

Effect of Head X-Irradiation on Adrenal Medullary Secretion

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The purpose of the present experiments was to investigate an immediate effect of head X-irradiation on the secretion of adrenaline and noradrenaline by the adrenal medulla. When the dogs were irradiated with 200 or 800 R of X-rays to their heads under pentobarbital anesthesia, the majority of the animals showed no stimulation of the adrenal medulla but the minority showed a slight but definite increase in the secretion of adrenaline, the peak being attained within 60 min after exposure.

INTRODUCTION

Little is known about the hormone secretion of the adrenal medulla in response to irradiation. A reduction in the concentration of adrenaline and noradrenaline of the adrenal medulla has been reported after whole-body X-irradiation in rats, rabbits and cats.⁴⁾ In a recent study, we found that localized X-irradiation to the adrenal area of dogs has no observable effects on the secretion of adrenaline and noradrenaline by the adrenal medulla.⁶⁾

The present experiments were undertaken to ascertain an immediate effect of localized X-irradiation to the head on the secretion of adrenaline and noradrenaline from the adrenal medulla.

MATERIALS AND METHODS

Adult mongrel dogs weighing 6.5-17.8 kg were used in the present experiments. The animals were anesthetized with 25 mg sodium pentobarbital/kg, injected intravenously,

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and were maintained by intravenous supplements of the drug as required. According to the method of SATAKE, SUGAWARA and WATANABE⁵⁾, the left lumboadrenal vein was approached through a longitudinal incision in the lumbar area and accessory branches of the vessel were ligated and sectioned. After a systemic administration of heparin, a silk thread was passed loosely around the adrenal vein which connects the adrenal gland to the inferior vena cava. A small glass cannula was then introduced into the lumboadrenal vein. By pulling at a ligature around the adrenal vein, the total venous effluent from the adrenal gland was obtained. During periods when blood was not being collected, a ligature was released so that the blood could flow the adrenal gland to the inferior vena cava. Approximately 2 to 3 hrs after the completion of cannulation, two control samples of adrenal venous blood were collected. The animals were then placed in a prone position on a table and designed so that the center of the head would be within a vertically oriented X-ray beam, and were irradiated with 200 or 800 R of direct radiation to their heads. The X-ray characteristics were : 200 KV peak, 20 mA, and filtration of 1.5 mm Cu and 0.5mm Al. A distance from X-ray tube to the central part of the head was 37 cm and a dose-rate approximately 60.6 R/min. Further samples of adrenal venous blood were collected immediately, 15, 30, 60 and 120 min after exposure.

The blood was chilled immediately and centrifuged under refrigeration. One ml of plasma from each sample was analysed for adrenaline and noradrenaline by the method of EULER and LISHAJKO³⁾. The secretion rate of adrenaline or noradrenaline by the one adrenal gland ($\mu\text{g}/\text{kg}/\text{min}$) was calculated by multiplying the concentration of the hormone in adrenal venous plasma ($\mu\text{g}/\text{ml}$) by the adrenal venous plasma flow ($\text{ml}/\text{kg}/\text{min}$).

RESULTS

A Direct Influence of Head X-Irradiation on the Secretion of Adrenaline and Noradrenaline from the Adrenal Medulla

To ascertain whether X-irradiation of the head is accompanied by adrenal medullary stimulation, observations were performed on anesthetized dogs and samples of adrenal venous blood were collected intermittently for up to 2 hrs after head X-irradiation.

The basal secretion of adrenaline or noradrenaline before head X-irradiation under anesthetized conditions was extremely low. These are harmony with the early work of LUND¹⁾ who found low levels of adrenaline and noradrenaline in adrenal venous blood of dogs during light anesthesia. After lower doses of X-rays, i.e. 200 R, there was little or no increase in the secretion of adrenaline and noradrenaline from the adrenal in 3 out of 4 dogs, but in the remaining one adrenaline secretion increased slightly 60 to 120 min after exposure (Fig. 1). Doses up to 800 R were given to 4 dogs but no detectable alterations in adrenaline and noradrenaline levels in samples of adrenal venous blood were observed in 2 animals. The remaining 2 animals showed a slight increase in the secretion of adrenaline 30 to 90 min postirradiation (Fig. 2).

