OPTIMIZATION OF THE CRYOPHYSIOTHERAPY TECHNOLOGY

The value of the recommended temperature for the conducting cryo-therapy in different sources varies from −180 to −100 ˚C. Frequently the selection of operating temperature it is determined not by physical therapy requirements, but by possibilities of the technology of cryostating, since temperature to −120 ˚C, can be ensured with the compression systems of cryostating.
The methods of mathematical simulation and the physical theory of cryo-therapy make it possible to estimate the effect of heat-transfer agent temperature on the results of procedures. The range of the selection of the heat-transfer agent temperature is from -180 to - 80 ˚C.

Table 2.4.1

Results of numerical experiment

Computable parameters, unit of measurements	Temperature of heat-transfer agent, K										
	90	100	110	120	130	140	150	160	170	180	190
Duration of procedure, s	43	57	74	96	124	159	193	200	208	216	225
Temperature of the epithelium at the end of procedure, ˚C	-2	-2	-2	-2	-2	-2	-0,9	2,9	6,3	9,4	12,3
Temperature of the muscular tissue at the end of procedure, ˚C	36,7	36,6	36,6	36,5	36,4	36,2	36,0	36,0	36,0	36,0	36,0
Maximum outlet of heat from the skin surface at the beginning of procedure, kW/m^2	5,9	5,0	4,2	3,5	3,0	2,5	2,1	1,9	1,6	1,4	1,2
Maximum outlet of heat from the body yard at the end of procedure, W/m^2	57	58	60	65	75	95	115	113	110	107	104
Maximum value of the hypothermal discomfort index, K/s	3,7	3,2	2,7	2,3	2,0	1,7	1,5	1,3	1,1	0,9	0,8
Total irritating action per unit of the skin surface, uia/m^2	92	119	153	196	251	325	118	32	19	13	11
Total outlet of heat from unit of the skin surface for the procedure, kJ/m^2	278	310	340	374	407	446	462	416	373	333	296

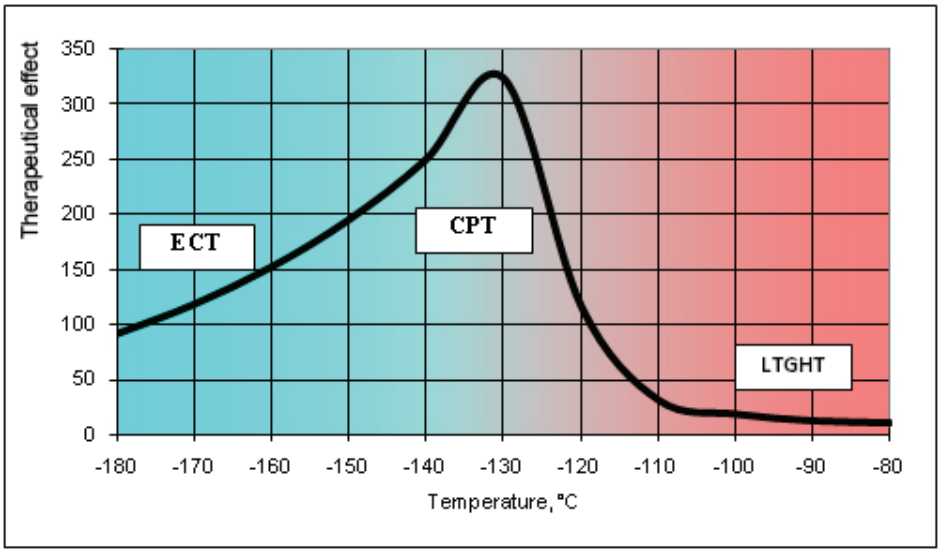
The results of experiment are represented in Table 1 and in the figures. The maximum value of the total irritating action is noted in the version with the temperature of gas - 130 ˚C and composes 325 uia/m^2 (see Fig.1). The results of numerical experiment will agree well with the subjective evaluations, comparing results from the visit of complexes with the nitrogen and compression systems, patients they note the qualitative difference in the intensity and the durations of positive consequences.

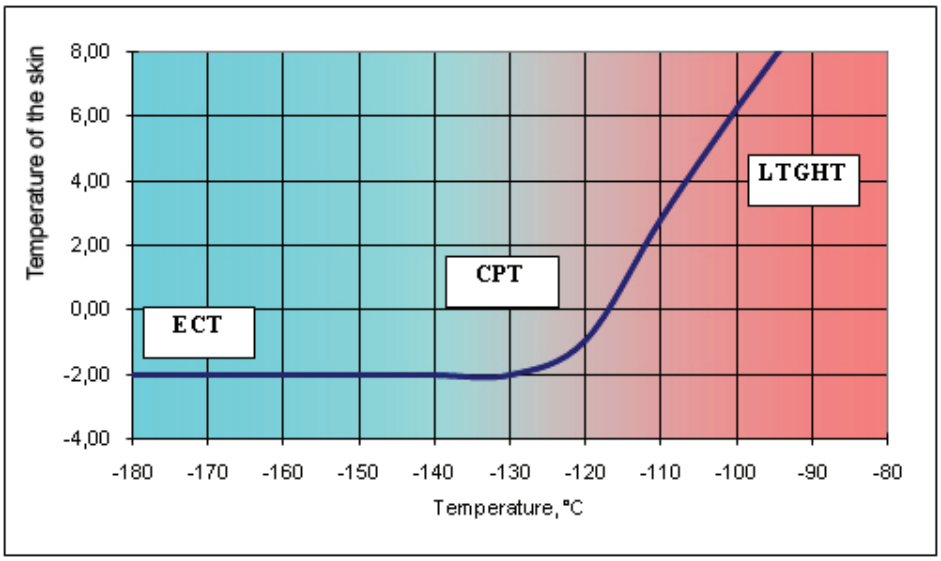
The temperature of optimum range (from - 150 to - 130 ˚C) it is not possible to reach in the devices by compression coolers. The producers of installations with the compression system of cryostating diligently go around questions of therapeutic effectiveness and is built their advertisement on the

