EFFECTS OF HYPOTHERMIA ON ISOLATED RABBIT ATRIA

By

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The effect of hypothermia on the heart has been studied in intact animals, heart lung preparations and isolated perfused mammalian heart. It has been generally agreed that occasional death under hypothermia is due to cardiac asystole or ventricular fibrillation. The rhythmicity and conductivity of the cardiac muscle are depressed considerably as is evident by a decrease in the heart rate and an increase in P-R interval. The excitability of the cardiac muscle is increased as few mechanical stimuli set up a condition of ventricular fibrillation as shown by Reissman and Kapoor (6). This work was done to find out the effects of progressive hypothermia on isolated auricles of rabbit.

MATERIALS AND METHODS

Fifteen young rabbits of either sex, weighing between 1 and 2 *kg*, were used. The rabbits were stunned by a blow on the head and the heart was removed and kept in a beaker containing Tyrode's solution. The atria were isolated from the ventricles and suspended in Dale's bath containing 100 *ml* of continuously oxygenated Tyrode's solution, having a *p*H of 8. All initial recordings of atrial contractions were made at 37°C after the atrial activity had become steady. The contractions were recorded on slowly moving kymograph.

Atria were cooled to any desired temperature by adding ice in the container surrounding the organ-bath.

The effects of progressive cooling and subsequent rewarming were studied on the rate and amplitude of contraction at 37°C, 30°C, 25°C and 20°C or still lower temperature, when needed. The temperature at which asystole occurred was noted in each experiment. Rewarming of atria was started after 5 minutes to 24 hours of complete asystole in different experiments. The temperature at which atria resumed beating on rewarming was noted.

RESULTS AND DISCUSSION

A curvi-linear relationship was seen to exist between the rate and temperature (Fig. 1) There was a 50% decrease in rate when the temperature was reduced from 37°C to 25°C. Knowlton and Starling (4) observed a linear relationship beween rate of isolated mammalian heart and temperature. However, Frank (3) did not observe linear relationship between the heart rate and temperature in intact rabbits.

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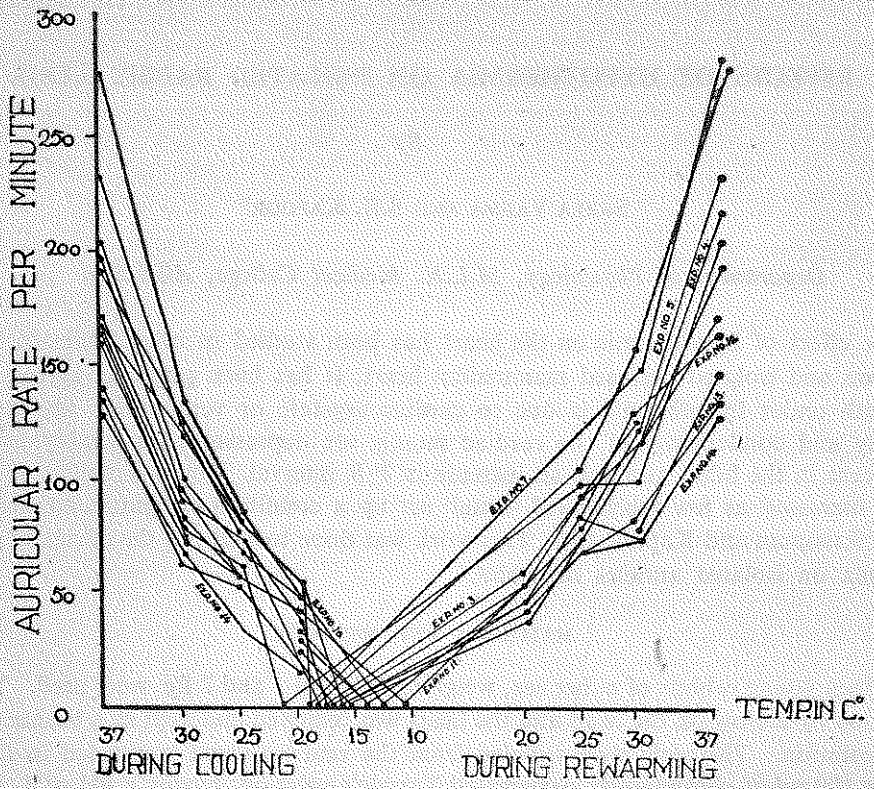


