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Functional recovery of hypoxic ischemic encephalopathy by atmospheric pressure plasma inhalation
大気圧プラズマ吸入による低酸素性虚血性脳症の機能改善

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Atmospheric pressure plasma is takaen notice not only industrial field ,but also medical field. We accomplished the experiment concerning the functional recovery of HIE by atmospheric pressure plasma inhalation. The mixture of mixes O_2 and N_2O with the atmospheric pressure plasma together has the possibility of influencing the cerebral blood vessel. It is thought that nitrogen oxides (NOx) can be expected of the improvement of the hypoxic ischemic encephalopathy.

1. Introduction

Atmospheric-pressure plasmas are indispensable for sterilizing, disinfecting, and disintegrating hazardous materials and modifying material surfaces. New biomedical applications have also been found for these plasmas, although the mechanisms of action remain unknown. We believe that the mechanism of action of plasma technology should be clarified. Plasma and pulsed electric field technologies have diverse applications, such as bacterial or bacteriophage inactivation by atmospheric pressure plasma, argon plasma coagulation during surgery, living tissue sterilization by floating-electrode dielectric barrier discharge (FE-DBD), skin regeneration using multiple low-energy plasma therapy. Moreover, the DC arc discharge plasma medical device for nitric oxide (NO) therapy, PLASON®, is used for various pathologies, such as burn wounds, necrotic suppurative ulcer (diabetic peripheral neuropathy), diabetic foot, rheumatoid arthritis, skin disorders, and herpes virus.

On the other hand, hypoxic ischemic encephalopathy (HIE) is a condition in which the brain does not receive enough oxygen. HIE can be fatal. Brain cells can begin dying within as little as five minutes without oxygen. There are a variety of causes of HIE. Although any injury and many health conditions can cause a lack of oxygen to the brain, there is no cure for HIE[1].

We accomplished the experiment concerning the functional recovery of HIE by atmospheric pressure plasma inhalation

2. Material and method

Atmospheric pressure plasma inhalation

A schematic diagram of the experimental setup is shown in Fig. 1[2,3]. The coaxial plasma source has a 1-mm-diameter tungsten wire inside a glass capillary that is surrounded by a grounded tubular electrode. The AC/DC amplifier and multifunction synthesizer are controlled by a PC and provides a high voltage for plasma generation. Plasma was generated under the following conditions; applied voltage: 8 kVpp, frequency: 3 kHz, helium (He) gas flow rate: 1 L/min, and duration of plasma irradiation: 90 s.

HIE model rat

A HIE model rat (Levine rat model) undergoing plasma inhalation is shown in Fig.1[3]. The rat HIE model used here involved ligating the left common carotid artery with 3-0 silk to induce ischemia in the brain. The 7-day-old rats were allowed to recover for an hour and placed for 2 h in hypoxia chamber (oxygen: 8%, nitrogen: 92 %, temperature: 37°C). HIE model rats (n: 5, initial body weight range: 10.3−14.9 g) were anesthetized with 1.5% sevoflurane, nitrous oxide (N_2O): 6 L/min, and oxygen (O_2): 2 L/min using an anesthesia device with a mechanical respirator (Dräger Fabius® Tiro [TW]).

The 3-week-old HIE model rats were anesthetized by sevoflurane inhalation, they were done the plasma inhalation for two weeks. The experimental conditions of the plasma inhalation are follows; Inhalation-1: O_2 (8.0 L/min) and Inhalation-2: (O_2: 2.1 L/min + N_2O: 5.9 L/min).

