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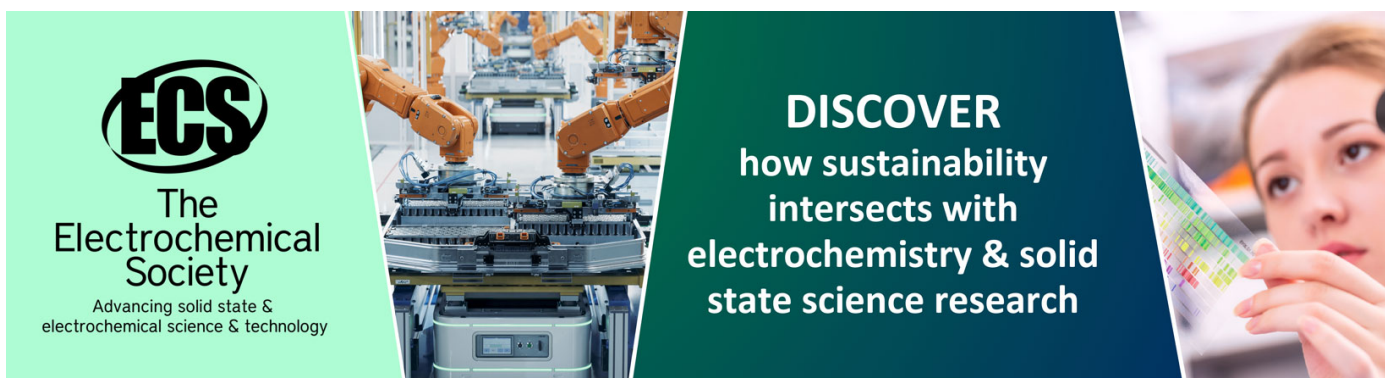
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The Effect of Plasma Treatment on the Speed of Healing of Wounds Similar to battle wounds

Tayiba Reath, Hammad R. Humud

Department of Physics, College of Science, University of Baghdad, Iraq

Email: hammad6000@yahoo.com

Abstract

Cold plasma has been successfully applied in several fields of medicine. Previous studies have provided evidence that plasma supports the healing of wounds. This work was done to study the effect of cold plasma on the speed of wounds recovery for wounds Similar to battle wounds implemented on rats. The rats were divided into four groups; the control group was injured and left untreated, in order to compare it with the groups that were treated. And the second group was treated with penicillin only Six hours after applying the wound. And the third group was treated with an argon plasma jet immediately after the wound is applied and polluted with dust. The fourth group was treated with penicillin and plasma, the plasma was used immediately, but the penicillin was used after six hours. The wound was 1 cm long and 0.5 mm deep. The rats were treated by plasm jet for three days 15 minutes per day, and the penicillin was used daily once according to the protocol. The wounds were photographed as soon as they were performed; it was visually monitored, and documented with photos after three days, seven days, and fourteen days later. It was found that wounds treated with plasma and penicillin are the best case of treatment with penicillin alone or with plasma alone, and treatment with plasma alone is better than treatment with penicillin alone. Where the wound size was became smaller and fully healed. That was by comparison with the control group that was left untreated. From this we can conclude that plasma is a possible way to speed of healing of wounds similar to battle wounds.

Keywords: Nonthermal plasma, healing wounds, Aragon plasma jet, battle wounds.

Introduction

Antimicrobial strategies are used to remove or kill bacteria and also to improve the wound's physical environment. In chronic wounds antiseptics are effective and well accepted [1]. They play an important role in the treatment of wound infection; however, especially in treating infections by multidrug-resistant strains such as MRSA they have limitations. Battle wounds, being a combination of wounds and burns at the same time, as well as contamination with dust, can turn into dangerous and chronic wounds if treatment is late, and this is what actually urges with most battle wounds, so cold plasma jet can be an appropriate solution [2,3]. Non-thermal atmospheric pressure plasma is an innovative new approach in medicine for treating chronic wounds and controlling infections and thereby improving wound healing



