ELIMINATION OF HYPOTHERMIA IN DOGS BY MEANS OF HIGH FREQUENCY CURRENTS

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N. V. Semenov

Department of Normal Physiology, Kalininsk Medical Institute
(Presented by Academician V. V. Parin)
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In a number of papers from our department [1, 3, 7], we have demonstrated the favorable course of hypothermia and the post-hypothermic period when the method of primary cooling of the cerebrum was used. When certain conditions are maintained, this method of cooling animals to rectal temperatures of 25-23° usually leads to moderate changes in the cooled organism. Restoration of vital functions in animals cooled in the above manner, after 30 min. of clinical death also proceeds favorably [8].

Despite the satisfactory induction and course of hypothermia with the above method, changes in the cooled organism begin to occur which indicate a decrease in the tonus of regulatory centers of important vital functions and some inhibition of the sympathetic-adrenal system. The consequence of the aforesaid changes are undesirable reactions which develop in the post-hypothermic period. In our opinion, an important role here is played by the length of the period in which the animal being warmed reaches a temperature of 32-33°, when thermoregulatory mechanisms become active.

There are scattered indications in the literature [9-10, 12] that it is possible to use high-frequency currents for warming the animal after hypothermia. These experiments, however, were carried out on small animals—rats, guinea pigs—with low power generators.

In our experiments tests were made to elucidate the possibility of using high-frequency currents to warm large animals—dogs.

METHODS

A diathermy apparatus with a working frequency about 165 kilohertz and an "LUCh-58" apparatus with working frequency of 2375 ± 50 millihertz were used in the experiments.

The experiments were performed on 33 adult dogs of both sexes, weighing 6.5-12 kg. Cerebral cooling was attained by circulating blood through a coil inserted into the blood stream in the common carotid artery and submerged in an ice bath. The large animals were continuously surrounded by ice bags. Initial anesthesia was produced by subcutaneous morphine (0.01 g/kg) and thiopental sodium intravenous (50-80 ml of 0.5% solution). Rectal temperature in deep hypothermia in most experiments was 24-26°. In one group of experiments to attain the given temperature electrodes from sheet lead squares 100 cm² each, attached under the diathermy apparatus, were attached to carefully selected areas of thoracic skin at the level of the third to eighth ribs. A triply repeated current of 0.8 amp was delivered to the electrodes during exposure periods of 10-15 min with breaks of five minutes. In the second group of experiments study was devoted to the effect of warming with the "LUCh-58" apparatus. In this case, a right-angle electrode of 30 × 9 cm size or a cylindrical electrode with a working surface of about 150 cm² was placed on the thorax eight cm above the body surface after the given level of cooling was achieved. The power of the current, as a function of the size of the animal, was 100-120 volts with thirty minutes exposure with double shocks for 15 min each and five minute intervals.

RESULTS AND DISCUSSION

The use of high-frequency currents for warming animals from a hypothermic state appears to be extremely effective. Already by 40-45 min of short wave diathermy the body temperature of the dogs had risen from 24.8-26.4° to 30.8-33.6°. As a result of careful preparation of the animals and deep placement of the electrodes we avoided producing burns, in distinction to the experience of Lewis [11].

The action of the "LUCh-58" apparatus was even more striking. In 15 out of 21 experimental animals a half-hour exposure led to a body temperature rise to 32-32.8°. In five instances the body temperature of the animals at the end of exposure varied from 31.2-31.9°. In only one case, when the body temperature rose to 30.4° after warming, there was an abrupt weakening of cardiac action and depression of respiration in an emaciated animal; despite the usual measures the animal died after $1^1/_2$ hours. Animals taken from the table subsequently did not require special measures and spontaneously reached normal temperature levels. Thus we avoided keeping the body temperature at the low level for a long time as is observed with the usual warming methods (excluding perfusion with warmed blood, which is not always acceptible). In the post-hypothermic period the activation of thermoregulatory mechanisms occurs gradually, probably not before the critical temperature of 32-33° is reached. Therefore, prolonged maintenance of the organism at a low temperature disrupts the normal course of the recovery reaction.

It may be supposed that the prolonged depression of central nervous system function by cooling creates at some period unfavorable interactions of neurohumoral regulatory factors, which leads to a peculiar disruption between the requirement of the organism returning to a normal vital condition and the possible maintainance of its central nervous system in the case of deep cooling and also when the post-hypothermic period is delayed. This consideration makes management of the length of the post-hypothermic period extremely important.

In our studies we turned our attention to the favorable subsequent course of the post-hypothermic period when high-frequency current was used. It must be considered that high-frequency currents possess the capacity for specific activation of the living organism. It is known, for example, that they have a stimulating effect on the trophic reactions of the nervous system, metabolic processes and the cardiovascular system. Evidently, the safe course of the post-hypothermic period as well as the shorter warming period is accounted for by this factor. We constantly observed in these experiments a considerable improvement in cardiac action, increased vascular tone and well regulated respiratory activity. These favorable changes occurred soon after the initiation of high-frequency current action. Use of the "LUCh-58" apparatus was particularly advantageous, since the electrodes of this apparatus, placed over the body surface, permit free access to the thorax of the animal and, if necessary, easy and rapid initiation of such manipulations as artificial respiration, indirect cardiac massage or defibrillation.

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