An-Najah University Journal for Research – A
Natural Sciences

Effect of Using Non-Thermal Plasma Torch on Bleeding and Coagulation Times in Patients with a Family History of Blood Clotting Diseases

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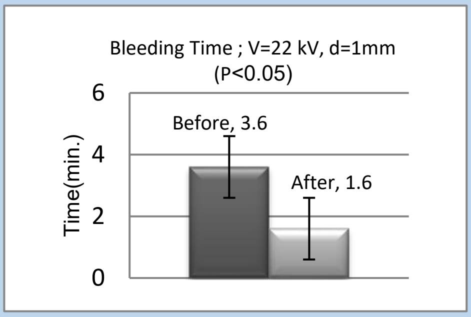
(Type: Full Article). Received: 28th Oct. 2024. Accepted:23th Jan. 2025, Published: 1st Feb. 2026,
DOI: https://doi.org/10.35552/anujr.a.40.1.2382

Abstract: Non-thermal plasma is considered one of the modern health tools that have been used in the medical field, especially in biological and clinical applications. Non-thermal plasma torch was designed and generated for medical use. Fifty Iraqi patients of different ages (25-50 years) and both sexes admitted to Ramadi Teaching Hospital, with a family history of blood clotting diseases were included in this study. Patients suffering from blood disorders (hemophilia) were excluded, as were those taking warfarin, those who underwent open heart surgery, and those with other clotting factors. Plasma torch was used, its effect on the coagulation time and the bleeding time for patients, the change that occurs using non-thermal plasma was observed. Two tests were performed on patients (Coagulation Time, CT and Bleeding Time, BT). The results showed that the plasma torch has a significant effect on clotting time and bleeding time; a decrease of (30-60%) according to the applied voltage and gap distance (the distance between the electrodes). The effect of plasma torch treatment was larger when the gap distance decreased from 2 mm to 1 mm. These results emphasize the therapeutic role of plasma in reducing clotting time and bleeding time at high applied voltages, thus accelerating wound healing in patients.



Keywords: Cold Plasma, Clotting Time, Torch Plasma, Bleeding Time.

Introduction

Plasma is one of the states that are widespread in the universe, such as stars and the sun. It is considered one of the most common states of matter [1]. Since the 19th century and earlier, plasma has been used for medicinal reasons;

I. Langmuir first coined the term "plasma" in 1928. As a result, laboratory-produced low-temperature plasma functioned under low pressure during the 20th century [1,2].

Plasma has been used in industrial, laboratory and medical fields because it is a gas consisting of electrons and ions in addition to being atoms and molecules [2,3].

Plasma is divided into two main types: hot plasma (thermal plasma), which is unbalanced and has a high temperature that reaches the ionization degree, and cold plasma (non thermal plasma), which has a low temperature and has electrons at high temperatures in addition to being low in ionization, which made it important in the medical field[4,5].

Arc discharge and plasma torch produce hot plasma, which is not appropriate for use in biomedical applications. This type of plasma is produced at atmospheric pressure. While atmospheric pressure plasma is a thermal plasma that is not appropriate for use in biomedical applications such as the destruction of bacteria, the surface modification of polymers, and surface treatment techniques in thin films, cold plasma, which is produced by arc discharge and plasma torches, has been used in industrial and medical fields [6].

Low-temperature plasmas produced at atmospheric pressure gained popularity in the late 1980s and were designed to safely interact with biological cells and tissues [4].

When low-temperature, atmospheric-pressure plasma was first used to inactivate germs and reactive species in plasma and proved to be usefull, plasma medicine began to take shape in the middle of the 1990s. With the first clinical studies on cancer therapy and wound healing, plasma medicine, an emerging medical area, has achieved significant milestones [7, 8].

In 2008, cold plasma sources were employed in dermatology as well as other medical and cosmetic fields. In Europe, other plasma devices are now employed in a variety of medical applications. In 2013, medical plasma devices received the Medical Device Certification. Plasma medicine has grown significantly over the past 20 years, as evidenced by the number of studies carried out globally, the number of research centers, institutions, and labs, as well as the publication of several books and community medical apps [9–11].