speed, in addition to a wide range of other applications, such as topical skin disease treatment, microbial intervention and cancer treatment [4, 5]. Atmospheric pressure non-thermal Plasma defines as partially ionizing gas [6]. Non-thermal atmospheric-pressure plasma can support wound healing by its antiseptic effects, by stimulation of proliferation and migration of wound relating skin cells, by activation or inhibition of integrin receptors on the cell surface or by its pro-antigenic effect [7,8] The wounds that do not heal are of the most important characteristic that distinguishes the chronic wounds is the presence of different types of bacteria, including the formation of biofilms. The effects of plasma can be summarize on in terms of, adhesion molecules and angiogenesis together with the role of reactive oxygen species and other components of plasma [9]. Bacterial concentrations exceeding 10^5 or 10^6 bacteria colony-forming units per gram of tissue have been shown to impair wound healing. In the majority of cases Staphylococcus aureus was identified in chronic wounds which caused together with the methicillin-resistant Staphylococcus aureus (MRSA) 20% to 50% of cases [10].MRSA infections contribute significantly to patient morbidity and mortality. New concepts and strategies controlling wound inflammation and thus improving chronic wound care are strongly needed. In this study, we will investigate the effectiveness of plasma jet in the healing of wounds similar to battle wounds. Battle wounds are burns and tear tissues with sharp tools the wounds are not clean and polluted with smoke and chemical compounds produced by weapons and dust. There is a delay in the sterilization and treatment of these wounds. Plasma jet small system does not require large electrical power and is used to treat wounds and burns of all kinds as it kills bacteria and helps tissue growth so it is a possible solution to cure and sterilize this type of wound in the field.

Experimental Work:

Materials:

Surgical blades, a shaving machine and a hair remover spray, anesthetic substance of the halothane solution, anesthetic substance of the ketamine, glass bell, Cotton, 1 CC syringes, penicillin antibiotic, scissors.

Method:

The rat was anesthetized using the solution of halothane through the nose, where the solution is placed on the cotton inside a closed bell, and the rat is placed inside it to inhale the smell of the solution and take it out after it numbs and remains under anesthesia for two minutes. After anesthesia, the rat's hair is shaved in the back using a shaving machine and a hair remover, in order to delay the hair growth for as long as possible during the treatment until the tissue is taken. Then wound was made for every rat using a scalpel to make an incision in the back of the rat with a length of 1 cm and with skin depth. Then the wound is polluted with dust mixed with the remainder of the burning powder with iron oxides to become close to the battle wounds. After completing these steps, the rats were divided into four groups to work on, and the total number of rats was twenty, with each group containing five rats. The first group: is the control group, the rats injured and leave without treatment in order to compare them with the groups that were treated. The second group: it was treated with a penicillin antibiotic, Six hours after applying the wound, the rat was injected with a 0.5cc penicillin dose, which is a ratio of the rat's size. The next day, 24 hours later, was also given penicillin the treatment continued for three consecutive days. If the treatment is with plasma, then the rat is injected using ketamine, where the rat remains under anesthesia for two hours. The third group: it was treated by plasma jet, immediately after applying the wound the rat was exposed to the plasma. The plasma jet used in this work is a home-made; it is a type of non-thermal glow discharge that works under normal atmospheric pressure, working by noble

Argon gas, by sinusoidal high voltage 10 kV peak to peak and 28 kHz frequency sustains by 150 W electrical power and plasma jet length is 3.5cm. The gas flow rate was 2.5 slm, which is the best treatment flow rate compared to previous studies. The rats were treated for 15 minutes, as the plasma was passed on to the wound and to the adjacent wound areas to expedite the wound healing process as shows in figure 1. The treatment lasted for three days. The fourth group: it was treated using plasma jet with the penicillin antibiotic. The treatment was performed by the same way that was accomplished in the case of plasma and penicillin, now they were collected together.



Figure (1): Rat was under Plasma jet treatment.

Results and discussion

Figure (2) represents the stages of wound healing for the four groups for the third, seven and fourteenth days respectively after wounds were applying and treated in the manner that was presented. The wounds were visually monitored and photographed with a camera. Figure 2A represents the control group in day 1, 3, 7 and 14 of healing process, Fig.2B represents the penicillin group, (Fig 2C) represents the plasma group, (Fig.2D) represents plasma and penicillin group For the same time period.





