Cardiovascular Effects of Hypothermia in the Chicken

During hypothermia the arterial blood pressure of the chicken has been reported to decrease *pari passu* with the diminution in body-temperature[1]. However, it is not known whether the decrease in blood pressure is the result of a diminution of the cardiac output or of the total peripheral vascular resistance. The purpose of the experiments reported here was therefore to obtain data on the cardiac outputs and blood pressures of chickens during hypothermia. From such data the total peripheral resistances could be calculated.

Experiments were performed on six adult White Leghorn hens. Their mean body-weight was 1,806 g ± 162 (*S.E.*). The birds were cooled by immersion up to the neck in a tank of stirred water at 18°–22° C. Before and during the immersion, measurements were made at approximately 10-min intervals of cardiac output, blood pressure, rectal temperature and respiratory rate. The techniques used in this investigation have been described elsewhere[2].

The effects of hypothermia were similar in the six birds. A record of the results obtained in one of the birds is given in Fig. 1. When the birds were first immersed in the water bath, there was a transient increase in cardiac output, following which the cardiac output diminished continuously throughout the remainder of the period of hypothermia. The central blood volume[2], like the cardiac output, increased at first during hypothermia, and later decreased. The heart rate also decreased during hypothermia but the stroke volume increased. The blood pressure was maintained during the first 20 min of the period of hypothermia but thereafter it decreased. Initially, while the cardiac output was increasing and the blood pressure was maintained, the calculated total peripheral resistance decreased. Later, when the blood pressure and cardiac output were both decreasing, the peripheral resistance increased. Shivering, accompanied by an increase in respiratory rate, was observed at first during hypothermia. However, the increased heat production which presumably resulted from the shivering was not sufficient to prevent the rectal temperature from decreasing, and as the rectal temperature decreased further the respiratory rate diminished also. The results for five of the six birds from which complete data were obtained are given in Table 1.

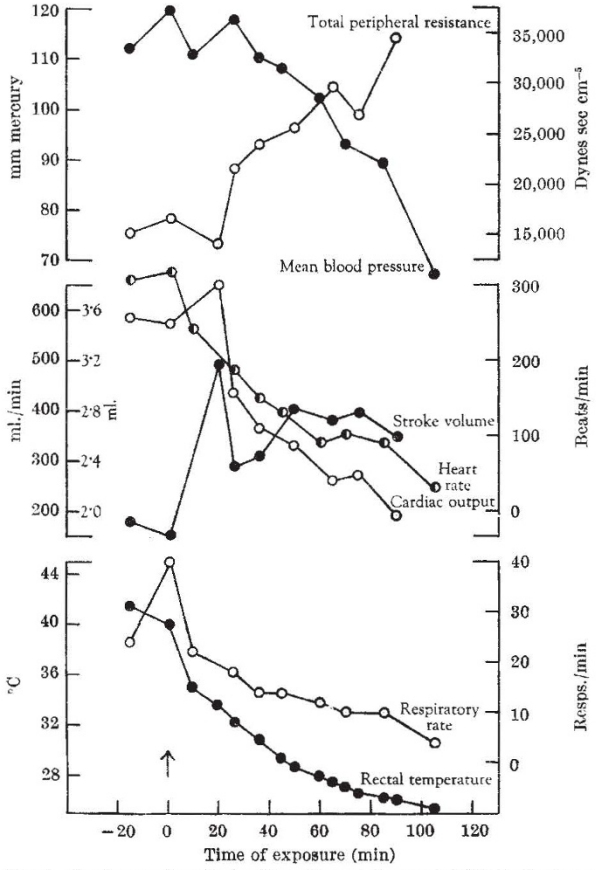

Fig. 1. Cardiovascular effects of hypothermia in an adult White Leghorn hen. The arrow indicates the time at which the bird was immersed in water at 20° C

Table 1. Mean (± *S.E.*) Values Before and at the End of the Period of Hypothermia (5 Birds)

	Before hypothermia	End of hypothermia
Time (min)	−10	79 ± 9
Rectal temp. (°C)	40·9 ± 0·2	27·0 ± 0·9*
Respiratory rate (respirations/min)	21 ± 2	10 ± 2*
Cardiac output (ml./min)	357 ± 71	187 ± 47*
Heart rate (beats/min)	329 ± 18	101 ± 9*
Stroke volume (ml.)	1·1 ± 0·3	1·8 ± 0·4*
Cardiac work (kg m/min)	0·588 ± 0·122	0·316 ± 0·058*
Mean blood pressure (mm Hg)	115 ± 8	88 ± 11*
Pulse pressure (mm Hg)	32 ± 4	30 ± 2
Total peripheral resistance (dynes sec cm⁻⁵)	30,146 ± 6,727	50,196 ± 13,350
Central blood volume (ml.)	38 ± 6	31 ± 6*

* Significantly different ($P < 0·05$) from control values before hypothermia.

It is quite clear from these results that the diminution of blood pressure in chickens during hypothermia is the result of a decrease in the cardiac output because the peripheral resistance increased. The decrease in the cardiac output was the consequence of a reduction in heart rate, since the stroke volume of the heart increased. The diminution in heart rate, following the initial increase, was related logarithmically to the decrease in rectal temperature as predicted by the Van't Hoff–Arrhenius effect of temperature on reaction rates[2]. The diminution in heart rate, cardiac output and blood pressure appears therefore to result directly from the lowered temperature of the heart itself. However, a reduction in the blood volume might also have contributed to the decrease in cardiac output[3].

The increases in cardiac output, heart rate and respiratory rate, which occurred when the chickens were first immersed in the water, were probably related to the shivering which was observed at this time and to the reflex effects of cooling the skin. Similar effects have been recorded in the dog during hypothermia[4,5]. It seems reasonable to assume that the increase in the total peripheral resistance during hypothermia was the result in part of an increased viscosity of the blood. The lowered temperature of the blood and the haemoconcentration which occurs in the chicken during hypothermia[3,6] could both have contributed to an increased viscosity of the blood[7].

From the results of this investigation it is apparent that the responses of birds to hypothermia are qualitatively similar to those of mammals.

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G. C. Whittow*
P. D. Sturkie
G. Stein, jun.

Avian Physiology Laboratory,
Department of Animal Sciences,
Rutgers: The State University,
New Brunswick, New Jersey.

* United States Public Health Service (National Institutes of Health) Post-Doctoral Fellow. Present address: Department of Physiology, the Hannah Dairy Research Institute, Ayr, Scotland.

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