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Availability of Low Potassium UW Solution for a 24 Lung

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A comparative study of preservation solution was made in a 24 hour storaged donor lung between original UW (University of Wisconsin) solution (k = 120mEq/l) and Low potassium UW (k = 30mEq/1) solution. Preservation of a donor lung with low potassium UW solution was superior to that with original UW solution in terms of static compliance and pulmonary vascular resistance.

In conclusion, the use of low potassium UW solution is of great value to storage a donor lung.

Introduction

In 1963, application of clinical lung transplantation was first reported by Hardy (1). Since Cooper *et al* (2) experienced a long survival after lung transplantation, donor lung procurment has become a great item as in case of other organs. UW solution was developed by Belzer *et al* (3) in 1983. The availability and validity of UW solution are clarly supported by many investigations concerning preservation of the pancreas, kidney and liver. In contrast, preservation of the lung is scant with the use of UW solution.

It is generally accepted that UW solution contains high concentration of potassium. The main drawback is that high potassium induces vasoconstriction to make increased vascular resistance, by which ill-effect on function of a donor organ may be caused.

The purpose of this study is to clarify as to whether high potassium is required for a donor lung preservation or not.

Material and Methods

1) Donor preparation

Mongrel dogs weighing 15 to 18kg were anesthetized with 25mg/kg of pentobarbital sodium, intratracheally intubated and connected with Harvard respirator (10ml/kg of tidal volume). Midsternotomy was performed. Temporary occusion of right main pulmonary artery and bronchus was made to measure arterial PO_2 and PCO_2, the pressure of pulmonary, artery, left atrium, extravascular water content, cardiac output, lung compliance, vascular resistance of the pulmonary artery. During the measurement, 500U/kg of heparin and 100ug/body of PGE1 were intravenously given. A donor lung was flushed out with original UW solution (Group 1) and low potassium UW solution (Group 2)

2) Preservation of a donor lung

The heart and lung were en block removed and preserved with simple immersion at 4-8 ℃ of cold solution for 24 hours.

3) Estimation of viability of storaged lungs

As shown in Fig. 1, the isolated lung perfusion model was used for assessment of viability of a 24 hour storaged donor lung. A donor lung was ventilated with air on the condition of 20ml/kg of tidal volume and 10/min of respiratory retes. After 120 minutes of perfusion, the variance of

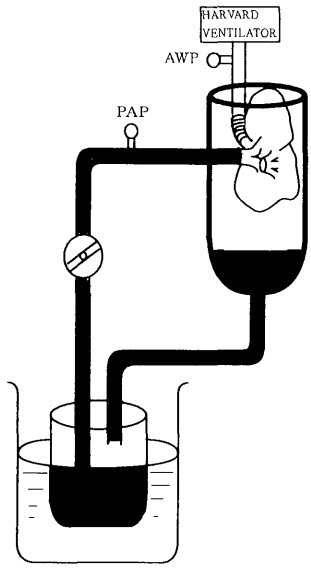

Fig. 1. Isolated Lung Perfusion Model

pulmonary hemodynamics were estimated in comparison in Group I (original UW solution) and Group 2 (low potassium UW solution) between prior to and after lung preservation for evaluation of superiority of low potassium UW solution to original UW one as a preservation solution.

Result

The time durations of flushing, cold ischemia and warm ischemia were compared in storaged donor lungs as shown in Table 1. The flushing time in Group I was elongated as compared with that in Group 2. It reflected a result of vasoconstriction due to high concentration of potassium in original UW solution. The cold and warm ischemic times were almost the same between both two groups.

Table 1. Flushing, Cold Ischemic and Warm Ischemis Time of Graft Lungs

	Group I (K^+ = 120mEq/L)	Group II (K^+ = 30mEq/L)
Flushing time	257.0 ± 101.4sec	160.0 ± 67.5sec
Cold ischemic time	24.1 ± 0.2hr	24.2 ± 0.3hr
Warm ischemic time	75.0 ± 11.8min	61.9 ± 15.1min

Fig. 2 revealed the results of changes in the aterial PaO_2. The levels of PaO_2 after perfusion were slightly declined in the both groups. There was not significant difference between both the groups. The pulmonary arterial (PAP) and left atrial pressures (LAP) were compared as shown in Fig. 3. The PAP was increased in postperfusion although LAP remained almost constant. And PAP in postperfusion of Group 1 was kept high as compared with that in Group 2.

