

Irradiation experiments to the mouse using the mild plasma generator for the medical application

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In order to explore new applications using plasma technologies, we have studied irradiation effects on mouse organs and cell lines by the mild plasma generator. Recent advances on plasma technologies promote to practical use of atmospheric pressure plasmas. Advantages on this type plasma technology are the simplified operation system and the low pyretic comparing with the arc plasma, the feasibility of which is appreciated in medical cares and bio-industry [1,2]. As an example of practical use of the plasma in medical cares, to stop bleeding has been performed in the case of the endoscopic mucosal resection [1]. This type of plasma is so-called argon plasma coagulator (APC) and flows the current through the human body. It has been reported that APC plasma accidentally occurred the arc like plasma to generate severe damages such as perforation of stomach wall, and was not controllable during the operation. Taken together, the system that generates the current must be improved for blood coagulator [2].

We have developed a mild plasma generator (MPG) which produces low temperature and glow like plasma. MPG is based on the dielectric barrier discharge [3] and designed to reduce the current flow and leakage of high frequency electric field. To produce the plasma, the voltage of $\pm \sim 10$ kV with the frequency of less than 100 kHz was applied, and the flow rate of working gas was ~ 2.0 l/min, here, helium gas was used. The Plasma produced under the atmospheric pressure was irradiated to the bleeding area of the mouse thigh. Here, bleeding is artificially generated by cutting femoral artery under the anesthesia. Within 10 seconds from beginning of the plasma irradiation, the blood was coagulated and the coagulated blood covered the cut out part of femoral artery, then stop bleeding. From the view point of pathological analysis, it was found that tissue damages which were typically induced by the heat injury were not observed. Coagulated blood was distributed also in the inner cavity of femoral artery as shown in Fig. 1. In cases of laser or high-frequency coagulator, the occlusion of the blood vessel due to the tissue damages which are induced by the scald is observed. However, blood coagulation by the mild plasma irradiation induces much less tissue damages than these techniques. It is considered that coagulation denature which induced by the plasma conducts to stop bleeding. Different principle of the bleed control between the plasma and leaser or high-frequency coagulator might exist. Therefore, it is concluded that MPG has a possibility to expand to the medical field as a stop bleeding principle with the safety.

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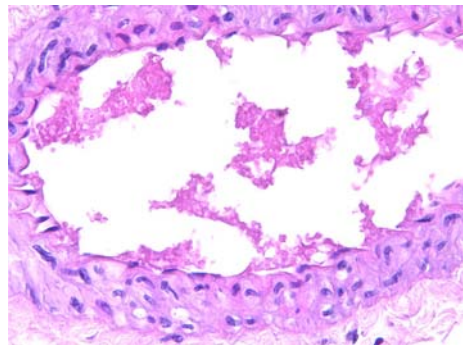


Fig. 1. Tissue image (histological specimen) around the blood vessel after the plasma irradiation (magnification of 400). Nucleuses of the smooth muscle and cytoplasm are dyed blue and pink, respectively. Pink colored matters in the cavity region indicate the coagulated blood.