EFFECT OF ARTIFICIAL HYPOTHERMIA ON REPRODUCTIVE FUNCTION OF MALE RATS

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Despite the widespread use of artificial hypothermia in clinical practice and intensive experimental research into the changes arising during its action in the internal medium of the body [3, 8], data in the literature on the effect of this factor on reproductive function in homoiothermic species is fragmentary [2, 10]. The urgency of such research is explained not only by the special place occupied by reproduction of a healthy progeny in the existence of a given biological species, but also by the fact that stable temperature homeostasis is a dominant condition for normal maturation of sex cells in male mammals [9, 11].

The object of this investigation was to study the fertilizing capacity of male albino rats at different times after a single exposure to deep artificial hypothermia.

EXPERIMENTAL METHOD

Experiments were carried out on 240 noninbred albino rats of both sexes weighing 250-370 g. Twenty male rats were cooled to a rectal temperature of 20°C by keeping them in a bath with ice under intraperitoneal hexobarbital anesthesia (50 mg/kg body weight, after premedication with trimeperidine (0.5-1.0 ml of a 0.2% solution). The mean duration of cooling was 40 min, whereas forced reheating with warm air to 34°C took 90-100 min. All the males were mated with females on the 7th, 14th, 30th-45th, and 60th-75th days of the posthypothermic period. At each of the above times 40 females in the stage of estrus, demonstrated by the vaginal smear method, were used. Copulation took place between 6 and 9 a.m. and was verified by the discovery of spermatozoa in the vaginal smear. If pregnancy was discovered, on the 20th day after fertilization the pre- and postimplantation and total embryonic mortality was determined, and the teratogenic effect was investigated by macroscopic examination of the embryos [4]. The embryos also were weighed. The control group, on which similar tests were carried out, included 20 males and 40 females.

EXPERIMENTAL RESULTS

In the control, pregnancy was found in 30 of the 40 mated females (75%). The mean number of embryos on the 20th day was 8 ± 0.6. The total embryonic mortality was $15.5 \pm 2.5\%$; $11.2 \pm 1.3\%$ of the embryos died before implantation and $3.8 \pm 0.8\%$ after implantation, in agreement with mean values for rats obtained by other workers [5].

The following results (Table 1) were obtained after mating between females and males exposed to hypothermia. The number of pregnant females fertilized by males in the first week of the posthypothermic period fell to four (10%), it remained low until the middle of the 2nd month after hypothermia (eight females, 20%), and not until the 60th-75th day did it approach the control level, at 60%. Under these circumstances the number of embryos per pregnant female remained virtually unchanged.

The total embryonic mortality in females fertilized by males during the first week of the posthypothermic period rose to $50 \pm 3\%$, it rose to $67.8 \pm 2.6\%$ by the middle of the 2nd month, after which it showed a normalizing tendency and returned to $17 \pm 3.6\%$ on the 75th day of the experiment. Meanwhile the ratio between pre- and postimplantation mortality showed a redistribution on account of the more rapid increase in the latter. Weighing and macroscopic examination of the embryos revealed no decrease in weight or abnormalities in anatomical structure and localization of internal organs compared with the control group.

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TABLE 1. Fertility of Male Rats at Various Times of the Posthypothermic Period (M ± m)

Index of fertility	Control	Experiment			
		7th day	14th day	30-45th days	60-75th days
No. of pregnant females among 40 experimental	30 (75%)	4 (10%)	6 (15%)	8 (20%)	24 (60%)
Mortality:					
Total embryonic	15,5±2,5	50±3	54±2	67,8±2,6	17±3,6
Preimplantation	11,2±1,3	17,2±1	18,4±2	19,3±1,2	13,4±2
Postimplantation	3,8±0'8	32,8±2	35,6±1	48,5±2,4	3,6±1
Mean number of embryos per pregnant female	8±0,6	7,8±0,6	8,2±1	8,1±1	7,8±0,6

Analysis of the results of this study of the fertility of male rats during the first 2 months after hypothermia thus showed that a single cooling to 20°C depresses the fertility of the sex cells, as reflected in a sharp decline in the success of conception, and also leads to a decrease in viability of the embryos in the preimplantation and, in particular, in the postimplantation period, whereas hypothermia has virtually no teratogenic effect.

The causes of these disturbances are injury to the spermatogenic epithelium during the first weeks of the posthypothermic period and disintegration of the trophic function of the epididymis, described by the writers previously [7]; in turn, these disturbances lead to slowing of maturation of spermatozoa and, in particular, to incomplete loss of their cytoplasm, which restricts their mobility, reduces their viability, and selectively prolongs energetically less efficient anaerobic metabolic pathways [1]. One result of the last of the above-mentioned disturbances is accumulation of an excess of incompletely oxidized metabolic products and, in particular, of lactate in the ejaculated semen, thus greatly reducing the fertilizing power of the sex cells [6].

The gonadotrophic effect of deep artificial hypothermia is thus realized at all levels of the male reproductive tract in rats, resulting in a marked and prolonged decrease in their fertility.

LITERATURE CITED

1. S. B. Artifeksov and A. V. Molodyuk, in: Hypothermia in Clinical and Experimental Medicine [in Russian], Gor'kii (1979), pp. 103-112.
2. R. T. Boiko, "The effect of hypothermia on the gonadotrophic functions of the pituitary and on the gonads," Author's Abstract of Candidate's Dissertation, Khar'kov (1963).
3. Ya. V. Volkolakov and A. T. Latsis, Deep Hypothermia in Pediatric Cardiac Surgery [in Russian], Leningrad (1977).
4. A. P. Dyban, V. S. Baranov, and I. M. Akimova, Arkh. Anat., No. 10, 89 (1970).
5. A. P. Dyban, V. F. Puchkov, V. S. Baranov, et al., in: Objects of Developmental Biology [in Russian], Moscow (1975), pp. 505-567.
6. V. K. Milovanov, Dokl. Vses. Akad. Sel'sk.-Khoz. Nauk im. Lenina, No. 10, 26 (1975).
7. A. V. Molodyuk and S. B. Artifeksov, in: Hypothermia in Clinical and Experimental Medicine [in Russian], Gor'kii (1979), pp. 96-102.
8. D. I. Ryzhakov, in: Hypothermia in Clinical and Experimental Medicine [in Russian], Gor'kii (1979), pp. 3-4.
9. J. M. Bedford, Am. J. Anat., 152, 509 (1978).
10. R. P. Das and S. Poy, Ind. J. Exp. Biol., 15, 1034 (1977).