The plasma torch is a non-thermal plasma source that can be operated with different gases such as argon gas at high pressure or atmospheric pressure [7].

Plasma can be generated in the laboratory through two connectors connected to a pulse power source, one of the poles is connected to an insulator to prevent arc formation after the breakdown voltage. So the plasma consists of a large number of micro channels or threads that are distributed randomly on the

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insulator layer despite the high voltage applied but with a low current. This promotes the use of this type of plasma for medical application such as open injuries or living tissue without any damage to it [12,13].

Wound healing is a chemical and biological process that requires several complex changes for healing. In order for a wound to heal, it needs to reduce tissue damage during treatment or stop it and prevent the formation of bacteria [14]. Wounds may be simple or difficult, such as diabetic or venous ulcers. Some wounds need longer periods of healing [15,16].

Materials and Methods

The plasma torch in this study included a discharge of an insulating barrier, operates with a high-voltage current that is applied to two conductors, one of which is covered with an insulating material to prevent arc transmission and limit the current. In this study, the distance between the sample and the plasma is changed, as well as the applied voltage through the electrical connection between the conductive electrode covered with an insulating material, thus the plasma is generated between the treated material or the target amid the insulator. In Figure (1) a simplified schematic diagram of a plasma torch undergoing medical treatment is shown.

Fifty Iraqi patients of different ages (25-50 years) and both sexes admitted to Ramadi Teaching Hospital, with a family history of blood clotting diseases were included in this study. Patients suffering from blood disorders (hemophilia) were excluded, as were those taking warfarin, those who underwent open heart surgery, and those with other clotting factors. The study was conducted from September 2023 to end of February 2024. In this study, patients who underwent open heart surgery were excluded, as well as those suffering from blood changes such as hemophilia, and those who take one of the anticoagulant factors such as warfarin. In addition, patients who underwent the study did not receive any previous chemotherapy or surgical treatment.

Time of coagulation (CT): patient's finger was pricked with a scalpel, and a drop of blood was extracted. When there was blood in the capillary tube, it was closed and put into a water bath. At that moment (1 min.), the capillary tube was broken into small pieces so that the fibrin thread appeared between the two broken ends, the method was repeated, but by exposing it to a plasma torch for comparison [17].

Time of bleeding (BT): Blood is taken from the earlobe of the patient. A glass slide is placed in the ear and fixed; then the earlobe is pierced with a scalpel to a depth of (3 mm) and blood drops are taken with filter paper at regular periods (30 seconds), by moving the filter paper to touch each drop so that no traces of blood appear on the filter paper. The stopwatch is stopped and the time is measured. The same method is repeated, but by exposing the earlobe to the plasma torch [18,19]. The data were analyzed using the statistical Package for Social Sciences (SPSS). Differences in coagulation and bleeding times before and after plasma torch treatment were examined using Paired t-test. The difference was declared significant at P ≤ 0.05.

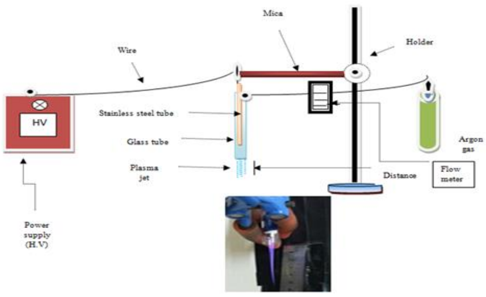


Figure (1): Torch plasma.

Results and Discussion

Plasma torch was used, its effect on the coagulation time and the bleeding time for patients, the change that occurs using non-thermal plasma was observed.

Effect of plasma torch on clotting time:

Non-thermal plasma (plasma torch) is generated with different voltages (17 and 22 kV) and gap distances (1 and 2 mm). Figure (2) and figure (3) show that the plasma torch has an effect on clotting time; a decrease of (30-60%) according to the applied voltage and gap distance. This emphasizes the therapeutic role of plasma in reducing the clotting time at high applied voltages, thus accelerating blood clotting and wound healing.

