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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 stored donor lung between original UW (University of Wisconsin) solution (k = 120mEq/l) and Low potassium UW (k = 30mEq/l) 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 procurement 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 clearly 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 occlusion of right main pulmonary artery and bronchus was made to measure arterial PO₂ and PCO₂, 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 °C 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 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).

Fig. 1. Isolated Lung Perfusion Model
pulmonary hemodynamics were estimated in comparison in Group 1 (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 stored donor lungs as shown in Table 1. The flushing time in Group 1 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 Ischemic Time of Graft Lungs**

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<th>Group I (K⁺ = 120mEq/L)</th>
<th>Group II (K⁺ = 30mEq/L)</th>
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<tr>
<td>Flushing time</td>
<td>257.0 ± 101.4sec</td>
<td>160.0 ± 67.5sec</td>
</tr>
<tr>
<td>Cold ischemic</td>
<td>24.1 ± 0.2hr</td>
<td>24.2 ± 0.3hr</td>
</tr>
<tr>
<td>Warm ischemic</td>
<td>75.0 ± 11.8min</td>
<td>61.9 ± 15.1min</td>
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Fig. 2 revealed the results of changes in the arterial PaO₂. The levels of PaO₂ after perfusion were slightly declined in both the 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. PaO₂**

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

It is difficult to preserve a donor lung to maintaining an excellent function after transplantation because of vulnerability of lung parenchyma to edema caused by high permeability 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 prolong 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 prolongation of a safety limit of lung preservation. Euro-Collins (EC) solution has been widely used for organ preservation prior to development of UW solution. However, since UW solution was recently 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 allopriol act as antagonist of oxygen free radical generated during ischemia. In fact, many investigators clarified the mechanism 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 prolong 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 conclusion, it is emphasized that low potassium UW solution is of great value in clinical use.

Reference