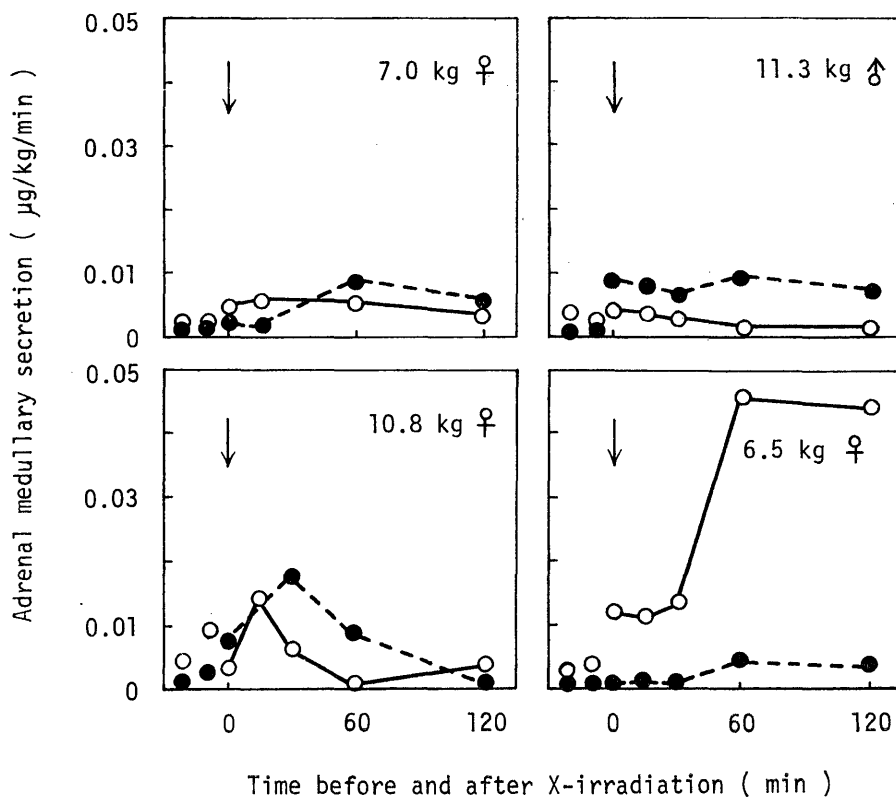


Fig. 1. Time course of secretion of adrenaline and noradrenaline for up to 120 min after head X-irradiation at doses of 200 R in dogs. The secretion rate of adrenaline or noradrenaline by the one adrenal gland ($\mu\text{g}/\text{kg}/\text{min}$) was calculated by multiplying the concentration of the hormone in adrenal venous plasma ($\mu\text{g}/\text{ml}$) by the adrenal venous plasma flow ($\text{ml}/\text{kg}/\text{min}$). ○—○: secretion rate of adrenaline, ●—●: secretion rate of noradrenaline.

DISCUSSION

Since electrical stimulation of various sites in the hypothalamus, midbrain and medulla oblongata has been shown to evoke signs of adrenal medullary activity, an attempt was made to see whether the adrenal medullary activating system in the central nervous system is affected by a direct X-irradiation of the head. Previously, doses of 400–600 R of X-rays have been reported to be sufficient to induce stimulation of the central nervous system²⁾. Doses of 200 or 800 R were therefore administered to canine heads in the present study. As the results of experiments, the majority of animals did not show any evidence of adrenal medullary stimulation at the doses used, but the minority responded to irradiation by secreting adrenaline from the adrenal. Therefore, there exists the possibility that the secretion of adrenal medullary hormones may be altered by a direct head X-irradiation of