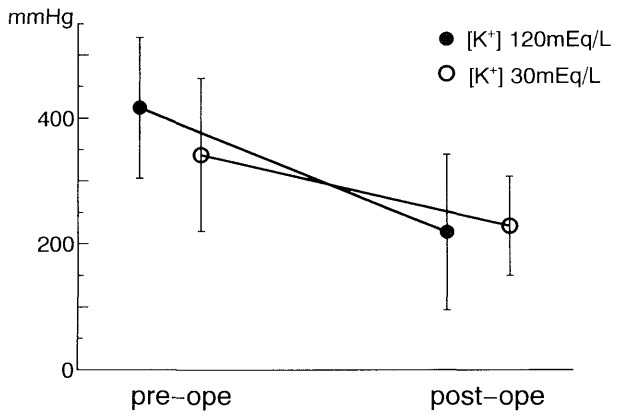

Fig. 2. PaO_2

Fig. 4 indicated changes in pulmonary vascular resistance. It was apparent that original UW solution carried significant hazard of increased vascular resistance ($p < 0.05$).

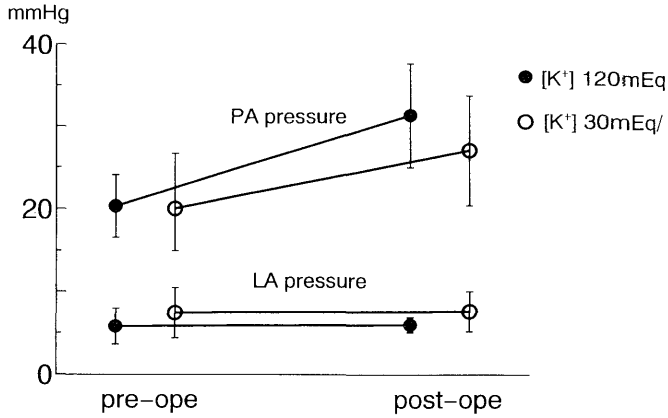

Fig. 3. Pulmonary Artery and Left Atrial Pressure

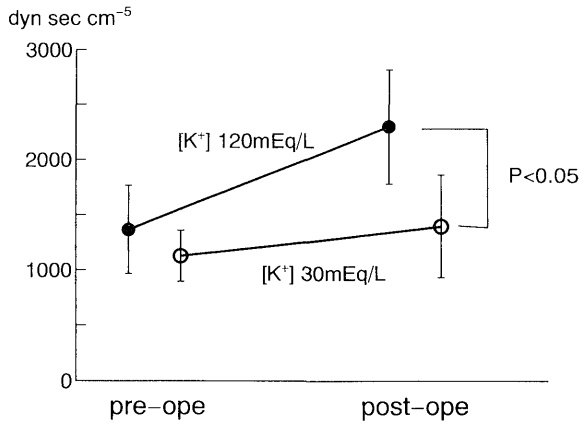

Fig. 4. Pulmonary Vascular Resistance

The static and dynamic compliance were compared in both the groups between prior to and after perfusion as shown in Fig. 5, 6. These were reduced in Group 1 after perfusion, in particular, the statistic compliance was significantly decreased ($p < 0.05$).

