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Research on skin tissue improvement to burn by plasma irradiation
火傷部位へのプラズマ照射による皮膚組織改善に関する研究

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The industrial applications of atmospheric pressure plasma are generally known as sterilization, surface modification of materials, welding and thermal cutting etc. However, plasma has currently attracted increasing attention in medicine. According to the recent researches, atmospheric pressure plasma has able to promote faster wound healing when it directly irradiated to a wound. This research investigates the tissue improvement on burn sample, and effects of atmospheric pressure plasma due to irradiating at regular time intervals (30, 90, and 150s). After 7 days, it has been found that the burn by plasma treatment was likely to be bulged, and hair growth under the scab confirmed. Those findings support plasma impacts on tissue activation, and there is a correlation between tissue and ions/radicals generated by plasma.

1. Introduction

Plasma dose exist in the form of lightning and in the aurorae in natural world. The characteristics of plasmas are various by generating conditions. Therefore, it has been artificially applied in a wide range of fields.

In industry, for example, welding, thermal cutting and surface modification of materials have mainly achieved, but the most significant development of plasma technologies in present are in the medical field such as blood coagulation or sterilizations.

Previous research has documented that atmospheric pressure plasma (APP) irradiation has appeal to better wound healing by Prof. Friedman group of Drexel University (Philadelphia, USA).[1]

And we also found that APP irradiation has promoted healing and cell proliferation.[3][4] However, there has no clear understanding for mechanism yet. It is important to understand this mechanism for medical use. Thus we investigate the effect of tissue by APP irradiation on wound.

2. Material and Methods

We used male Wistar rats [Total of n: 12, specific pathogen free (SPF), 5 weeks-old, initial body weight: 92−110 g], anesthetized using Somnopentyl (Kyoritsu Seiyaku, main ingredient: pentobarbital sodium). Back bristles of rats were shaved and made a full thickness burn (28 mm^2) on the back of them by homemade burn formation device that can freely control temperature, pressure, and height of heating unit. The irradiation of APP on burns was performed daily. Irradiation time was at 30, 90, and 150 s respectively. And the state of each burn had observed for 16 days.

These animal experiments conformed to the Guidelines for Animal Experiments at Tokyo City University.

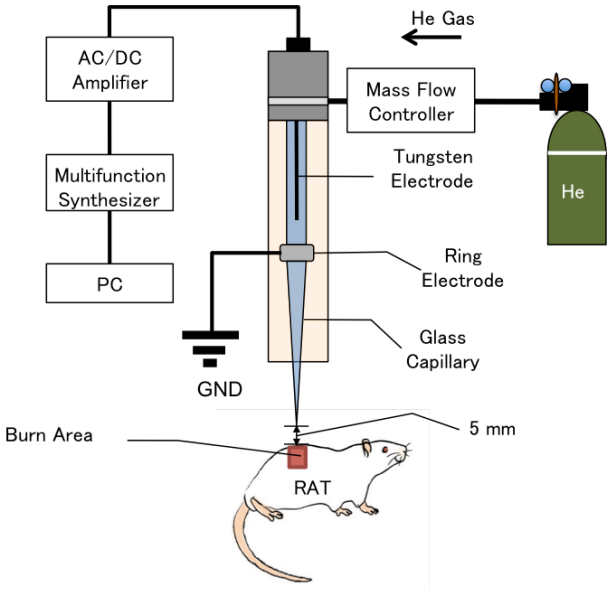

Fig.1. Atmospheric Pressure Plasma apparatus

Figure 1 shows APP apparatus; both multifunction synthesizer (NF WF1945B) and AC/DC amplifier (NF HVA4321) under the conditions of voltage 8 $kV_{p\text{-}p}$, frequency 3 kHz are connected to plasma reactor. This reactor consists of tungsten electrode inserted inside the glass capillary and surrounded by a grounded (GND) ring

electrode. Helium (He) gas under the control of mass flow controller is also supplied on contrast side (He gas flow rate: 1 L/min). Irradiation distance from top of capillary to rat's skin surface is 5 mm.

3. Result

Figure 2 below shows burn images of 0, 7, 14 days after created burn in the back of rats. The burn in control had unexpected scars because it was bitten by other rats. After 7 days, the burn found in slight bulging only in plasma treatment. Here, one of burn rat in group by plasma irradiation at 90 s died because of improper anesthesia which injected into organ. Then, burn skin sample in death took out and cut for the observation. Figure 3 shows the state of burn and cross section of rat's tissue from one that found in mortality. It has confirmed hair growing under the scab.

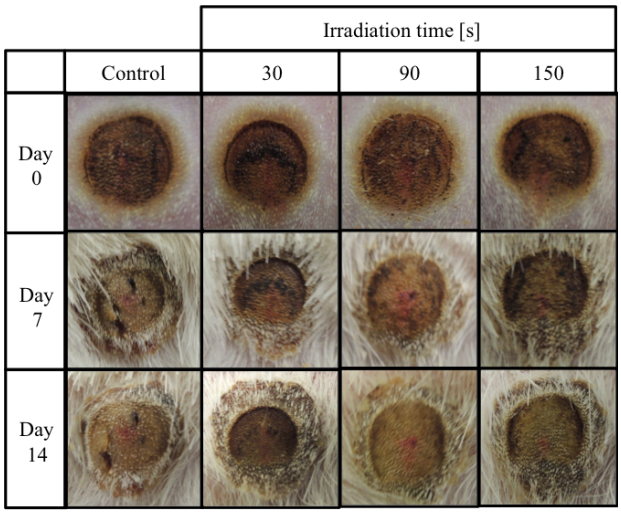

Fig.2. Photographs of plasma-irradiated burn rats

Fig.3. Burn and cross section of rat's tissue

4. Discussion

Formation or types of reactive oxygen and nitrogen species are changing when plasma irradiation time changes. Therefore, our concern is to examine how the burn changes by different irradiation times. It is assumed that activate tissues related to both ions and radicals inside plasma. In particular, reactive oxygen and nitrogen species, such as superoxide (O_2^-), hydrogen peroxide (H_2O_2), OH radicals, nitrites (NO_2^-), nitrates (NO_3^-) and peroxynitrite ($ONOO^-$) are closely connected with tissues activation. However, Figure 2 obtained shows no remarkable difference on burns with gross pathology until 14 days. Besides, we found hair under the scab in plasma treated rat in 7 days. So, there is possibility of appearing other effects of plasma after 14 days. Oxidative stress caused by reactive oxygen and nitrogen species which are involved in proliferation of cells. The research indicates that cell proliferation caused by low degree of oxidative stress.[4]

Hair growing under the scab is conceivable that this tissue was activated by plasma irradiation. Hair matrix cells damaged when made a burn but from the results, it seems to promote tissue repairing on it through plasma irradiation. So far, the significance of this finding is unclear but plasma treating on the bulge of burn skin influenced hair growth.

5. Conclusion

This research investigates the tissue improvement on burn sample, and effects of atmospheric pressure plasma due to irradiating at regular time intervals (30, 90, and 150 s). From the outcome of our investigation it is possible to conclude that the APP irradiation lead to tissue activation on burns following the activity of oxidative stress. This included the process of broken hair matrix cells to be repaired. Clearly, further research will be needed to measure the degree of oxidative stress during APP irradiating on burn.

References

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