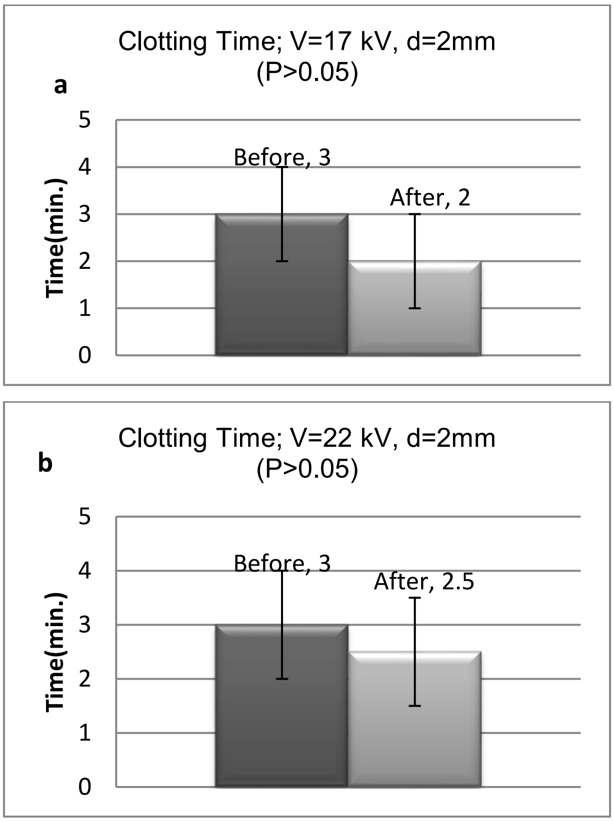
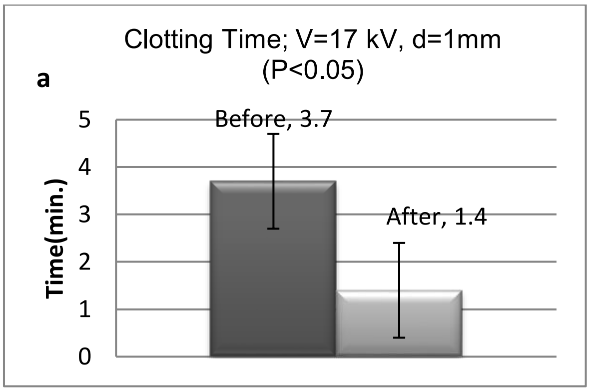


Figure (2): Clotting times prior to and during plasma torch treatments when the gap distance is 2mm and applied voltages are a) 17kV, b) 22kV

The effect of plasma torch treatment on the coagulation time was larger when the distance between electrodes decreased. At 2 mm gap distance, clotting time decreased from 3 to 2 minutes (P>0.05) at 17 kV and decreased from 3 to 2.5 minutes (P>0.05) at 22 kV (Figure 2). At 1mm distance, it decreased from 3.7 to 1.4 minutes (P<0.05) at 17 kV and from 3.5 to 1.35 minutes (P<0.05) at 22 kV (Figure 3).



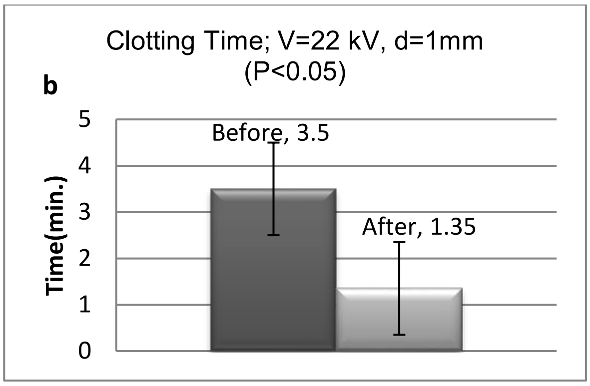


Figure (3): Clotting times prior to and during Plasma Torch treatments when the gap distance is 1mm and applied voltages are a) 17kV, b) 22kV.

The shrinking distance is significant in creation of Cold Plasma, the plasma torch properties depend on the applied voltage in addition to the distance between the electrodes, thus decreasing the coagulation time and accelerating the blood coagulation process.

Through the two figures, it is clear that the medical and physical effects of plasma torch depend on the voltage and gap distance, which leads to the biological activity of the various forms of produced plasma and the homogeneity of Cold Plasma.

