# EFFECT OF SCREENING AN AREA OF BONE MARROW ON HEMATOPOIESIS AND SURVIVAL OF IRRADIATED ANIMALS AFTER OPERATION

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To determine the effectiveness of partial screening of an area of bone marrow in cases of combined whole-body irradiation and trauma, cats were exposed to a single whole-body irradiation procedure with x rays in a dose of 208 R. In the latent period and at the height of development of radiation sickness, a full-thickness sample of tissue was excised from the anterior wall of the stomach, measuring 2.5-3.5 cm, and the hole in the stomach wall was closed by sutures. In the animals which underwent this operation and which had an area of their bone marrow screened during irradiation, the decrease in the circulating blood count was smaller and it recovered more rapidly, while the rate and duration of their survival were higher than those of totally irradiated animals undergoing the same operation.

Partial screening of the bone marrow in totally irradiated animals led to a significant decrease in their mortality [1-3].

The objective of the present investigation was to determine the effectiveness of partial screening of the bone marrow on the combined effect of whole-body irradiation and trauma.

## EXPERIMENTAL METHOD

A full-thickness piece measuring $2.5 \times 3.5$ cm was removed from the anterior wall of the prepyloric part of the stomach of 53 adult cats under hexobarbital anesthesia, and the defect closed with sutures. The operation was performed 25 h (latent period), or 7 days (the time when radiation sickness reached its severest stage) after irradiation. The operations were preceded by a single exposure to whole-body x-ray irradiation in a dose of 208 R (dose rate 16 R/min) in the case of 29 cats (series I) or by irradiation under the same conditions but with screening of one hind limb by a lead sleeve 1.5 mm thick in the case of 24 cats (series II). Of the 29 animals in series I, 19 underwent the operation in the latent period of radiation sickness and 10 at its height; of the 24 animals in series II, 14 underwent the operation in the latent period, and 10 at the height of radiation sickness. Bone marrow of both femora and the stomach wall of the killed and dying animals were fixed in 10% formalin and embedded in paraffin wax. Sections were cut to a thickness of 7 $\mu$ and stained with hematoxylin and eosin, while the sections of the stomach were stained, in addition, by Van Giesen's method, with mucicarmine and by Hotchkiss's method.

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TABLE 1. Survival of Irradiated Animals after Operation

| Series of experiments | Period of radiation sickness when operation was performed | No. of animals undergoing operation | No. of animals dying | No. of animals dying with manifestation of hemorrhagic syndrome | Mean duration of survival after irradiation (in days) |
|---|---|---|---|---|---|
| I. Irradiation without screening of limb | Latent period | 19 | 12 | 10 | 11.1±1.6 |
| | Height of disease | 10 | 10 | 9 | 12.8±1.3 |
| II. Irradiation with screening of hind limb | Latent period | 14 | 7 | 4 | 28.8±4.0 |
| | Height of disease | 10 | 5 | 4 | 19.4±4.6 |

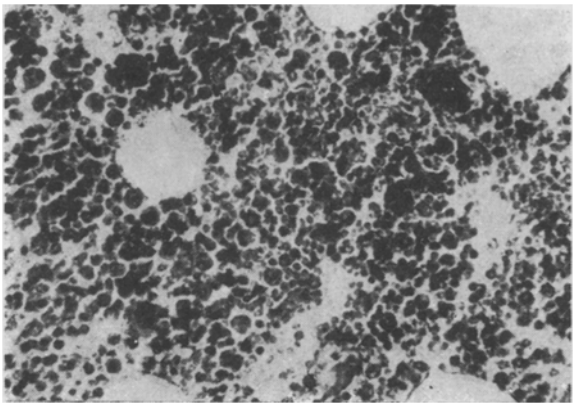

Fig. 1. Bone marrow of femoral metaphysis of the screened limb 9 days after irradiation and two days after operation at the height of radiation sickness: normal cell composition of bone marrow. Hematoxylin-eosin, 280×.

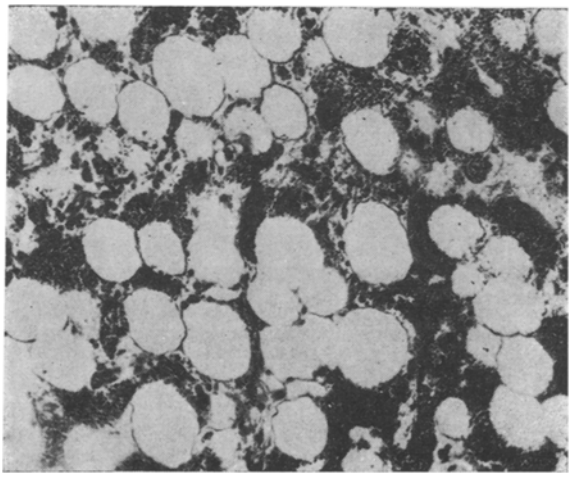

Fig. 2. Bone marrow of femoral metaphysis of unscreened limb 9 days after irradiation (opposite limb screened) and two days after operation at height of radiation sickness: congestion of capillaries; numerous fat cells between capillaries; plasma cells and lymphocytes visible singly or in small groups. Hematoxylin-eosin, 140×.