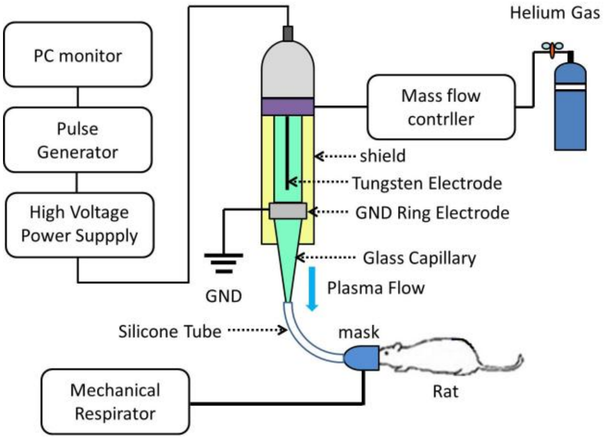


Fig1. Atmospheric pressure plasma generator

CT imaging analysis

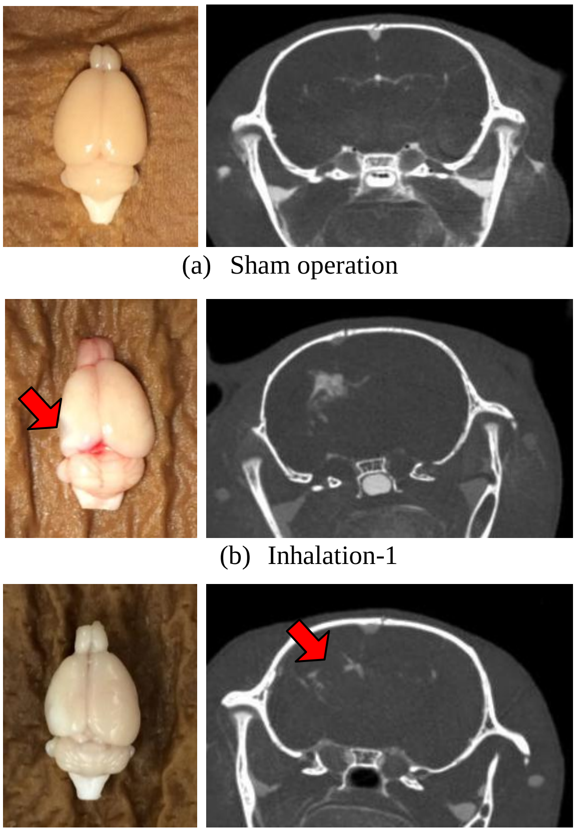
The six-week-old rats were anesthetized with pentobarbital sodium (0.8 ml/kg) and perfused transcardially with saline followed by ioamidol and formalin. Before doing the paraffin treatment, the rat head and the brain were diagnosed by using CT. After perfusion, we made CT imaging for rat's head. Here, the X-ray computed tomography (CT) scanner for experimental animals (Latheta LCT-200, Hitachi Aloka Medical, Ltd., Tokyo, Japan) was used for the rat's head imaging. The scanning conditions are following; 1 pixel: 80×80 µm, slice thickness: 80 µm, X-ray tube voltage: 50 kV, respectively. We measured left hemisphere volume of 5-6 mm from interaural.

3. Result

Figure 2 shows removed brain and CT images obtained the position at 6 mm from interaura. The rat's left brain in case of the Inhalation-1 is larger than that of Inhalation-2. The brain for Inhalation-1 is bigger than Inhalation-2. The rat's head had an aneurysm and a brain edema in left side as shown in Fig.2 (b), had intricately-shaped blood vessels in left brain [Fig.2 (c)]. The volume of left hemisphere is shown in Table.1. The rat's brain is bigger than Inhalation-2.

Table. l The volume of left hemisphere

	Volume (cm^3)
Inhalation-1 (n=3)	0.0540 ± 0.00227
Inhalation-2 (n=2)	0.0494 ± 0.00153
sham (n=4)	0.0626 ± 0.00217



(a) Sham operation

(b) Inhalation-1

(c) Inhalation-2

Fig2. Visual contact &CT imaging

4. Discussion

The gas that mixes O_2 and N_2O with the atmospheric pressure plasma together has the possibility of influencing the cerebral blood vessel. Therefore, it is thought that nitrogen oxides (NO_x) can be expected of the improvement of the hypoxic ischemic encephalopathy.

References

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