The First Attempt of CO_2 Removal with an Artificial Heart-lung Machine

—Revisited a Quarter of Century Later—

(Key words: Carbon dioxide narcosis, artificial heart lung machine, history of medicine, ECMO)

To the Editor: In 1965, a moribund patient with CO_2 narcosis was saved using an artificial heart-lung machine. This case was presented at the 13th General Assembly of the Japan Society of Anesthesiology[1], but its background was never published in detail. So that we describe the case as a commemorable event in the history of anesthesiology in Japan.

Case Report: The patient was a 42-y-old male. He had been treated for pulmonary tuberculosis and vertebral caries for more than 20 years. During this period, the treatments included open drainage, right upper lobectomy, and right thoracoplasty.

Respiratory function tests in July 1965 revealed a severe restrictive respiratory disturbance. Arterial blood gas analysis with spontaneously breathing room air showed a Pa_{O_2} of 47 mmHg, Pa_{CO_2} of 68 mmHg, and pH 7.27. Polycythemia, hypochloremia, and pulmonary P wave on the ECG were present. The patient complained of dyspnea, headache and insomnia but was able to continue activities of daily life in the hospital with occasional oxygen inhalation.

In September 1965, his respiratory status gradually deteriorated and at the noon of September 20, he became comatose with severe dyspnea. At 2:00 pm, blood gas analysis under oxygen therapy showed a Pa_{O_2} of 106 mmHg, Pa_{CO_2} > 200 mmHg, pH 6.97, BB 54.1 $mEq \cdot l^{-1}$, BE 3.45 $mEq \cdot l^{-1}$.

Endotracheal intubation was performed, and the patient was connected to a Bird Mark 7 respirator. At 6:55 pm, with maximal ventilator settings, Pa_{CO_2} was still over 200 mmHg. Tracheostomy was performed to facilitate endotracheal suction of profuse secretion. Manual ventilation showed an extremely low lung-thorax compliance (LTC). After the discussion among the surgeons and anesthesiologists, the removal of CO_2 by an artificial heart-lung machine was decided. The femore-femoral veno-arterial bypass was initiated with a Kay-Cross type artificial heart lung machine with a rotating disk oxygenator (Pemco Incorporated, Cleveland, Ohio). The bypass circulation was a flow rate of 500 $ml \cdot min^{-1}$ initially, and increased to 2 $l \cdot min^{-1}$ maximum, and the patient was ventilated manually. After 45 min, of these treatments blood gas findings improved to a Pa_{O_2} 460 mmHg, Pa_{CO_2} 130.2 mmHg and pH 7.18. The patient became slightly responsive to painful stimuli.

After an interval of about 1 hour, bypass circulation was reinstituted for 25 min. Facial edema and venous engorgement of the neck veins diminished, and the electroencephalogram became normal. Pa_{CO_2} lowered to 110 mmHg with a pH 7.26. The LTC gradually increased after the extracorporeal CO_2 removal, and a volume limited ventilator (Ichikawa Shiseido, Co. Tokyo) could be applied. As the physical condition improved, the patient preferred to an assisted ventilation. Thereafter, his physical status remained stable for several months.

In March 1966, Pa_{CO_2} was between 70 and 50 mmHg with pH at approximately 7.4. Periodical assisted ventilation allowed the patient to live comfortably until the end of June 1966.

On July 28, the patient again became comatose and had seizures with severe hypoxia and acidosis. An oxygenated blood transfusion was performed with 1,000 ml of stored bank blood, and 1,200 ml of autologous blood taken from the femoral artery. He regained consciousness temporarily with this procedure but his general condition deteriorated, and he expired on August 4, 1966, 317 days after the bypass operation.

Soon after the first success of an open heart surgery with an artificial heart lung machine in the U.S.A. in 1953, an idea of using the heart lung machine to manage cardiopulmonary failure was borne in Morioka's mind[2]. A Kay-Cross type artificial heart lung machine became available a few months before this episode. In the U.S.A., a randomized national study of prolonged ECMO for acute respiratory distress syndrome was begun under the sponsorship of the N.I.H. Since then, ECMO has been applied clinically and experimentally to acute respiratory failure, but the value of this method is sill controversial. However, for the past decade, the techniques and knowledges of extracorporeal CO_2 removal tremendously improved, and now many physicians have become increasingly aware of this promising treatment.

It was only after the long ordeal of ECMO studies in the past two decades that we realized the significance of leaving the record of this early success in respiratory care, as a part of history of the life support systems in Japan.

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