CALLUS FORMATION IN OFFSPRING OF CHRONICALLY IRRADIATED ANIMALS

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The study of the reactions of various organs to ionizing radiation in small doses is particularly important from the point of view of the late sequelae. According to reports in the literature [4], irradiation causes damage to the genetic structures of the embryonic cells, affecting later generations.

A matter of great interest is the course of the posttraumatic regeneration of injured tissues in the offspring if pregnancy in the female took place at various times after prolonged irradiation.

The study of the reactions of bone tissue, especially its reparative regeneration in offspring of parents subjected to irradiation is of particular interest. No adequate discussion of this problem can be found in the literature, whereas reparative regeneration of bone in irradiated animals has received fairly detailed study [1-3,5].

In the present investigation, callus formation was studied in the offspring of rabbits exposed to chronic irradiation.

EXPERIMENTAL METHOD

Experiments were carried out on 49 rabbits: 10 control animals and 39 which were the offspring of males and females irradiated daily with x-rays from a type RUM-3 apparatus in a dose of 5-10 R (total dose 300 R) over a period of 1.5-2 months. The conditions of irradiation were: 170 kV, 10 mA, 0.5 mm Cu + 1 mm Al, skin-focus distance 145 cm, dose rate 1.46 R/min in air.

The controls were animals aged 3 months, born from unirradiated parents. All 39 rabbits belonged to the first litter: 26 of them were born 34-36 days after the end of irradiation of the parents, 6 were born 3 months after, and 7 were born one year after irradiation. Neither at birth nor in their subsequent development were any malformations or visible anatomical changes observed. The animals developed well and by the age of 3 months they weighed 2.0-2.2 kg, i.e., the same as the control animals.

A fracture of the second metatarsal bone was produced in all the rabbits (control and experimental) at the age of three months. The hair was first shaved in the dorsal region of the right hind limb, an incision 1 cm long was made in the soft tissues, and the bone was divided with scissors; the fragments were set and a soft bandage was applied for 2-3 days.

The process of healing of the fracture was studied by clinical and roentgenological observations. Films were taken 1, 7, 15, 30, 45, 60, 75, 90, 105, and 120 days after the fracture.

EXPERIMENTAL RESULTS

The roentgenological observations showed that the healing processes followed a different course in the animals of the control and experimental groups. For instance, in the roentgenograms of the control rabbits taken 7 days after the fracture, slight resorption of the ends of the fragments could be seen, extending along the medullary canal of the distal and proximal fragments. After 15 days marked resorption of the fragments was present, accompanied by some degree of separation and by a visible periosteal and endosteal reaction. After 30 days, periosteal and endosteal callus were clearly visible, and the gap between the fragments remained, although it was not very distinct (it consisted of a narrow line of translucency); in some cases a layer of ensheathing callus was formed. By the 45th day in most of the rabbits, the callus was reduced in size, the fracture line had disappeared, the medullary canal was completely or partly restored, but in some cases slight deformity of the metatarsal bone was present. Occasionally the restoration of the medullary canal was complete by the 60th day after the fracture. The changes described were seen

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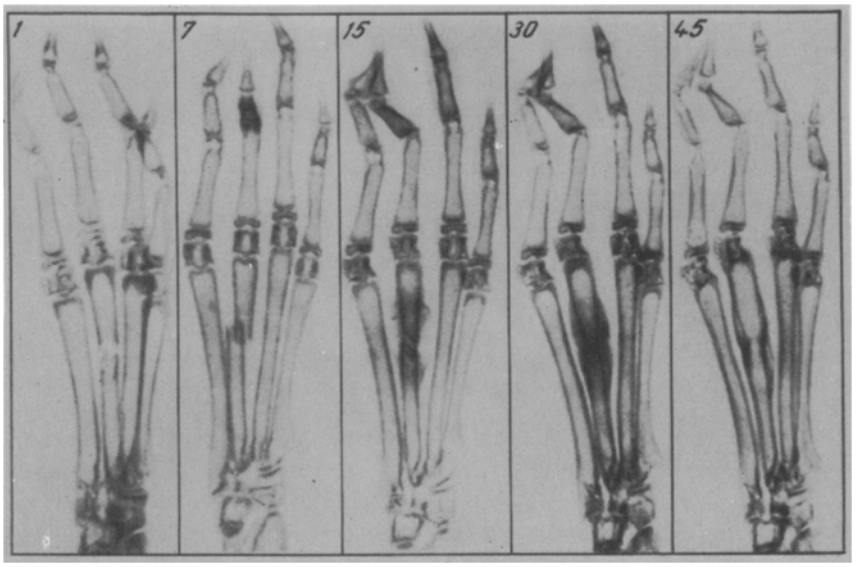

Fig. 1. Roentgenograms of the right hind limb of a control rabbit. Fracture sustained at the age of three months. Consolidation of the fracture after 45 days with restoration of the medullary canal. Here and in Fig. 2, the numbers denote days after the fracture.

