

EFFECT OF X-RAY IRRADIATION ON COPPER AND ALUMINUM  
CONTENT IN FUNCTIONALLY AND MORPHOLOGICALLY  
DIFFERENT SPINAL CORD TISSUES

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The copper and aluminum content in functionally and morphologically different parts of the spinal cord was determined spectrographically. Ionizing radiation, whether local or to the whole body, changes the copper and aluminum concentrations in the spinal cord.

Trace elements influence the reflex activity of the spinal cord [2,4-6, 10]. Under normal physiological conditions, their concentration in the tissues is maintained in a definite ratio depending on the functional state of the central nervous system [8, 9, 11]. Ionizing radiation is known to produce substantial disturbances of spinal cord function [12].

It was therefore decided to investigate the dynamics of trace elements in the spinal cord.

EXPERIMENTAL METHOD

Cats were used for the experiments. After decapitation of the animals the lumbar enlargement of the spinal cord was removed and divided in the cold by a method previously developed in the writers' laboratory [7] into the following parts: the gray matter of the anterior and lateral horns (motor region), the gray matter of the posterior horns (sensory region), white matter, and ventral and dorsal roots. Whole-body irradiation of the animals was given as a single dose of 1200 R under the following conditions: voltage 185 kV, current 15 mA, filters 0.5 mm Cu and 0.5 mm Al, skin-focus distance 50 cm, dose rate R/min. Local irradiation of the lumbar division of the spinal cord was carried out by means of a special lead screen.

Trace elements in the test tissues were determined spectrographically by the triple label method 1, 24, and 48 h and 5 and 8-10 days after irradiation. The spectrophotometric determinations were made with an MF-2 microphotometer. The concentration of trace elements in the samples was determined from the characteristic curve. The results were analyzed by a statistical method for small samples.

EXPERIMENTAL RESULTS

The results of determination of the dynamics of the trace elements after irradiation are given in Table 1. Their analysis shows that x-ray irradiation causes changes in the concentrations of copper and aluminum in functionally and morphologically different parts of the spinal cord and in the animals' blood at various times after irradiation.

In tissues of the gray matter of the anterior and lateral horns, the copper concentration was almost doubled 1, 24, and 48 h and 8-10 days after irradiation. The copper concentration in the tissue of the gray

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TABLE 1. Concentration of Copper and Aluminum (in mg% per dry weight) in Spinal Cord of Animals after X-Ray Irradiation (results of 7-10 experiments;  $M \pm m$ )

Tissues	Trace elements	Control	Whole-body irradiation		Local irradiation	Whole-body irradiation			
			1h	24h		24 h	48 h	5 days	8-10 days
Gray matter: of anterior and lateral horns of posterior horns	Cu	0,60 $\pm$ 0,03	0,76 $\pm$ 0,04*	0,80 $\pm$ 0,04*	2,17 $\pm$ 0,40*	2,17 $\pm$ 0,40*	1,10 $\pm$ 0,07*	1,00 $\pm$ 0,20	1,10 $\pm$ 0,10*
	Al	4,60 $\pm$ 0,50	0,44 $\pm$ 0,04*	1,10 $\pm$ 0,20*	1,21 $\pm$ 0,13*	1,21 $\pm$ 0,13*	3,20 $\pm$ 0,30*	1,10 $\pm$ 0,10*	0,67 $\pm$ 0,04*
	Cu	0,78 $\pm$ 0,09	0,33 $\pm$ 0,02*	0,86 $\pm$ 0,08	0,93 $\pm$ 0,13	0,93 $\pm$ 0,13	0,68 $\pm$ 0,02	1,10 $\pm$ 0,10*	1,40 $\pm$ 0,29*
	Al	16,0 $\pm$ 3,30	1,30 $\pm$ 0,10*	1,16 $\pm$ 0,24*	1,43 $\pm$ 0,34*	1,43 $\pm$ 0,34*	3,50 $\pm$ 0,30*	1,90 $\pm$ 0,40*	0,41 $\pm$ 0,05*
White matter	Cu	0,30 $\pm$ 0,02	0,59 $\pm$ 0,04*	1,85 $\pm$ 0,70	0,46 $\pm$ 0,08	0,46 $\pm$ 0,08	0,46 $\pm$ 0,08*	2,20 $\pm$ 0,60*	0,90 $\pm$ 0,01*
	Al	2,10 $\pm$ 0,50	0,47 $\pm$ 0,04*	1,20 $\pm$ 0,09	1,37 $\pm$ 0,05	1,37 $\pm$ 0,05	0,80 $\pm$ 0,06*	22,0 $\pm$ 0,40*	0,17 $\pm$ 0,06*
Roots ventral dorsal	Cu	0,23 $\pm$ 0,02	0,46 $\pm$ 0,04*	0,24 $\pm$ 0,02	0,46 $\pm$ 0,09	0,46 $\pm$ 0,09	0,66 $\pm$ 0,01*	2,00 $\pm$ 0,40*	2,60 $\pm$ 0,10*
	Al	1,70 $\pm$ 0,26	0,58 $\pm$ 0,03*	1,01 $\pm$ 0,10*	0,41 $\pm$ 0,04*	0,41 $\pm$ 0,04*	2,60 $\pm$ 0,30*	22,0 $\pm$ 1,70*	0,70 $\pm$ 0,04*
	Cu	0,42 $\pm$ 0,04	0,41 $\pm$ 0,07	0,79 $\pm$ 0,08*	0,98 $\pm$ 0,07*	0,98 $\pm$ 0,07*	0,31 $\pm$ 0,02	2,40 $\pm$ 0,40*	1,10 $\pm$ 0,20*
Blood	Al	4,20 $\pm$ 0,30	0,64 $\pm$ 0,04*	1,40 $\pm$ 0,20*	0,93 $\pm$ 0,09*	0,93 $\pm$ 0,09*	1,60 $\pm$ 0,10*	23,0 $\pm$ 2,60*	0,33 $\pm$ 0,04*
	Cu	0,26 $\pm$ 0,20	1,00 $\pm$ 0,39	0,43 $\pm$ 0,06	—	—	2,00 $\pm$ 0,60*	1,20 $\pm$ 0,10*	0,85 $\pm$ 0,07*
	Al	0,25 $\pm$ 0,04	1,20 $\pm$ 0,40*	0,43 $\pm$ 0,05			2,10 $\pm$ 0,16*	1,80 $\pm$ 0,40*	0,66 $\pm$ 0,07*

\* Differences significant.

matter of the posterior horns was reduced 1 h after irradiation, but almost doubled on the 5th and 8th-10th days after irradiation. The copper concentration was increased by 3-10 times in the tissues of the white matter and spinal roots after irradiation.

At all times of investigation after whole-body x-ray irradiation, the aluminum concentration in the gray matter of the spinal cord was reduced by 4-10 times. It was also reduced in the white matter and spinal roots, and only on the 5th day after irradiation was the aluminum concentration there significantly increased over the control level. Corresponding changes in the copper concentration in the anterior and lateral horns and dorsal roots and in the aluminum concentration in the gray matter and spinal roots were found 24 h after local and whole-body irradiation.

The copper and aluminum concentrations in the blood of the irradiated animals were raised. This protective response of mobilization by the animal has also been observed by other workers [1, 3].

Local irradiation of the lumbar division of the spinal cord produced similar changes in the concentrations of trace elements as whole-body irradiation of the animals.

In view of the important role of copper and aluminum in functional activity of the nervous system, it can be concluded that the disturbance of the concentration of these trace elements in functionally and morphologically different parts of the spinal cord by the action of ionizing radiation influences the course of post-radiational changes.

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