Fig. 1 : Atrial rate at different temperatures during cooling and rewarming

The force of atrial contraction became greater as the temperature was reduced from 37°C to 25°C (Figs. 2, 3, A). Improvement in amplitude ranged from 5.1 to 271.4%. The amplitude was reduced on lowering the temperature below 25°C but in some hearts the improvement was maintained even down to 20°C. The initial increase in amplitude might be due to decrease of atrial rate providing greater diastolic rest. Webb (7) also observed that the amplitude of contraction improved when the temperature of the bath was lowered from 37°C to 30°C. However, Clark (1) had observed diminution of the force of contraction in isolated perfused frog's heart. Erlanger (2) observed irregularities in the force of contraction in perfusion experiments on isolated mammalian heart during hypothermia. In the present study, it was observed that atrial contractions became feeble when the temperature was reduced below 20°C (Fig. 3, B). On further reducing the temperature atrial irregularity in the form of alternate big and small contractions (mechanical alterans) appeared. No other kind of atrial irregularity was observed. The atrial activity came to a stand still in 57 per cent of hearts between 16.5°C and 19°C. In two hearts the asystole appeared only when the temperature was reduced to as low as 10.5°C (Fig. 3, B). Repeated cooling of the same atria demonstrated that the activity persisted to a lower temperature in subsequent experiments.

On rewarming, the rate and amplitude of atrial contractions recovered completely, except when asystole exceeded 2 hours.

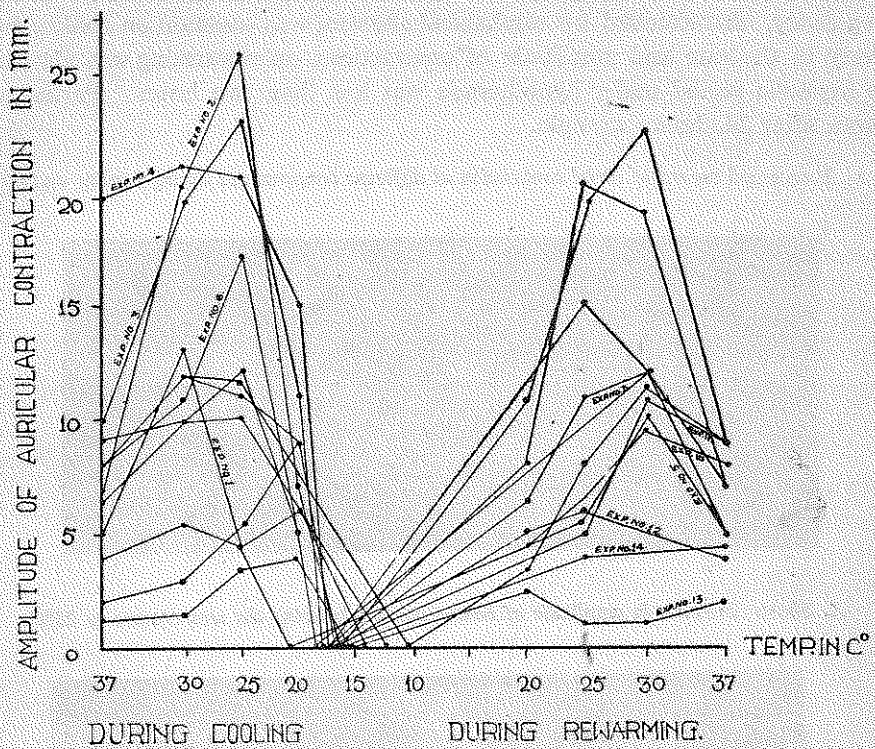


Fig 2 : Amplitude of atrial contractions at different temperatures during cooling and rewarming

Marshall and Williams (5) had observed that, although rhythmical (propagated) electrical activity (action potentials) of the auricular preparations ceased simultaneously with the reduction of temperature to 14°C, still some small rhythmical electrical potentials persisted in the region of pace maker. During rewarming the first signs of activity were in the form of rhythmical nonpropagated potentials in the region of pace maker. On further rewarming, the normal action-potentials "took off" from the pace maker potentials. In one experiment the asystole was maintained for 24 hours. On rewarming, signs of activity in the atria were noted (Fig. 3, C).