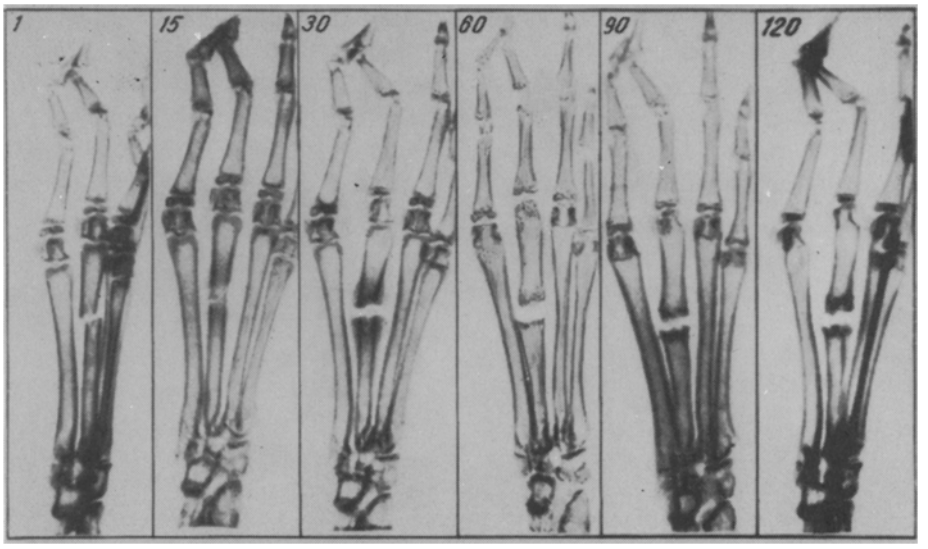

Fig. 2. Roentgenograms of the limb of a rabbit born from irradiated parents. Fracture sustained at the age of three months. No consolidation of the fracture. A pseudarthrosis was formed after the 60th day. The ends of the medullary canals are closed at the fracture line by layers of bone.

on the roentgenograms of the right hind limb of a rabbit sustaining a fracture of the second metatarsal bone at the age of three months (Fig. 1).

Consequently, the process of callus formation in the control animals took 45-60 days, corresponding to data in the literature and confirmed by numerous experiments undertaken in the author's laboratory [1,3,5,6].

In the experimental rabbits, the processes of reparative regeneration took place almost identically in all cases regardless of the time elapsing from the moment of irradiation of the parents. The first signs of callus formation were seen 15 days after the fracture: the ends of the fragments were indistinct, their shadow was less intense, i.e., processes of resorption had begun to take place, although usually only to a slight degree; only occasionally (in 3 rabbits) was the resorption more pronounced. Concurrently with this, a slight periosteal reaction was observed, sometimes affecting a considerable part of both the proximal and the distal fragments. Very slight signs of resorption

of the fragments were observed in a few animals earlier than this – 7 days after the fracture. In these circumstances, the resorption was more marked in the distal fragment. Changes of this type were found in offspring born three months and one year after the end of irradiation of the parents. In the group of animals born 34-36 days after irradiation, hardly visible changes in the roentgenograms taken 7 days after the operation were detectable only in three of the 26 rabbits.

Later, by the 30th day after the fracture, the roentgenograms showed periosteal and endosteal callus, moderately well developed, but a fairly wide fracture line could still be seen. After 45 days, the size of the shadow of the callus was reduced, the fracture line was wider, and at the ends of the fragments, bands of consolidation resembling end-plates could be seen. By the 60th-75th day after the fracture, the excess callus was absorbed, the gap between the fragments remained, the end-plates were visible as dense, sclerotic bands, closing the medullary canal of each fragment. On the films taken 90, 105, and 120 days after the fracture, the picture was the same, i.e., a pseudarthrosis was present.

A clear illustration of the healing of the fracture in the offspring is given by the roentgenograms in Fig. 2, showing that 15 days after the fracture the ends of the fragments were in apposition, yet resorption of the fragments and a very slight periosteal and endosteal reaction were clearly visible. By the 30th day, periosteal and endosteal callus were present at each end of the fragments, between which the wide fracture line could be seen. On the 60th day after the fracture, the callus was undergoing resorption, the fracture line was wide, and the ends of the fragments were closed by dense end-plates. On the next roentgenograms, taken 75, 90, 105, and 120 days after the fracture, as before the picture of a typical pseudarthrosis could be seen.

The type of reparative regeneration of bone tissue described above was observed in most of the experimental rabbits. In 25 of the 34 animals remaining under prolonged observation, a pseudarthrosis was formed. Consolidation of the fracture with partial or complete restoration of the medullary canal was observed in only 9 rabbits, and 5 (of the 39) rabbits were sacrificed in the early period after the fracture (on the 15th day).

LITERATURE CITED

1. F. M. Golub and A. I. Britun, Med. Zh. Uzbekstana, 12, 53 (1961).
2. F. M. Golub and A. I. Britun, Klin. Khir., 1, 43 (1964).
3. N. F. Dokuchaeva, Med. Zh. Uzbekistana, 8, 58 (1964).
4. N. P. Dubinin, M. A. Arsen'eva, and Yu. Ya. Kerkis, in the book: Radiation Genetics [in Russian], Moscow (1962), p. 5.
5. I. P. Prokhorova and A. I. Britun, in the book: Problems in Anatomy and Histology [in Russian], Frunze (1964), p. 182.
6. R. K. Sattarov, The Effect of Neurotomy on Consolidation of Fractures in Irradiated Animals, Candidate Dissertation, Samarkand (1963).
