

PRIMARY RESPONSE OF THE PITUITARY-ADRENAL SYSTEM TO IONIZING RADIATION

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The primary response of the pituitary-adrenocortical system of rats to ionizing radiation was investigated. An increase in the hormone-producing and secretory function of the adrenals was observed after exposure for 5 min to ionizing radiation in a dose of 650 R. The corticosterone level in the plasma and adrenals 20 min later was the same as in the control animals.

Changes in the hypothalamo-hypophyseal-adrenocortical system under the influence of ionizing radiation have frequently been investigated [1, 5, 9, 11]. The main reason for this interest is that many of the symptoms of radiation sickness are associated with increased activity of the hypophyseal-adrenocortical system [3, 4]. Most evidence in the literature shows that the adrenal responds by a biphasic increase in the glucocorticoid level, the first phase of activation of adrenal function usually occurring 1-4 h after exposure to ionizing radiation [2, 10, 11, 19]. If this is true, this response of the pituitary-adrenocortical system to total irradiation differs in its temporal characteristics from the response to other stressors (ether, cold, surgical trauma, etc.), for activation of the pituitary-adrenal system in the latter case develops much sooner [6, 13, 16].

The object of this investigation was to determine the time of appearance of the first glucocorticoid peak during exposure to ionizing radiation and to compare the rate of onset of this response with that reported in the literature during the action of classical stressor agents.

EXPERIMENTAL METHOD

Experiments were carried out on 60 noninbred male rats weighing 200-250 g. For 2 weeks the animals underwent mock irradiation daily, to accustom them to the experimental situation. The rats were then irradiated on the ÉGO-2 apparatus in a dose of 650 R (dose rate 457.84 R/min), both the true and the mock irradiation procedures being carried out at the same time of day. The rats were sacrificed by decapitation 5 and 20 min and 1 h after the end of the true or mock irradiation. Blood was collected in heparinized tubes and centrifuged at 2500 rpm. The plasma corticosterone level was determined fluorometrically by De Moor's method in Rozental's modification [8]. The adrenals were excised, weighed, and homogenized. Corticosterone in the adrenals was determined by the method of Guillemain et al. [14] in Rozental's modification [8]. Fluorescence was measured on a Hitachi MPF-2A spectrofluorometer at wavelengths of excitation of 470 nm and fluorescence of 530 nm.

EXPERIMENTAL RESULTS AND DISCUSSION

In animals subjected to mock irradiation, the corticosterone concentration in the plasma and adrenals was virtually indistinguishable from its original values, namely $15.8 \pm 0.8 \mu\text{g}\%$ and $3.5 \pm 0.4 \mu\text{g/g}$ respectively. This shows that the effect of the experimental situation on the pituitary-adrenocortical system was eliminated as a result of preliminary training (Table 1).

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TABLE 1. Effect of Irradiation on Corticosterone Concentration in Plasma and Adrenals

Experimental conditions	Corticosterone concentration in plasma (in $\mu\text{g}\%$) and adrenals (in $\mu\text{g}/\text{g}$)			
	initial values		5 min after irradiation	
	plasma	adrenal	plasma	adrenal
Irradiation (650 R)			$35.9 \pm 2.1^*$	$14.1 \pm 1.5^*$
Mock irradiation			15.8 ± 0.8	3.5 ± 0.4
Control	15.8 ± 0.8	3.2 ± 0.4		

(Continuation)

Experimental conditions	Corticosterone concentration in plasma (in $\mu\text{g}\%$) and adrenals (in $\mu\text{g}/\text{g}$)			
	20 min after irradiation		1 h after irradiation	
	plasma	adrenal	plasma	adrenal
Irradiation (650 R)	15.8 ± 1.1	3.2 ± 0.5	11.3 ± 1	3.9 ± 0.3
Mock irradiation	13.2 ± 1.7	1.5 ± 0.3	15.2 ± 0.8	2.4 ± 0.7
Control				

* $P < 0.001$.

Activation of the pituitary-adrenal system in the irradiated animals was recorded 5 min after irradiation. The increase in corticosterone concentration in the blood and adrenals was considerable: $35.9 \pm 2.1 \mu\text{g}\%$ ($P < 0.001$) and $14.1 \pm 1.5 \mu\text{g}/\text{g}$ ($P < 0.001$) respectively, but was of short duration. The corticosterone concentration in the adrenals and plasma returned to normal 20 min after irradiation. The hormone level still remained close to its initial value 1 h after exposure to ionizing radiation. These times of activation of the pituitary-adrenal complex (5 min) agree with those obtained by Flemming [12].

Total irradiation evidently evoked the same primary response of the pituitary-adrenocortical system as other stressor agents (surgical trauma, ether, etc.).

There is evidence in the literature that the response of the pituitary to stressors of various types consists of a rapid liberation of ACTH, which can be detected in the blood 2 min after exposure [6, 7, 15, 17]. The adrenals respond by an increase in corticosterone concentration 5 min after exposure [6, 8]. The plasma glucocorticoid level is increased after 10-30 min [6, 13, 16]. The magnitude and duration of the increase in synthetic and secretory ability of the adrenals depend on the quantity of ACTH circulating in the blood stream [18]. This probably explains the difference between the present results and those obtained by Flemming for the duration of activation of the distal component of the pituitary-adrenocortical system. The more prolonged secretory activity of the adrenal (2.5 h) observed by Flemming may be the result of a more intensive liberation of ACTH from the pituitary than occurred under the conditions of irradiation used in the present experiments.

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