

## Emergency & critical care medicine for brain disease by irradiation / inhalation of atmospheric pressure plasma flow

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We performed to clarify the healing mechanism by which the irradiation / inhalation using atmospheric pressure (APP) plasma source promotes disease treatments such as burn healing, lung / heart disease treatment, bone regeneration, and cancer treatment. In this paper, the targeted disease treatment is functional recovery of hypoxic ischemic encephalopathy (HIE) by plasma inhalation.

Atmospheric pressure plasma (APP) are indispensable for sterilizing, disinfecting, decomposing hazardous materials, and modifying material surfaces. Clarifying the mechanisms of plasma technologies that are used in practical applications is of critical importance. Against this background, we are trying to clarify the healing mechanism by which the APP inhalation promotes disease treatments. [1-3]

The APP reactor with a coaxial structure is composed of a tungsten wire applied the high voltage inside a glass capillary that is surrounded by a grounded tubular electrode. The following conditions were applied pulse voltage: 5-8 kV; frequency: 1-5 kHz; helium (He) gas flow rate: 1 L/min; plasma irradiation time: 60-120 s.

The hypoxic ischemic encephalopathy (HIE) is a condition in which the brain does not receive enough oxygen. Although any injury and many health conditions can cause a lack of oxygen to the brain, there is no cure for HIE. We accomplished the experiment concerning the functional recovery of HIE by APP inhalation.

The rat HIE model used here involved ligating the 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 the infant incubator for hypoxia (oxygen (O<sub>2</sub>): 8 %, temperature: 37°C). HIE model rats were anesthetized with sevoflurane, nitrous oxide (N<sub>2</sub>O), and O<sub>2</sub> using an anesthesia device with a mechanical respirator. The 3-week-old rat HIE model were done the plasma inhalation for two weeks. The experimental conditions of the plasma inhalation are follows; Inhalation-1: plasma including O<sub>2</sub> gas and Inhalation-2: plasma including O<sub>2</sub> + N<sub>2</sub>O gas. The rat's head and the brain were diagnosed by using X-ray computed tomography (CT). Here, the CT scanner for experimental animals (Latheta LCT-200, Hitachi, Ltd.) was used for the rat's head imaging.

According to the CT images of rat's brain, left brain in case of the Inhalation-1 is larger than that of Inhalation-2. The aneurysm, cerebral ischemia, and

intricately shaped blood vessels were confirmed to the left brain. Especially, the cerebral ischemia makes a further trouble progressed so that not only causing the organization trouble at the cell level but also a rapid oxygen supply may generate a free radical such as super-oxides (OZ).

The APP including N<sub>2</sub>O gases has the possibility of influencing the cerebral blood vessel. In addition, the condition of the cerebral ischemia is reported to be ameliorable by the promotion of the endothelial NOS (eNOS) activation in the brain cell.[4] Here, eNOS is a family of enzymes catalyzing the production of NO from L-arginine.

Therefore, it is thought that nitrogen oxides (NO<sub>x</sub>) such as NO, nitrite (NO<sub>2</sub>), and nitrate (NO<sub>3</sub>) produced from plasma source and N<sub>2</sub>O gas can be expected of the improvement of the hypoxic ischemic encephalopathy.

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