ELECTROLYTE CONCENTRATIONS IN THE ISOLATED RABBIT'S HEART PERFUSED WITH A DONOR RABBIT

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A decrease in the K^+ concentration and increase in the Na⁺ concentration were observed in the myocardium of the isolated heart kept in a state of anoxia for 60 min. In the isolated heart recovering its functional activity after perfusion with the aid of a donor the K^+ concentration in the myocardium fell still more. Administration of large quantities of glucose by frequent injection of small doses into the blood stream during perfusion aggravated the electrolyte imbalance caused by anoxia. Adrenalin, if injected into the systemic circulation (0.025 mg/100 g body weight), did not change the electrolyte composition of the donor's myocardium, but considerably lowered the K^+ level in the myocardium of the isolated heart.

The object of this investigation was to study the concentration of Na⁺ and K⁺ ions in the myocardium of the left ventricle of the isolated, denervated rabbit's heart when its functional activity was restored after a state of prolonged anoxia by perfusion with the aid of a donor rabbit. The aim of one series of experiments was to detect the effect of glucose on the Na⁺ and K⁺ levels in the isolated heart when perfused after a state of anoxia. The object of another series of experiments was to compare the effect of adrenalin on the electrolyte composition of the myocardium of the donor rabbit and of the isolated, perfused heart, since catecholamines are known to alter the electrolyte composition of the myocardium [1-3].

EXPERIMENTAL METHOD

The isolated rabbit heart was connected to the circulatory system of a donor rabbit through the carotid artery (connected to the left ventricle of the isolated heart) and jugular vein (connected to the right ventricle of the isolated heart).

In control experiments the isolated heart was connected to the circulatory system of the donor soon after isolation. In the experiments to study the effect of prolonged anoxia on the electrolyte composition of the isolated perfused heart, the circulation in the heart was stopped for 1 h at room temperature, and the heart was then connected to the donor's circulation. When the effect of glucose on the electrolyte balance of the isolated perfused heart was investigated, a 40% glucose solution was injected into the systemic circulation during perfusion in repeated small doses (20 doses each of 0.75 ml during 1 h). Altogether 15 ml of 40% glucose solution was given together with 4 units of insulin.

The volume velocity of perfusion of the isolated heart averaged 10-12 ml/min, the heart rate was 120-140/min, and the arterial pressure was 90-110 mm Hg.

In the series of experiments to investigate the effect of adrenalin on the Na⁺ and K⁺ concentrations in the myocardium of the isolated heart and the heart of the donor rabbit, 0.1% adrenalin solution was injected into the systemic circulation by repeated small doses throughout the period of perfusion at a mean rate of $17 \mu g/min$. The total dose of adrenalin injected was 1 mg. The rate of perfusion in these experiments was 12-14 ml/min, the rate of contraction of the isolated heart was 160-170 beats/min, and the arterial pressure in the perfusion system under the influence of adrenalin was 150-160 mm Hg.

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TABLE 1. Effect of Various Conditions of Perfusion on K⁺ and Na⁺ Concentrations (in meq/100 mg fresh tissue) in Myocardium of Left Ventricle (M±m)

	Heart	of donor rabbit	1		i i	Isolated heart			
Index studied		injection of glucose	injection of injection of glucose advenation	Perfusion without previous anoxía	it previous	Anoxia for	Perfusion after anoxia for 1 h	noxía for 1 h	Injection of
)		without glucose	with glucose	1 h	without glucose with glucose	with glucose	adrenalin
K+ P- Na+ P- K+/Na+	78,8±3,66 38,6±3,56 2,04	78,8±4,56 38,2±3,77 >0,5 2,06	77,0±3,60 >0,5 45,6±6,94 >0,2 1,69	69,2±1,93 (0,05 44,3±11,01 >0,5 1,56	67,9±4,00 67,9±4,00 60,05 53,3±6,07 <0,05 1,27	53±1,73 <0,001 51,5±3,10 <0,02 1,03	49,8±5,74 <0,01 36,0±4,51 >0,5 1,38	36,1±6,09 <0,001 51,9±5,67 <0,05 0,70	53,3±5,86 4,3±7,47 >0,5 1,20

In all series of experiments the duration of perfusion was 60 min and the temperature of the isolated heart was maintained automatically at 38°C throughout the period of perfusion.

The concentrations of Na⁺ and K⁺ in the myocardium of the left ventricle were determined by flame photometry [4] after preliminary incineration of the tissue.

The heart of the donor rabbit, into which neither adrenalin nor glucose was injected, was used as the control.

EXPERIMENTAL RESULTS AND DISCUSSION

It will be clear from Table 1 that the level of intracellular K⁺ was very slightly lower in the left ventricle of the isolated rabbit heart receiving continuous oxygenation than in the control while the Na⁺ concentration was unchanged.

A decrease in the K^+ concentration (by 30%) and an increase in the Na⁺ concentration (by 30%) were observed in the myocardium of the isolated heart in a state of anoxia, with a consequent marked decrease in the K^+/Na^+ concentration ratio. During subsequent perfusion of the isolated heart with the blood of a donor rabbit the intracellular Na⁺ concentration returned to normal but the K^+ concentration fell still more (Table 1).

Injection of large quantities of glucose into the blood stream merely aggravated the disturbance of the electrolyte composition of the isolated heart produced by anoxia.

Injection of glucose in the doses used into the general blood stream did not change the levels of the electrolytes in the donor's myocardium. A slight decrease in the level of intracellular K^+ and an increase in the Na+ concentration were observed in the myocardium of the isolated heart which had not been in a state of anoxia under the influence of glucose, but these changes were extremely slight by comparison with those observed as the result of the action of glucose on the isolated heart perfused after a state of anoxia. It is also clear from Table 1 that the adrenalin concentrations used did not alter the electrolyte balance of the donor's myocardium, whereas a statistically significant decrease in the K^+ concentration was observed in the myocardium of the isolated heart.

These results show that certain changes in the electrolyte composition of the myocardium, manifested as a decrease in the intracellular K⁺ concentration, take place in the isolated heart when maintained under continuous oxygenation and perfused by means of a homologous donor. A state of anoxia leads to marked disturbance of the electrolyte composition of the myocardium of the isolated heart due to a change in the permeability of the cell membranes. These changes are stable in character and persist to a considerable degree in the myocardium of the isolated heart when its functional activity has been restored by subsequent perfusion with the aid of a donor. Injection of glucose into the systemic circulation causes the most marked disturbances of the electrolyte balance in the heart perfused after being in a state of anoxia.

In the concentrations used glucose did not affect the electrolyte concentrations in the donor's heart but it produced some changes in the electrolyte concentrations in the myocardium of the isolated perfused heart kept under continuous oxygenation. All these results indicate complications which may arise following the use of glucose during perfusion of a heart destined for transplantation when it is in a state of anoxia before perfusion.

In the concentrations used adrenalin did not affect the electrolyte composition of the myocardium of the intact donor although it considerably reduced the level of intracellular K^{\dagger} in the myocardium of the isolated heart.

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