When comparing Figure (2) with Figure (3) at the same voltage and changing the distance, it appears that the coagulation time is different before and after treatment, and this shows the role of the gap distance in coagulation acceleration.

A plasma torch is produced as the powered electrode gets closer, reducing the distance to less than 2 mm. If the distance grows, thin plasma will be produced, which will lower the concentration of ions and prevent wounds from healing, slowing blood coagulation [20, 21].

Effect of plasma torch on bleeding time:

The bleeding time represents the constriction of the blood vessels and the formation of a plug from the blood plate. When changing the gap distance and applied voltage, the changes appear as shown in Figure (4).

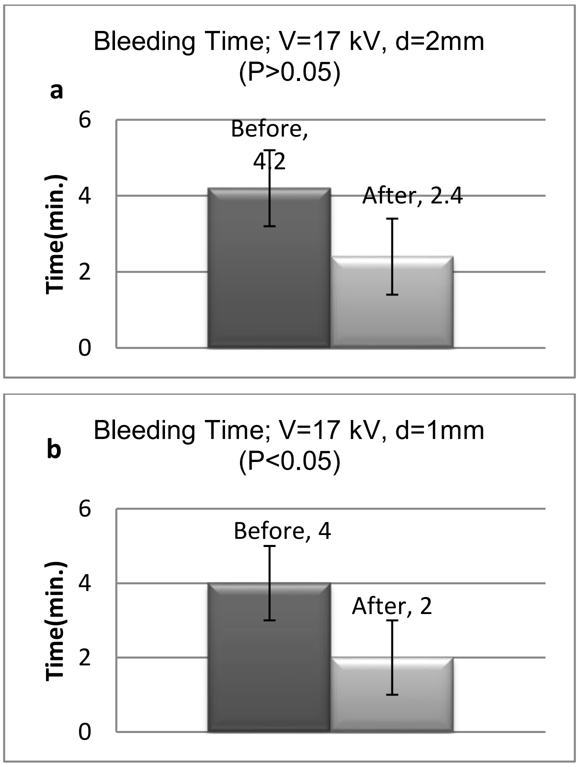


Figure (4): Bleeding Time before & after Plasma Torch treatments when applied voltages (17kV), the gap distance is a) 2mm b) 1 mm.

At voltage time 17 Kv, plasma torch reduced bleeding time approximately 50% (Figure 4). The mean bleeding time decreased from 4.2 to 2.4 minutes at 2mm gap distance (P>0.05) and decreased from 4 to 2 minutes (P<0.05) at 1 mm gap distance (Figure 4).

Figure 5 shows bleeding time for applied voltage of 22 kV and gap distances of 2 and 1 mm. The figure shows the same previous behavior with larger effect at lower gap distance; the bleeding time decreases more when using 1 mm gap distance compared to 2 mm. Average bleeding time after plasma torch treatment decreased from 3.5 to 2.4 minutes (P>0.05) at 2 mm gap distance and decreased from 3.6 to 1.6 minutes (P<0.05) at 1 mm gap distance (Figure 5).

The stimulation of the ions to the plasma torch causes stimulation of a number of coagulation processes when the applied voltage is increased and the distance between the electrodes is reduced, thus stopping bleeding and accelerating coagulation processes.

Non-thermal plasma system is an effective method in medical application and stimulation of coagulation without any thermal effect. Therefore, plasma plays a role in its ability to accelerate wound healing as well as sterilizing wounds [22], this is consistent with *Kuo, S*. who discussed the mechanism of cold atmospheric air plasma and blood coagulation.[23].

The activation of platelets and the formation of fibrin threads resulted from the ability of the plasma to activate and strengthen it. It can quicken the blood clotting process, and this affects protein concentrations in blood. The higher the ion concentrations in the non-thermal plasma, the higher the stimulation for coagulation processes [23, 24].

The plasma ions stimulate the complex biological and chemical processes that occur during blood coagulation, this appears in the increase in the volume of the plasma treated model while maintaining the surface area and the formation of a mass of coagulation on the surface, not the volume [25,26].