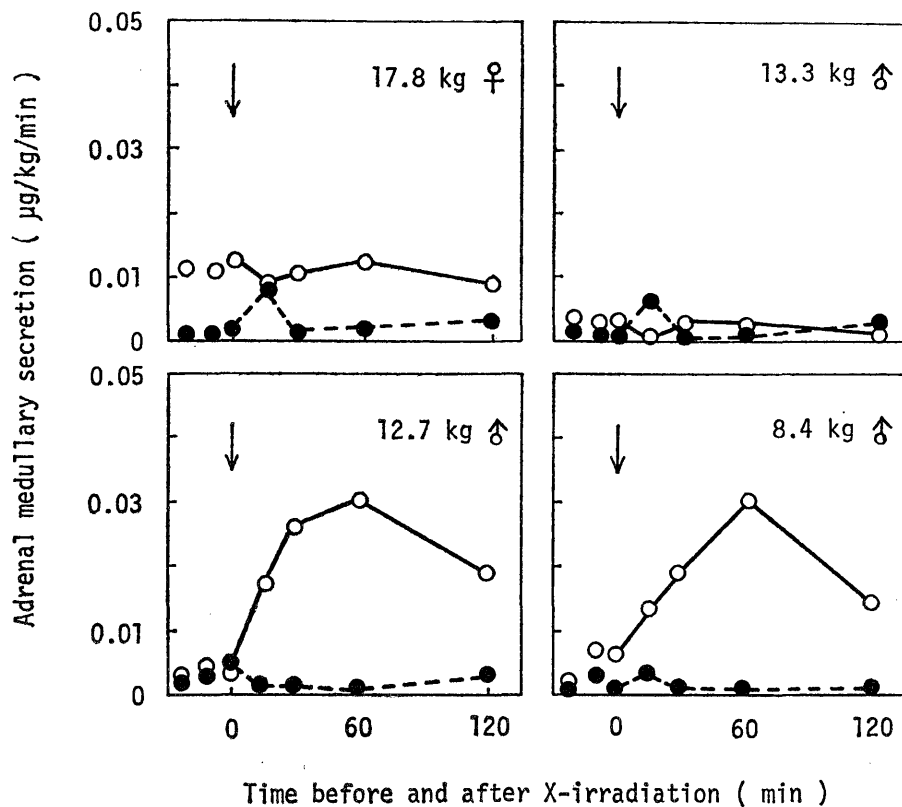


Fig. 2. Effect of exposure of the head to 800 R of X-rays on the secretion of adrenaline and noradrenaline by the adrenal. In each dog, adrenal venous blood was collected intermittently for up to 120 min after the end of X-irradiation and analysed for adrenal medullary hormones. ○—○ : secretion rate of adrenaline, ●- - -● : secretion rate of noradrenaline.

200 or 800 R. Previously GOODALL & LONG⁴⁾ have reported that whole-body X-irradiation with 800–1170 R in rats and rabbits causes a decrease in the adrenaline and noradrenaline content of the adrenal medulla. This reduction occurred immediately after irradiation and continued for approximately 96 hrs. They suggested that the response was probably due to the increased output rather than any fault in biosynthesis. It would appear that changes observed after whole-body irradiation may be due to an effect of irradiation on adrenal tissue and an effect due to irradiation on the head, which may be attributed to the adrenal medullary activating system of the central nervous system. Our previous data showed that the localized X-irradiation to adrenal tissue with 200–5000 R had no direct stimulatory effect nor did it significantly alter the secretion of adrenaline and noradrenaline for up to 2 hrs after exposure⁶⁾. It is therefore highly probable that the central mechanism, as one of their mechanisms of action, plays a major role. In the present experiments, head X-

irradiation of the relatively lower doses had a stimulating effect on adrenal medullary activity in the minority of animals used. Since we used the animals anesthetized with sodium pentobarbital, this might in part be responsible for the ineffectiveness of head X-irradiation observed in the majority of animals.

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