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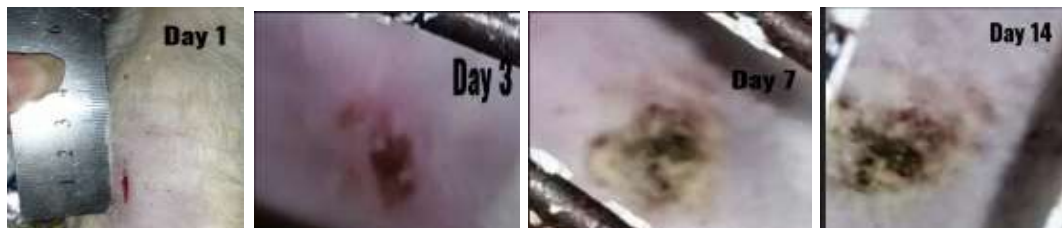


Figure (2): The stages of wound healing for the four groups for the third, seven and fourteenth days respectively, after wounds were applying and treated (A) the control group (B) the penicillin group, (C) the plasma group, (D) plasma and penicillin group

The best healing group is group (4) actually that is because the synergism effect of both plasma and Penicillin. When comparing penicillin (group 3) and plasma (group 2) the best is the plasma group that refers to the plasma mechanism in treating wounds because it helps to kill bacteria and other microorganisms which have the ability to cause infection. Cold plasma jet are complex mixtures of charged particles, reactive atoms, and molecules e.g., atomic oxygen, ozone, hydroxyl group, oxides of nitrogen, electric fields, and ultraviolet (UV) radiation. Each one of these individual agents can cause microorganisms deactivation. Also plasm jet has another action on wounds it promotes healing and cause blood clotting. Plasma can support wound healing by its antiseptic effects, by stimulation of proliferation and migration of wound relating skin cells, by activation or inhibition of integrin receptors on the cell surface or by its pro-antigenic effect. Another advantage of the plasma is the exposure time we only expose the wound for 15min per day while in penicillin we expose the whole rat body for penicillin since penicillin works for 24hr. There are special cases the plasma healing process became the most preferable one , These cases include penicillin sensitive individuals, impaired liver function individuals , impaired kidney individuals and penicillin resistance individuals (penicillin doesn't works) these groups of patients have serious danger effects if we used the penicillin so we have an option to replace by plasma.

Conclusions

It can be conclude that wounds treated with plasma and penicillin are the best case of treatment with penicillin alone or with plasma alone, and treatment with plasma alone is better than treatment with penicillin alone. Where the wound size was became smaller and fully healed. That was by comparison with the control group that was left untreated. Plasma is a possible way to speed of healing of wounds similar to battle wounds. There are special cases where plasma healing has become the most preferred, and these cases include individuals sensitive to penicillin, poor liver function, weak kidney members and individuals with penicillin resistance (penicillin does not work) These groups of patients their use of penicillin has serious effects so we have the option to replace with plasma.

References

- [1] Daeschlein G. “Antimicrobial and antiseptic strategies in wound management”, *Int Wound J*, 2013, 10 (1), 9–14.
- [2] Zilan Xiong, *Permits unrestricted use, distribution, and reproduction in any medium, Licensee IntechOpen, Chapter 1*, 2017.
- [3] Haertel B, von Woedtke T, Weltmann K-D, Lindequist U. “Non-thermal atmospheric pressure plasma possible application in wound healing”, *Biomolecules & Therapeutics*. 2014, 22(6), 477-490
- [4] Xiong Z., Lu X. P., Feng A., Pan Y., and Ostrikov K., “Highly effective fungal inactivation in He+O₂ atmospheric-pressure nonequilibrium plasmas”, *Physics of Plasmas*, 2010, 17 (123502), 1–6.
- [5] Weltmann K-D, von Woedtke T. Plasma medicine—Current state of research and medical application. *Plasma Physics and Controlled Fusion*. 2017, 59(1), 14031
- [6] Yousfi M, Merbahi N, Pathak A, Eichwald O. “Low-temperature plasmas at atmospheric pressure: Toward new pharmaceutical treatments in medicine”. *Fundamental & Clinical Pharmacology*. 2014, 28(2), 123-135
- [7] Beate Haertel, Thomas von Woedtke, Klaus-Dieter Weltmann and Ulrike Lindequist, *Biomol Ther*, 2014, 22(6), 477-490.
- [8] Werdin F, Tennenhaus M, Schaller H-E, Rennekampff H-O. “Evidence-based management strategies for treatment of chronic wounds”, *Eplasty*, 2009, 9, 19.
- [9] Lloyd G, Friedman G, Jafri S, Schultz G, Fridman A, Harding K. Gas plasma: Medical uses and developments in wound care. *Plasma Processes and Polymers*. 2010, 7(3-4), 194-211
- [10] Sayyada G.N., Amna S., Shazia T. Hakim, Yasmeen A., and Shahana U. Kazm., "Effect of Growth Media, pH and Temperature on Yeast to Hyphal Transition in *Candida albicans*" *Open Journal of Medical Microbiology*, 2013, 3, 185-192.