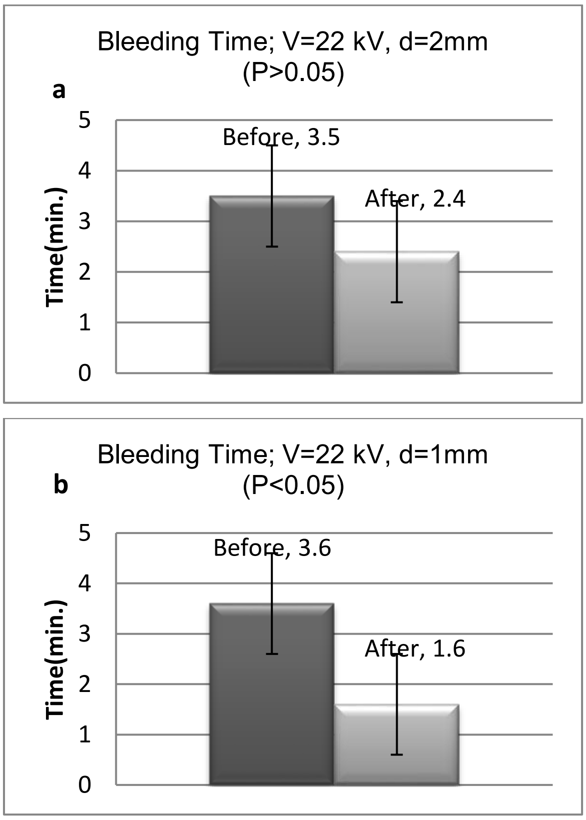


Figure (5): Bleeding Time before & after Plasma torch treatments when applied voltages (22kV) and the gap distance is a) 2mm b) 1 mm.

Conclusion

The plasma torch is a tool used in medicine without any harm, and it has a role in coagulating the blood quickly. The degree of coagulation depends on the time of exposure and the applied voltage, in addition to the distance between the electrodes.

Two tests were performed on patients (Coagulation Time, CT and Bleeding Time, BT). The results showed a decrease in clotting and bleeding times compared to the control, particularly at smaller gap distance, thus acceleration of wound healing resulting from an acceleration of the clotting time for blood samples and generating free radicals such as OH,O3.

Disclosure Statement

- **Ethics approval and consent to participate:** The study was conducted under a protocol approved by a local ethics committee at the University of Anbar / College of Medicine /Ramadi under the reference number (133) dated on September (4\9\2023).
- **Consent for publication:** Not applicable
- **Availability of data and materials:** The raw data required to reproduce these findings are available in the body and illustrations of this manuscript.
- **Author's contribution:** The authors confirm contribution to the paper as follows: study conception and design: Mohammed U., theoretical calculations and modeling: Mohammed U.; data analysis and validation, Enas S., draft manuscript preparation: Enas S. All authors reviewed the results and approved the final version of the manuscript.
- **Conflicts of interest:** The authors declare that there is no conflict of interest regarding the publication of this article

- **Funding:** This research did not receive any specific grant from funding agencies in the public commercial or not –for profit sectors.
- **Acknowledgements:** All appreciation and thanks to the medical laboratories at Al-Ramadi Teaching Hospital and to all its employees, and I express my thanks to the College of Medicine at University of Anbar.

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References

1] Conrads H, Schmidt M, Plasma generation and plasma sources, Plasma Sources Sci. Technol. 2000; 9: 441–454.

2] Tendero C, Tixier C, Tristant P, Desmaison J, Leprince P, Atmospheric pressure plasmas, A review. Spectrochim Acta Part B. 2006; 61:2–30.

3] Backer M., Development and characterization of a plasma needle for Biomedical Application, Thesis submitted to Aachen University of Applied Science. 2007.

4] Hammad R., Ahamad S.Wasfi, Wafaa Abd Al-Razaq, Mazin S. El-Ansary, Argon plasma needle source", Iraqi Journal of physics. 2012; 10(17): 53-57.

5] Chen C.Y., Fan H.W., Kuo S.P., Chang J., Pedersen T., Mills T., Huang C.C., Blood Clotting by Low Temperature Air Plasma, IEEE Transaction on Plasma Science. 2009; 37: 993-999.