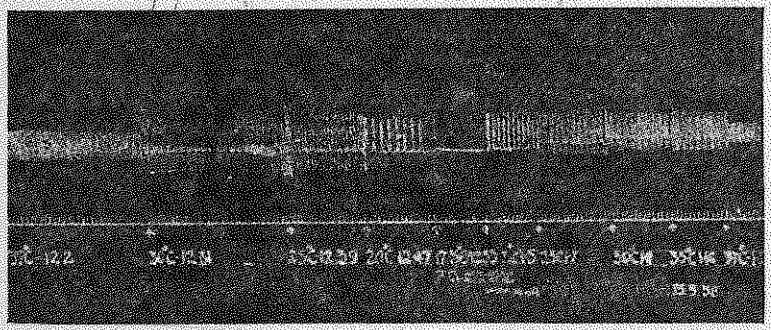
The present work suggests that hypothermia of moderate duration may produce only a reversible depression of heart leading to a decrease in the rate and force of contraction.

SUMMARY

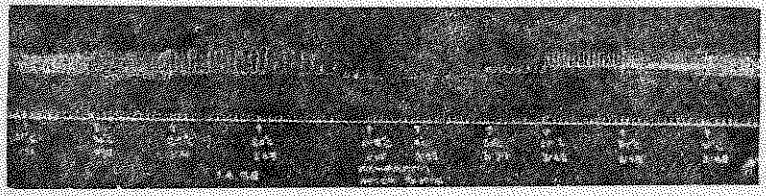
The effect of temperature on the isolated atria of rabbit was studied. There was a decrease in rate of contraction on cooling the atria. A curvi-linear relationship existed between rate and temperature. Improvement in the amplitude of contraction up to 50 per cent was observed on lowering the temperature from 37°C to 25°C. On further lowering the temperature, the amplitude was reduced, except in two hearts where it improved down to 20°C. The atrial activity apparently came to a stand still in 57 per cent hearts between 19 and 16.5°C. However, a few atria continued to show signs of activity even at temperature as low as 10.5°C.

Atrial irregularity, characterized by mechanical alterans, was common on cooling below 20°C. The recovery in the rate and amplitude of contractions on rewarming was almost complete where the asystolic period under hypothermia was less than two hours. Partial revival was possible even after 24. hours asystole.

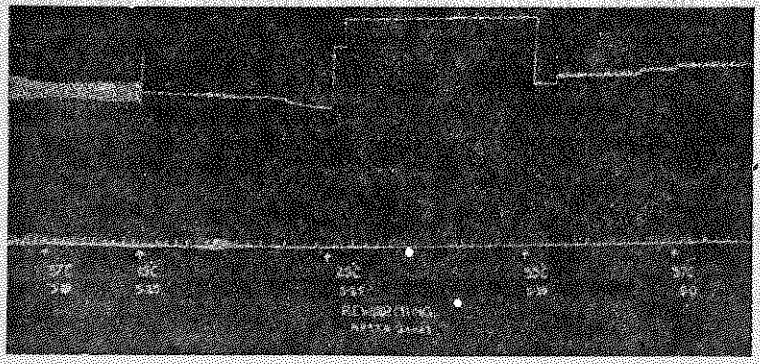
Fig. 3 : Kymograph record of atrial contraction at different temperatures during cooling and rewarming



A. Shows increase in amplitude of contraction on lowering the temperature to 25°C.



B. Shows a decrease in amplitude of constraction at temperature lower than 25°C Note that asystole appeared at a temperature of 10.5°C.



C. Showing cession of atrial activity on cooling to 19°C. Asystole was maintained for 24 hours. Note signs of activity on rewarming.

REFERENCES

1. Clark, A.J. The effect of alterations of temperature upon the function of the isolated heart. *J. Physiol.* **54**:275, 1920.

2. Erlanger, J. Observations on the auricular strips of the cat's heart. *Am. J. Physiol.* **27**:87, 1910.

3. Frank, W.B. Zeitschrift fur Biologie. **49**:892, 1907. Quoted by Clark, A.J. The effect of alterations of temperature upon the functions of the isolated heart. *J. Physiol.* **54**:275, 1920.

4. Knowlton, F.P. and E.H. Starling. Experiments on the consumption of sugar in the normal and the diabetic heart. *J. Physiol.* **44**:206, 1912.

5. Marshall, J. and E.M. Vaughan Williams. Pacemaker potentials. The excitation of isolated rabbit auricles by acetylcholine at low temperature. *J. Physiol.* **131**:186, 1956.

6. Reissman, K.R. and S.R. Kapoor. Dynamics of hypothermic heart muscle (heart lung preparation). *Am. J. Physiol.* **184**:162, 1956.

7. Webb, J.L. The actions of metabolic substrates and inhibitors on the rabbit auricle. *Brit. J. Pharmacol.* **5**:87, 1950.