it is cleaned with a surgical soap and saline solutions, before the cold application in plasma. After three hours of treatment, the appearance of the wound is shown in **Figure 2**. The patient reports that he no longer had non-itching pain and that he was able to withstand the clothing perfectly, as well as an increment in the epithelialization of the wound. There is no inflammatory process, which according to Farina et al. [24] is convenient for patients with burns. It is convenient indicating that the plasma process is a surface treatment and does not act

Figure 2. Injuries after three hours of the first treatment (A) shin and (B) thigh.

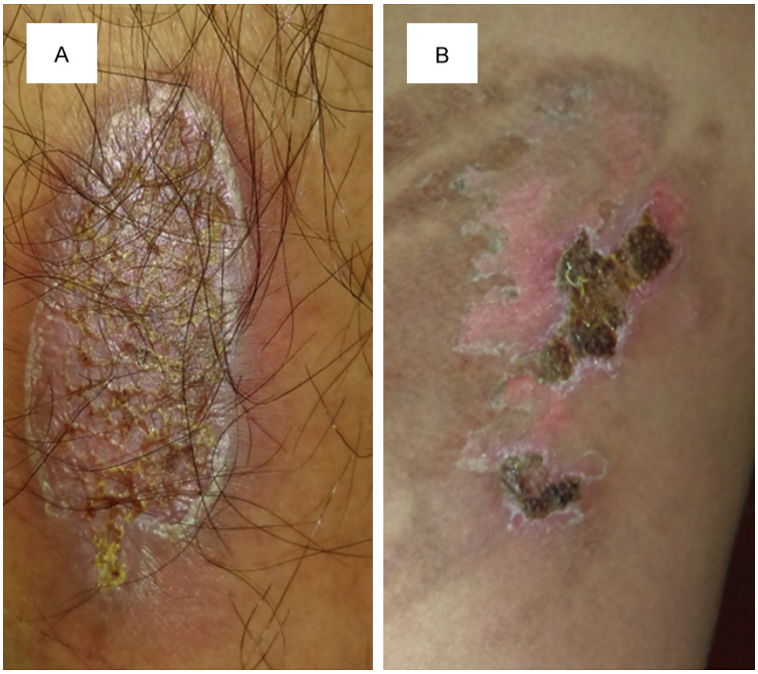

Figure 3. 16 hours after second treatment (A) shin and (B) thigh.

on the already formed crusts, this is observed in both wounds of **Figure 2**.

After three hours of the first treatment with the cold plasma, it is applied for the second time on both wounds and again for three minutes in each of them. The patient returns the next day after 16 hours after the second treatment was applied, the results are shown in **Figure 3**. First, the patient reports having no discomfort except in the crusts that have a little itch, in particular, the crust area was not modified and remained in the 9 cm^2. Also, there is a process of reepithelialization of both wounds and no longer bacterial presence.

Increased levels of free radicals generated by the cold plasma procedure may potentiate the process of wound reepithelialization, aiding the promotion of angiogenesis and influencing the bactericidal capacity of neutrophils and macrophages.

Conclusion

This new procedure for the treatment of burn wounds by the cold plasma can significantly assist in wound healing. Also, burn injuries can be directly treated since the cold plasma generates free radicals during the process preventing the infection of the wound. At the same time that the process of reepithelialization of the wounds presented in this case report did not show any inflammation effect. Possibly with the application of cold plasma early in lesions caused by burn can prevent serious complications thereof, since it can decrease the release of inflammatory mediators and bacterial colonization of wounds.

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Disclosure of conflict of interest

None.

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