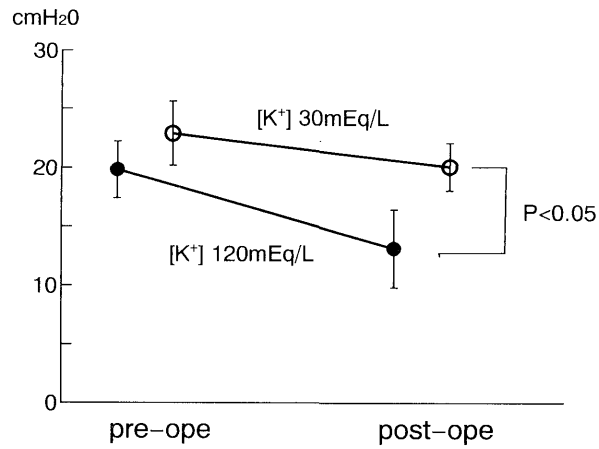

Fig. 5. Static Compliance

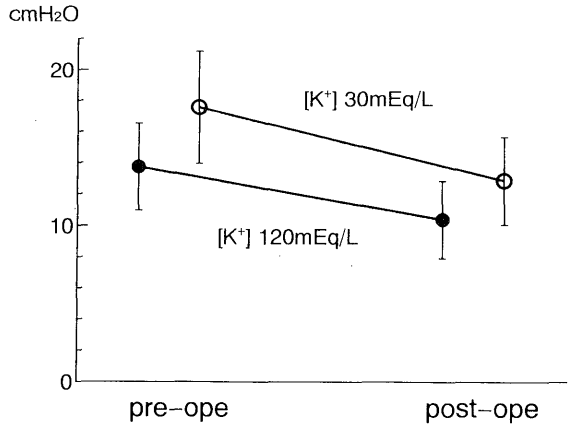

Fig. 6. Dinamic Compliance

Discussion

It is difficult to preserve a donor lung to maintaining an excellent function after transplantation because of vulnerability of lung parenchym to edema caused by high permiability of pulmonary capillaries and alveoli. The maximum of lung preservation time is limited to be 3 to 4 hours at room temperature in inflated state. Since Blumenstock (4) first applied for cold preservation, cold storage has prevailed for the purpose of suppression of oxygen demand in the field of various organ preservation and also preservation solution was developed to prolonge the storage time with a mixture of various cytoprotective agents (5-7). The success in 24 hour preservation was reported by Crane *et al* (8) with Collins-Sack solution and the possibility of a 24 to 72 hour preservation was suggested by Toledo-Pereyra *et al* (9) with modified silicagel fraction in animals. However, a 6-8 hour preservation is now ensured in clinical use. Therefore, development of better solution is desired for prelongation of a safety limit of lung preservation. Eeuro-Collins (EC) solution has been widely used for organ preservation prior to development of UW solution. However, since UW solution was recenlty developed as a solution similar to the composition of intracellular fluid, UW solution has been regarded as the best preservation solution in the kidney, pancreas and liver. Reports are now scant concerning lung preservation with respect to UW solution. It is defined that UW solution is characteristic in that (1) lactobionate inhibits enlargement of cells (2) phosphate plays a role in prevention of intracellular acidosis as buffer to hydrogen (3) hydroxyl starch serves as harmless colloid to avoid occurring edema (4) glutathion and alloprinol act as antagonist of oxygen free radical generated during ischemia. In fact, many investigators clarified the mechanisim of reperfusion injury. Prevention of reperfusion injury is the most important to succeed in prolonged lung preservation. It is well known that active oxygen plays an important role in reperfusion injury (10) and also calcium overload at the time of reperfusion is a cause of reperfusion which is termed as calcium paradox phenomenon (11). Recent studies (12) reported that UW solution with extracellular fluid composition was more effective than other solutions similar to intracellular fluid composition in making it possible to prolonge the preservation time. In this study, low potassium content of UW solution was superior to original one in evaluation of a preserved donor lung function.

In conclution, it is emphasized that low potassium UW solution is of great value in clinical use

Reference

1) Hardy JD, Webb WR, Dalton ML jr et al: Lung homotransplantation in man, J. A. M. A 186:1065-1069, 1963.
2) The Toronto Lung Transplant Group: Unilateral lung transplantation for pulmonary fibrosis, N. Engl Med. 314:11140-11145, 1986.
3) Wahlberg JA, Love R, Belzer FO et al: 72-hour preservation of the cenine pancreas. Transplantation 43:5-8, 1987.
4) Blumenstock DA, Hechtman HB, Collins JA: Preservation of the canine lung J. Thorac Cardiovasc Surg 44:771-778, 1962.
5) Oyamagui, Y Sato, S, Okajima, T.: Suppression of ischemic paw oedema in mice, rats and guinea pigs by superoxide dismutase from different sources. Free Rad. Res. Comms. 4:385-396, 1988.
6) Bando, K. Tago M, Teraoka. H. et al.: Extended cardiopulmonary preservation for heart-lung transplantation J. Heart Transplant 8:59-66,1989.
7) Suzuki J, Fujimoto, S. et al: The pretective effect of combined administration of anti-oxidants and perfluorochemicals on cerebral ischemia Strock 15:672-679, 1984.
8) Crane R, Torres, M. Hagstrom, JWC et al: Twenty-four hour preservation and transplantation of the lung without functional impairment. Surg. Forum. 29:111-118, 1975.
9) Teledo-Pereyra LH, Northrup WF, Humphrey EW. et al: Maintenance of lung viability for transplantation after long periods of hypothermic perfusion. J. Surg REs, 18:99-104, 1975.
10) Granger DN, Rutili G, McCord JM: Superoxide radicals in feline intestinal ischemia. Gastroenterol. 81:22-29, 1981.
11) Zimmerman, ANE Hulsmann, WC,: Paradoxical influence of calcium ions on the permiability of the cell membranes of the isolated rat heart. Nature 211:646-647, 1966.
12) Moen, J. Claeson K, Belzer FO et al: Preservation of dog liver, kidney and pancreas using the Belzer-UW solution with a high sodium and low potassium content, Transplantation 47:940-945, 1989.