THE EFFECT OF ENVIRONMENTAL TEMPERATURE ON THE RATE OF HEALING OF FRACTURES IN TAIL VERTEBRAE OF MICE

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The effect of the environmental temperature on the healing of fractures was assessed in vertebrae of tails of young albino mice. It was found that fractures in animals kept at 33 degrees Celsius healed very rapidly (bony callus by 14 days) while in animals kept in the cold (8 degrees Celsius) fractures were still at the stage of granulation tissue at this time. Controls were at an intermediate stage. This result might have a clinical application.

In cold climates the exposed skin of the hands and face is well below body temperature. Indeed, inflammatory lesions of the skin only feel hot in contrast to adjacent normal cool parts. It is well recorded that lesions of the hands of coldstore workers heal slowly, and it has been shown that a cold environment reduces the mitotic rate in the skin of the tails of mice (Shewell and Wright 1967).

The purpose of this communication is to demonstrate that cold also profoundly affects healing in deeper structures such as bone, and to discuss the clinical implications.

Fig. 1
Photomicrographs of the histological picture of healing 14 days after the fracture. (Haematoxylin and eosin, × 100.) Figure 1—Cold fractures: showing only granulation tissue. Figure 2—Control fractures: showing well-developed cartilage. Figure 3—Hot fractures: showing cartilage and bone formation.
MATERIALS AND METHODS

Albino mice, randomly bred in a closed colony, were used. They were of either sex and between four and five weeks old, weighing 20 to 25 grams.

One vertebra, usually the seventeenth, was fractured. The mouse was anaesthetised with Nembutal (pentobarbitone sodium), 0.065 milligrams per gram body weight, and ether added if necessary. The tail was exsanguinated by slipping a soft rubber disc with a two-millimetre central hole over the tail and pulling it towards the body. The skin was incised and the shaft of one vertebra was exposed. This was cut transversely with a small pair of bone forceps. The mice were then divided into three groups: one group was placed in an incubator at 33 degrees Celsius, one group was put in the cold room at eight degrees Celsius and the third group was housed in the animal house at 21 to 24 degrees Celsius. Two animals from each group were killed after four, seven, 14, 21, 28 and 35 days. Histological preparations, stained with haematoxylin and eosin, were made of all the fractures.

RESULTS

The animals kept in the cold showed extremely slow healing while the animals kept in the incubator healed very rapidly (Figs 1 to 3). Whereas cartilage and new bone were well developed in the callus of the "hot" mouse after 14 days, there was only early granulation tissue in the "cold" fracture. The control fracture, kept at 21 degrees Celsius, showed some cartilage in its callus and was intermediate in development between the hot and cold fractures. A semiquantitative assessment was made of the amount and maturity of the granulation tissue, the cartilage, the bony callus and remodelling. These assessments were plotted cumulatively, using the maximal reading for any assessment (Fig. 4). The mice housed in the hot environment healed two to four times as rapidly as those kept in the cold.

DISCUSSION

The temperature of the tail of the mouse approximates closely to that of its environment. That this affects the bones as well is shown by its effect on the bone marrow which is fatty when cool or cold and haemopoietic when kept warm (Noel and Wright 1972). The peripheral bones of man in normal temperate climates are also significantly colder than those of the axial skeleton. This is supported by finding an absence of red marrow in peripheral human bones. Red marrow usually only occupies the most proximal third of the human femoral shaft and is absent from the tibia, the fibula and the more distal bones.

What significance do these results have for human fracture healing? It is clear that fractures should be kept warm but there is little information in the literature to suggest what is the optimal temperature. There appears to be only one recent investigation (Eagleson et al. 1967). These authors fractured the humerus in dogs and embedded electrically heated resistance wires in the immobilising plaster so as to raise the temperature two degrees Celsius above that of controls. They observed a slightly better healing in the warmed fractures but the results were not very dramatic or encouraging and no difference was observed histologically. It is possible that because of the larger bodily mass of the human, and the well-padded plaster that is applied to most fractures, the temperature of fractures is high enough to allow satisfactory healing. Also the inflammatory reaction surrounding the fracture will raise the region to something approaching body temperature.

However, there remain several questions which are posed but not answered by our experiment. Would human fractures benefit by being kept continuously warmer? One thinks particularly about the more peripherally situated fractures and especially situations where the toes or fingers are exposed. Most people (we hope) are kept warm in hospital beds but when patients first start walking after a fracture they will often get cold and may not be adequately warmed afterwards. Finally the essential question that must be asked is: what is the optimal temperature for fracture healing? It is not inconceivable that a local temperature slightly above 37 degrees Celsius might be beneficial.

We are currently attempting to answer some of these questions but until there is more evidence it would seem advisable to keep fractures warm.

REFERENCES


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