ANALYSIS OF DISTURBANCES OF CARDIAC ACTIVITY IN CATS WITH CORTICOSTEROID DEFICIENCY

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Marked hypotension and various disturbances of mechanical and electrical activity of the heart were observed in cats following bilateral adrenalectomy. Administration of desoxycorticosterone acetate to such animals restored some of the studied indices to normal, whereas hydrocortisone was almost without positive effect.

Adrenal deficiency leads to marked circulatory disorders, including arterial hypotension and a decrease in the minute volume of the heart [4-6], due largely to a diminution of the contractile power of the myocardium [1-4]. The hemodynamic disturbances, in turn, play an important role in the further development of the pathological state characteristic of adrenal deficiency. Investigations of the hemodynamics thus shed considerable light on functional disorders in the body associated with corticosteroid insufficiency.

In the investigation described below, cardiac activity was studied in total adrenal insufficiency and also after replacement of the mineralocorticoid or glucocorticoid function.

EXPERIMENTAL METHOD

Experiments were carried out on cats of both sexes weighing 1.5-3 kg. Total adrenal deficiency was simulated by two-stage adrenalectomy under nembutal anesthesia, with an interval of 5-6 days between stages. After removal of the second adrenal, replacement therapy was instituted, with corticosteroid (DOCA 0.5 mg/kg, and hydrocortisone 1 mg/kg) for 3 days. Administration of the hormones was then either stopped (series with total adrenal deficiency) or DOCA (series with glucocorticoid deficiency) or hydrocortisone (series with mineralocorticoid deficiency) was given alone.

Recordings of the EKG in three standard leads, the phonocardiogram (PCG), and pressure in the carotid artery were made in all series of experiments under nembutal anesthesia 12 days after removal of the second adrenal.

EXPERIMENTAL RESULTS

During total adrenal deficiency, shortening of the expulsion phase (from 0.122 ± 0.007 to 0.076 ± 0.012 sec) was observed. This was not due to any changes in the duration of the cardiac cycle which, on the contrary, was significantly increased. Shortening of the expulsion phase was evidently due to a decrease in the cardiac output, in agreement with data in the literature [1, 2]. The phase of isometric contraction showed no significant changes, although the decrease of arterial pressure (from 125 to 73 mm Hg; $P < 0.01$) observed in total adrenal deficiency could lead to a marked decrease in the duration of this period. On the whole, the fraction of the cardiac cycle represented by the period of contraction was greater than the period of expulsion, as shown by an increase in the index of myocardial contraction and a decrease in Blumberger's coefficient. The mechano-electrical coefficient also was reduced (Table 1).

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TABLE 1. Changes in Phase Relationships of Left Ventricular Systole during Adrenal Insufficiency

Ratio between phases of cardiac cycle	Control	Total adrenal deficiency	Replacement of glucocorticoid function	Replacement of mineralocorticoid function
Intrasystolic index $\frac{E}{Sm} \cdot 100$ %	70,9±2,21	60,4±5,60	65,5±3,70	71,0±3,30
Index of myocardial contraction $\frac{T}{S_G} \cdot 100\%$	40,3±1,95	$P<0,01$ 55,0±4,25*	46,4±2,50*	40,0±2,86*
Mechanoelectrical coefficient $\frac{Sm}{Se}$	0,732±0,038	0,524±0,040*	0,618±0,044*	0,616±0,034*
Blumberger–Mueller coefficient $\frac{E}{T}$	1,53±0,13	$P<0,05$ 0,99±0,18*	1,25±0,12	1,53±0,17

Legend: E represents period of expulsion; Sm mechanical systole; Se electrical systole; St total systole; T period of contraction; * differences from control are significant (also in Table 2).

TABLE 2. Changes in Electrocardiographic Indices in Adrenal Insufficiency

EKG indices	Control	Total adrenal deficiency	Replacement of glucocorticoid function	Replacement of mineralocorticoid function
R—R (in sec)	0,355±0,007	0,440±0,003*	0,430±0,037* $P<0,02$	0,400±0,015*
P—Q (in sec)	0,080±0,002	0,075±0,013	0,073±0,003	0,080±0,001
QRS (in sec)	0,037±0,003	0,048±0,004*	0,050±0,005*	0,040±0,004
P_2 (in mm)	2,5±0,23	3,2±0,43	3,1±0,42	3,0±0,49
R_2 (in mm)	14,4±1,40	8,3±1,35*	9,7±0,77*	10,0±1,50*
T_2 (in mm)	3,5±0,50	0,8±0,34*	1,5±0,65*	2,0±0,63

Analysis of the electrocardiographic data revealed considerable changes in electrical activity of the heart in the animals with total adrenal insufficiency. Slowing of the rhythm, depression of intraventricular conductivity, and lowering of the amplitude of the R waves in all three leads were observed (Table 2). The amplitude of the T waves was reduced, and isoelectric and negative waves were frequently found. These changes are evidently associated with disturbances of electrolyte metabolism developing in adrenal deficiency [3].

In animals with mineralocorticoid deficiency, despite administration of maintenance doses of hydrocortisone, no significant improvement in cardiac activity could be detected. Just as in the experiments with complete adrenal insufficiency, significant differences with the controls still remained in these animals (Tables 1 and 2), although a tendency for the indices to come together could be detected.

Administration of mineral corticoids (DOCA) to adrenalectomized cats gave a marked effect, because several indices of the phase structure of the cardiac cycle (Blumberger's coefficient, index of myocardial contraction) and of the electrical activity of the heart were restored completely to normal. DOCA therapy restored ventricular conductivity and quickened the heart rate by comparison with animals with complete adrenal deficiency. Some decrease in amplitude of the P_3 wave was observed, but the amplitude of the T_2 and T_3 waves was increased. The mean arterial pressure in this series also remained significantly lower than in the control, namely 82 mm Hg.

The individual adrenal cortical hormones thus cannot completely restore the hemodynamics, because in experimental animals with partial substitution of adrenal function the hypotension as well as certain changes in mechanical and electrical activity of the heart still persist. The greater degree of restoration of cardiovascular functions by administration of a mineralocorticoid such as aldosterone, compared with

DOCA, must be noted. This follows from analogous experiments previously undertaken on dogs [2], and it confirms the general conclusion that mineralocorticoids are more effective in the abolition of disturbances of cardiac activity in adrenal insufficiency.

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