TABLE 2. Changes in Blood Morphology in Irradiated Animals after Operation

| Series of experiments | Period of radiation sickness when operation was performed | Maximal decrease in number of cells in circulating blood | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | leukocytes, $10^3$ | | | heterophils, $10^3$ | | | lymphocytes, $10^3$ | | | platelets, $10^3$ | | | red cells, $10^6$ | | |
| | | time after irradiation, days | $M \pm m$ | % of initial number | time after irradiation, days | $M \pm m$ | % of initial number | time after irradiation, days | $M \pm m$ | % of initial number | time after irradiation, days | $M \pm m$ | % of initial number | time after irradiation, days | $M \pm m$ | % of initial number |
| I. Irradiation without screening of limb | Latent period | 8 | 8,88± 1,19<br>$n=15$ | 77,4 | 8 | 5,96± 1,06<br>$n=15$ | 75,1 | 8 | 2,52± 0,35<br>$n=15$ | 84,3 | 16 | 247,11± 48,81<br>$n=9$ | 62,8 | 41 | 0,83± 0,30<br>$n=5$ | 24,3 |
| | Height of disease | 11 | 11,17± 2,27<br>$n=6$ | 93,9 | 11 | 7,65± 1,99<br>$n=6$ | 93,2 | 11 | 2,86± 0,35<br>$n=6$ | 96,2 | 14 | 162,00± 23,94<br>$n=4$ | 61,9 | 14 | 0,63± 0,20<br>$n=4$ | 20,9 |
| II. Irradiation with screening of hind limb | Latent period | 11 | 7,00± 1,46<br>$n=13$ | 58,1 | 11 | 4,03± 1,02<br>$n=13$ | 67,3 | 8 | 2,55± 0,35<br>$n=14$ | 75,9 | 16 | 241,76± 26,41<br>$n=13$ | 68,0 | 61 | 0,86± 0,24<br>$n=7$ | 26,5 |
| | Height of disease | 14 | 7,01± 1,57<br>$n=8$ | 63,5 | 14 | 4,35± 1,24<br>$n=8$ | 57,3 | 14 | 1,97± 0,36<br>$n=8$ | 78,3 | 17 | 188,57± 34,80<br>$n=7$ | 60,6 | 67 | 1,21± 0,29<br>$n=5$ | 34,6 |

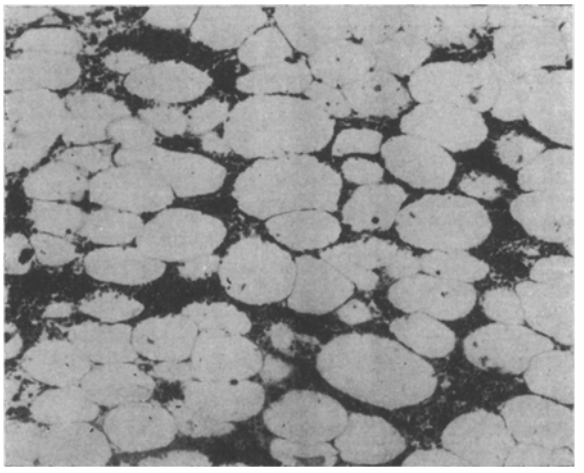

Fig. 3. Bone marrow of femoral metaphysis 9 days after total irradiation and 2 days after operation at height of radiation sickness: congestion of capillaries; many fat cells; destruction of hematopoietic tissue, with lymphocytes and cells of plasma type lying singly and in groups. Hematoxylin-eosin, 140×.

## EXPERIMENTAL RESULTS

The results given in Table 1 show that screening part of the bone marrow increased the rate and duration of survival of the animals undergoing the operation. The beneficial effect of screening was seen more clearly when the operation was performed during the latent period of radiation sickness.

The results given in Table 2 show that screening the limb slightly reduced the changes in the blood morphology after irradiation. This effect was least marked on the changes in the platelet and red cell count.

Together with this general effect, a beneficial local action of screening of part of the bone marrow was seen on the course of postoperative healing of the stomach wound in the irradiated animals. On the 8th-9th day after the operation, when performed during the latent period or at the height of radiation sickness, microscopic examination revealed that the entire base of the wound was covered by a layer of cylindrical epithelium, and the process was completed at the same time and in the same way in the animals undergoing the operation but not irradiated. In the animals whose hind limb was screened during irradiation and in the unirradiated animals, by the 17th-19th day after the operation instead of a layer of epithelium, a mucous membrane with cyst-like structures and mainly pyloric glands was discovered; later, 90-120 days after the operation, these glands were replaced by fundal glands.

Microscopically, the bone marrow of the screened limb 9 days after irradiation (2 days after the operation) at the height of radiation sickness was normal in its cell composition (Fig. 1). The bone marrow of the unscreened limb of the same cats contained numerous fat cells, the capillaries were sharply congested, and plasma cells and lymphocytes were arranged singly or in small groups (Fig. 2). At the same times after the operation, the bone marrow of the totally irradiated animals showed destruction of its parenchyma (Fig. 3).

Hence, partial screening of the bone marrow had some protective action against a combination of irradiation and operative trauma. It was less marked if the trauma to the stomach wall took place at the height of the radiation sickness and more marked if it took place during the latent period of radiation sickness. The basis of the partial protective effect of screening was integrity of the normal cell composition of the bone marrow parenchyma in the limb screened by a lead sleeve.

## LITERATURE CITED

1. G. S. Strelin and N. K. Shmidt, Med. Radiol., No. 10, 44 (1962).
2. L. J. Cole, H. M. Haire, and E. L. Alpen, Radiat. Res., 32, 54 (1967).
3. V. Nincov, Strahlentherapie, 134, 463 (1967).