PERFUSION OF THE ISOLATED HEART WITH THE PERFLUOROCARBON EMULSION FTOXYKOL

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UDC 615.361.12.014.41:612.26

KEY WORDS: oxygen consumption; contractility of the myocardium; isolated rat heart.

At the present time a blood substitute consisting of an oxygen carrier based on organic perfluorochemicals (PFC), known as ftoxykol, is being developed at the Central Research Institute of Hematology and Blood Transfusion [1, 2]. The use of PSC emulsions as the oxygen-carrying basis of a perfusion medium appears to be a promising method of preserving isolated organs. The present investigation, conducted on the isolated rat heart, examines the possibility of using ftoxykol for organ perfusion.

EXPERIMENTAL METHOD

Heparin was injected onto male albino rats weighing 200-300 g 1 h before the experiment in a dose of 250 i.u. per animal. After decapitation the thorax was opened. The heart was removed and placed in cold physiological saline. Retrograde perfusion was started 80-100 sec after thoracotomy through a cannula introduced via the aorta. The pulmonary artery was catheterized and subsequently used for taking samples of the perfusion fluid. The heart was placed in a constant-temperature glass chamber filled with perfusion fluid of the following composition: 138 mM NaCl, 5.4 mM KCl, 1.26 mM $CaCl_2$, 0.83 mM $MgSO_4$, 3.7 mM Na_2HPO, 4.2 mM $NaHCO_3$, 5.5 mM glucose, and a mixture of perfluorodecaline and perfluorotributylamine emulsion in a final concentration of 10 vol. %. The perfusion fluid was supplied from a reservoir into the aorta under a constant pressure of 70 cm water. Having passed through the coronary system of the myocardium, the liquid escaped freely through the opened vessels of the right heart (venae cavae and pulmonary artery) into the interior of the chamber. The outflowing perfusion fluid was oxygenated with medical oxygen, filtered through a glass filter, and reintroduced into the heart through the reservoir by means of a peristaltic pump. The perfusion fluid was thus used over and over again. The temperature of the perfusion fluid was (37°C) and maintained by means of an ultrathermostat. Salt solution (SS) without ftoxykol, pH 7.4, was used as the control. In the course of perfusion the heart rate (HR), the volume of the coronary flow, and the oxygen concentration in the arterial and venous perfusion fluid, determined by means of the Lex-O_2-Con (USA) apparatus, were recorded after 15, 30, 60, 90, and 120 min. From the results of these measurements the arteriovenous oxygen difference (A-VO_2) and the oxygen consumption (OC) were calculated. After the experiment the heart was dried with filter paper and weighed.

Contractility of the isolated heart was assessed by a modified Langendorff's method [3]. The isolated heart was perfused with SS until a constant amplitude of contractions was established, which was usually 10-15 min after the beginning of perfusion. A change was then made to the perfusion medium containing ftoxykol emulsion (FE). The amplitude of the cardiac contractions during perfusion with SS was taken as 100%, and the change in amplitude of the contractions was determined after the change of perfusion fluid.

EXPERIMENTAL RESULTS

FE contains twice as much oxygen as SS, in both arterial and venous samples (Tables 1 and 2). This difference was due to the presence of 10 vol. % of the perfluorocarbon compounds in FE. This concentration can be regarded as optimal, although no special investigations were carried out [3]. A-VO_2, the velocity of the coronary blood flow (CBF), OC, and

Laboratory of Biologically Active Emulsions and Lyophilization of Biological Products, Central Research Institute of Hematology and Blood Transfusion, Ministry of Health of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR N. A. Fedorov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 93, No. 5, pp. 109-111, May, 1982. Original article submitted July 21, 1981.

0007-4888/82/9305-0683$07.50

TABLE 1. Oxygen Supply of Myocardium during Perfusion of Isolated Heart with SS (n = 5; M ± m)

Parameter	Duration of perfusion, min				
	15	30	60	90	120
CAO_2, vol%	2,4±0,06	2,3±0,09	2,1±0,08	2,1±0,18	1,7±0,10
CVO_2, vol%	0,6±0,02	0,6±0,04	0,4±0,03	0,3±0,18	0,3±0,02
A-VO_2, vol%	1,70±0,40	1,70±0,21	1,66±0,30	1,72±0,20	1,68±0,40
CBF, ml/g·min	6,4±0,5	5,8±0,5	4,5±0,6	3,7±0,4	3,3±0,4
OC, μl O_2/g·min	114±9	111±7	86±3	76±3	59±7
HR, beats/min	294±14	258±9	234±9	228±10	180±8

TABLE 2. Oxygen Supply of the Myocardium during Perfusion of the Isolated Heart with FE (n = 5; M ± m)

Parameter	Duration of perfusion, min				
	15	30	60	90	120
CAO_2, vol%	4,8±0,18*	4,5±0,25*	3,7±0,18*	3,5±0,12*	2,8±0,16*
CVO_2, vol %	2,8±0,16*	2,5±0,11*	1,9±0,12*	1,5±0,09*	0,9±0,07*
A-VO_2, vol %	1,93±0,32	1,93±0,41	1,93±0,31	2,27±0,30	2,23±0,25
CBF, ml/g·min	6,1±0,6	4,4±0,4	3,9±0,4	3,1±0,4	2,5±0,4
OC, μl O_2/g·min	143±24	109±4	93±11	78±18	74±22
HR, beats/min	280±15	266±10	227±11	200±8	186±8

*Signifance of difference between parameters and data obtained with SS ($P < 0.05$).

HR did not differ during perfusion with FE and SS. Both in the experiment and in the control, toward the end of the second hour of perfusion a marked fall was observed in the oxygen concentration in the arterial (CAO_2) and venous (CVO_2) samples of perfusion fluid. This could be attributable to the low efficiency of the method used to oxygenate the perfusion fluids. However, the value of A-VO_2 in both cases was practically unchanged in the course of 2 h of perfusion. A marked fall in CBF toward the end of the second hour of perfusion with FE and SS led to a decrease in OC of the heart muscle. The myocardial OC thus adequately reflected the change in coronary flow of perfusion fluids. HR also decreased toward the end of the second hour of perfusion with FE and SS. It is an interesting fact that perfusion with FE did not lead to any marked increase in OC despite the fact that it contained twice as much oxygen as SS. No comparison of OC during perfusion of the isolated heart with emulsions of PFC and with SS has been reported in the literature. However, it has been observed that OC remained low during perfusion of the heart with 10% PFC emulsions [3].

Estimation of contractility of the rat heart showed that on average perfusion with FE did not change the amplitude of the contractions, although individual differences in the response were noted during perfusion of the isolated hearts with FE. In some investigations myocardial contractility has been found to depend completely on the quality of the PFC emulsion. For example, perfusion with Fluocol DK reduces the amplitude of contractions compared with SS. At the same time, Fluocol DA increases the contractility of the perfused heart and maintains it for a long time. Our own data showed that the contractility of the myocardium during perfusion can serve as a test of the quality of a PFC emulsion.

Ftoxykol emulsion can thus bind with oxygen, transport it, and give it up to the tissues. Its addition to a perfusion fluid does not affect the contractility of the perfused rat heart.

LITERATURE CITED

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