HEART PRESERVATION

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Background

In clinical practice the dominant method for heart preservation is cold static storage which gives acceptable heart preservation for 4-6 hours. A novel method where the heart is perfused with an albumin-based, cardioplegic electrolyte solution containing erythrocytes has been developed and tested experimentally giving 24 hours’ safe preservation (Safe orthotopic transplantation of hearts harvested 24 hours after brain death and preserved for 24 hours; Steen et al; Scand Cardiovasc J 2016;50:193-200) and the first clinical transplantation with this method was successfully done in August 2017.

To obtain good heart preservation two structures of the heart are of particular importance, the coronary vessels, including the endothelium, and the myocardium. These structures are the topic for this work. The aim of the first study was to find out if non-ischemic perfusion-preservation can preserve the coronary arterial endothelial and smooth muscle function for 8 hours. The second study focus on the oxygen consumption of the explanted perfusion-preserved (non-ischemic) cardioplegic heart at different temperatures.
**Methods**

In the first study an automatic pressure and flow-controlled perfusion system equipped with an oxygenator was used. The system is temperature controlled and equipped with an oxygenator. Porcine hearts were perfused with a perfusion pressure of 20 mmHg for 8 hours at 8 °C, either in cycles of 15 minutes’ perfusion followed by 60 minutes’ non-perfusion, or by continuous perfusion. The perfusate consisted of a cardioplegic, hyper-oncotic nutrition solution containing washed erythrocytes from the same animal. After 8 hours the preservation the heart was taken out and coronary artery segments were excised and studied in organ baths. Fresh coronary artery segments were used as controls. Dry weight/wet weight of the hearts were measured.

In the second study, the hearts received continuous perfusion within a temperature controlled system. The whole system was carefully sealed to the air by means of the plastic and silicon tubes and a plastic film covering the heart container. The same perfusate was used as in the previous study. Five temperatures were studied: 37, 30, 22, 15, and 8°C. When the erythrocytes in the perfusate were fully saturated, the oxygenator was excluded from the circuit and blood gases were analyzed repeatedly. The oxygen consumption at different temperatures could be calculated by means of the change of values from the blood gases; the total volume of the perfusate and the pump flow of the perfusate are known variables.

**Results and significance**

After 8 hours of preservation-perfusion no myocardial edema was seen; water content of the myocardium was 79.5 ± 0.2%, 79.0 ± 0.4% and 79.0 ± 0.3% for fresh controls, intermittently perfused, and continuously perfused hearts, respectively. The result shows that endothelium-dependent relaxation and smooth muscle contractility were
fully preserved after both intermittent and continuous perfusion, as compared to fresh controls.

In the second study, the oxygen consumption expressed in mL/min/100 g heart muscle was 1.10 ± 0.04, 0.58 ± 0.02, 0.33 ± 0.01, 0.21 ± 0.01, and 0.16 ± 0.02 at 37°C, 30°C, 22°C, 15°C, and 8°C, respectively. Compared to the cardioplegic pig heart at normothermia, the oxygen consumption is reduced by 85% at 8°C. By using cardioplegic perfusion at 8°C, the metabolism of the heart is so low that a minimal perfusion is needed to supply the heart with its need. Thereby myocardial edema is omitted which is otherwise a problem by perfusing cardioplegic hearts.