independence from the deliveries of liquid nitrogen. However, the physical therapy uselessness of autonomous systems deprives prospects this direction of cryo-therapeutic instrument manufacture.

The obtained result has clear physical causes. Procedure flows into two stages, reduction in the surface epithelium temperature to the values of the capable of irritating threshold receptors, this period is named preparatory. On the reaching for the epithelium surface temperatures lower than 2˚C, the cooling is caused the hyperbolic reaction of the thermostatic control system. Procedures with the temperature of gas which are above - 120 ˚C do not ensure the passage of action during the stimulating phase.

Taking into account the revealed differences expedient about to classify procedures which they are considered cryo-therapeutic (see Table 2).
Extreme cryo-therapy (ECT) - procedure with the temperature of gas is less than −150 ˚C, they are characterized by smaller effectiveness and significant discomfort. ***Cryogenic physiotherapy (CPT)*** - procedures with the temperature of gas from −150 to −130 ˚C, are characterized by high efficiency and low discomfort. Procedures at a temperature higher than −130 ˚C, do not cause hyperbolic irritation, and in the action they are analogous to classical hypothermia. This group characterizes concept low-temperature gas hypothermia (LTGHT).





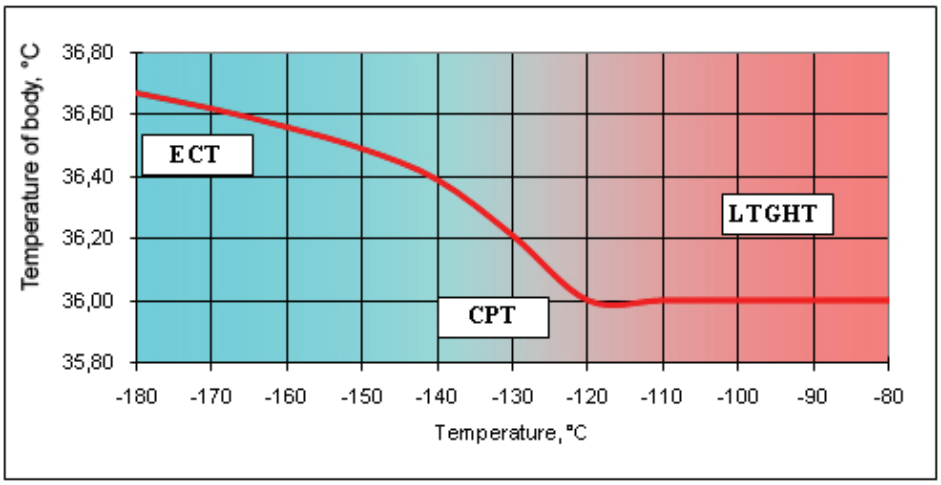


Fig. 1 Change in the physical therapy effect (a) and the finishing values of the temperature of the external and internal boundaries of the body layer in the dependence on the gas temperature in the cryogenic chamber The given analysis shows that the technology of conducting procedures, in particular the selection of the temperature of gas and exposure of contact, has the determining effect on the therapeutic result.

Table 2

Characteristics of low-temperature physical therapy procedures

Designation	Temperature in the cabin of patient, ˚C		Results of cooling			
			S_{ti}, *uia/m²*		K_{hd}, *K/s*	
	max	*min*	*max*	*min*	*max*	*min*
Extreme cryo-therapy	-180	-160	152	92	3,7	2,7
Cryo-therapy	-150	-130	325	196	2,3	1,7
Low-temperature gas hypothermia	-120	-90	118	11	1,5	0,8

It is technically difficult to ensure the optimum temperature of heat-transfer agent in the complexes with the compression system of cryostating; therefore developers diligently go around questions of effectiveness and is built their advertisement on what their equipment does not depend on the deliveries of liquid nitrogen. However, the physical therapy uselessness of autonomous systems deprives prospects this direction of cryo-therapeutic instrument manufacture. The autonomous systems of the cryostatings, based on production and accumulation of liquified air, are exception, which are capable of ensuring the optimum temperature in the zone of cryogenic physical therapy action.