6] Hussein, M.U, Mohsen, R.T., Ambient Decontamination by Non -Thermal Plasma in Atmospheric Pressure Air, Journal of Physics: Conference Series. 2018; 1032(1): 020014-1–020014-5.

7] Kasih T.P, Development of novel potential of plasma polymerization techniques for surface modification, dissertation submitted to graduate school of engineering Gunma University for degree of doctor of Engineering. 2007.

8] Metelmann H-R et al, Clinical Plasma Medicine. 2015; 3: 17–23

9] Metelmann H-R, von Woedtke T and Weltmann K-D ed, Comprehensive Clinical Plasma Medicine (Berlin: Springer). 2018.

10] Toyokuni S, Ikehara Y, Kikkawa F and Hori M, Plasma Medical Science (London: Academic). 2018.

11] Keidar M, Plasma Cancer Therapy (Cham, Switzerland: Springer Nature). 2020.

12] Kitano K. , Furusha H., Nagasaki Y., Ikawa S., and Hamaguchi S., 28th International Conference on Phenomena in Ionized Gases was held in prague, the capital of the Czech Republic. 2007;1131-1134.

13] Fridman G., Direct plasma interaction with living tissue, a thesis submitted to the faculty of Drexel University in partial fulfillment of the requirements for the degree of Doctor of Philosophy. September 2008.

14] Hussein, M.U., Mohsen, R.T, Evaluation of a Plasma Torch in the Inhibition of Escherichia Coli Bacteria in Water, AIP Conference Proceedings. 2024;3051(1): 020014.

15] Kuo, S.P., Chen, C.Y., Lin, C.S. and Chiang, S.H., Applications of Air Plasma for Wound Bleeding Control and Healing, IEEE Transaction on Plasma Science. 2012; 40: 1117-1123.

16] Chang M H, Wu J Y, Li Y H, Surface &Coatings Technology. 2010; 204: 3729.

17] Tendero C, Tixier C, Tristant P, Spectrochimica Acta:. 2006;Part B 61: 2.

18] Gregory Fridman, Alexey Shereshevsky, Marie Peddinghaus, Alexander Gutsol, Victor Vasilets, Ari Brooks, Manjula Balasubramanian, Gary Friedman, Alexander Fridman, Bio-Medical Applications of Non-Thermal Atmospheric Pressure Plasma, Plasma Medicine Lab, Drexel Plasma Institute, Chestnut, Philadelphia, Drexel University. 2006;3141: PA 19104.

19] Mahapatra B. & Mishra N., Comparison of Bleeding Time and Clotting Time in Different Blood Groups, American Journal of Infectious Diseases. 2009; 5 (2): 106-108.

20] Ivy, A. C., Nelson, D., & Beecher, G., J. Lab. Clinical Medicine.1989; 26: 1812.

21] Kuchenbecker, M., Bibinov, N., kaemlimg, A., Wandke, D., Awakowicz, P. & Viol, W., characterization of DBD plasma source for biomedical applications, .J.Phys.D:Appl.phys. 2009; 42:045212.

22] Abbas, I.K, Hussein, M.U., The effect of non-thermal plasma needle on staphylococcus aureus bacteria, Biochemical and Cellular Archives. 2018; 18(2): 1767–1771.

23] FridmanG., M.Peddinghaus, M.Balasubramanian, H.Ayan, A. Fridman, A.Gustol, and A.Brooks, Blood Coagulation and living tissue sterilization by floating–electrode dielectric barrier discharge in air, Plasma chem., plasma process. 2006; 26: 425-442.

24] Kuo, S., Hemostasis Efficacy and Mechanism of Cold Atmospheric Air Plasma, *Open Journal of Emergency Medicine*. 2021; 9: 66-83.

25] O'Connell SM, Impeduglia T, Hessler K, Wang XJ, Carroll RJ, Dardik H, Autologous platelet-rich fibrin matrix as cell therapy in the healing of chronic lower-extremity ulcers, Wound Repair Regen. 2008; 16 (6): 749–56.

26] Knighton DR, Ciresi KF, Fiegel VD, Austin LL, Butler EL, Classification and treatment of chronic Nonhealing wounds. Successful treatment with autologous platelet-derived wound healing factors (PDWHF), Ann. Surg. 1986; 204 (3): 322–30.