HISTOLOGIC MANIFESTATIONS OF THE SPARING EFFECT OF COLD PROTECTION DURING THERMAL DISSECTION OF THE CEREBRAL CORTEX AND LIVER

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The search for new methods of tissue dissection during surgical operations, capable of reducing the severity of trauma during those procedures and of giving a hemostatic effect, continues at the present time. Thermal methods of tissue dissection, realized with the aid of laser and plasma scalpels [2, 3], have become widely adopted. Golub [1] suggested a sparing method of acting on biological tissues, namely thermal dissection under the protection of cold, realized by means of a specially designed surgical instrument, a multipurpose cryothermal coagulotome (MCC). Its mode of operation is based on automatic repetition of an identical technological cycle of action on biological tissues by ultrarapid cooling and heating, with a temperature polarity change of 0.1-0.2 sec. As the controlling signal the parameters of the temperature conditions of the tissues are used. The design of the MCC is such that tissues can be dissected in accordance with a preassigned program of temperature conditions of between 200 and 800°C after preliminary measured cooling to between −20 and −100°C. The possibility of controlling the conditions of cooling and heating of the tissues separately enables the coagulation zone for particular procedures in the course of the operation to be actively formed. The total duration of one technological cycle (cooling and heating of the tissues) is set automatically at 1.5-3 sec. The depth of dissection of the tissues during a single procedure is 0.1-2 mm and the length of the incision is determined by the geometric shape of the working zone of the coagulotome, and can be varied within wide limits (from 0.2 to 100 mm or more). During dissection of tissues with the MCC a local stable analgesic effect is observed both during the operation and in the postoperative period, so that it is unnecessary to use anesthetics.

The aim of this investigation was a histologic study of the degree of trauma to the tissues and of the hemostatic effect during the formation of a wound of the brain and liver by means of the MCC.

EXPERIMENTAL METHOD

Experiments were carried out on 20 albino rats. Under ether anesthesia, wounds were inflicted on 10 experimental animals by means of the MCC and on 10 control animals by an ordinary scalpel. The brain wounds were inflicted in the parietal region after trephining of the skull, the liver wounds in the region of the right lobe after laparotomy. After infliction of the wounds the animals were killed by decapitation. The brain was fixed in 96° alcohol and embedded in celloidin; sections were stained by Nissl's method. The liver was fixed in a 12% solution of neutral formalin and embedded in paraffin wax; sections were stained with hematoxylin and eosin.

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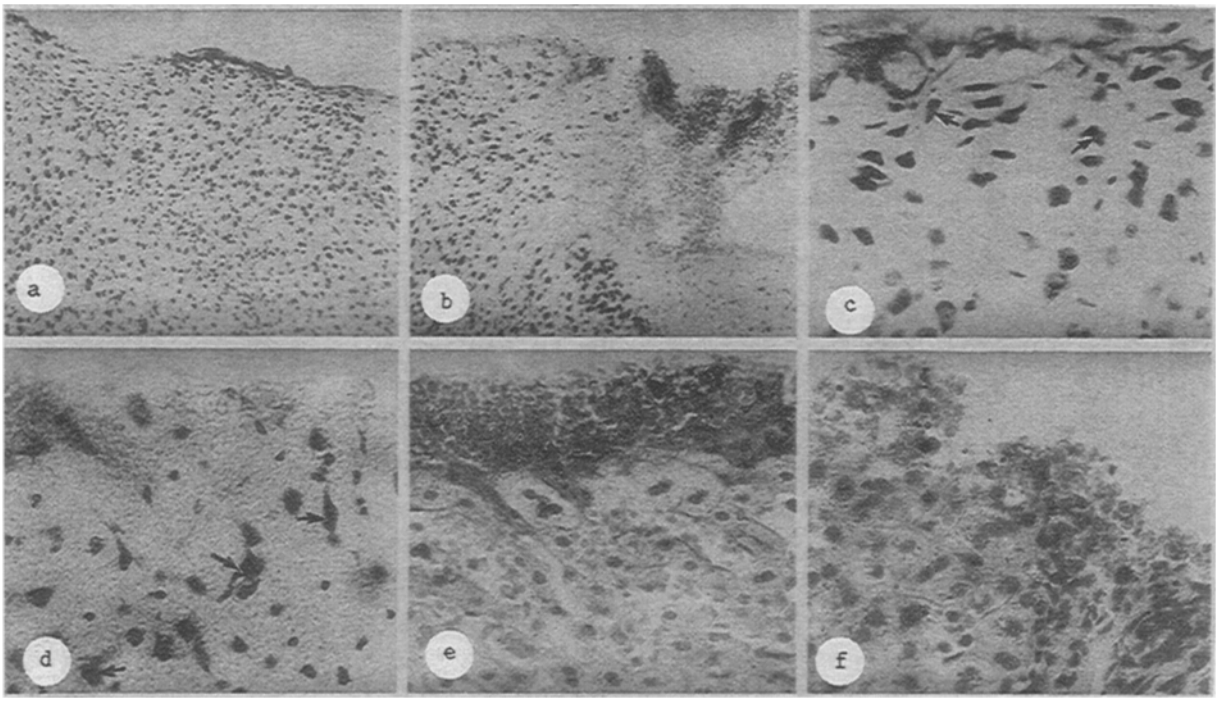

Fig. 1. Tissue morphology after action of scalpel and MCC: a) smooth edges of brain wound inflicted by MCC; b) lacerated wound edges after dissection by scalpel; c) hyperchromic staining and shrinking of nerve cells (arrow) near surface of wound inflicted by MCC; d) widespread distribution of structural changes in depth of tissue surrounding wound after use of scalpel; e) smooth wound edges, well preserved hepatocytes after use of MCC; f) lacerated wound edges, hemorrhage, and destruction of hepatocytes after dissection of liver by scalpel. a, b) 80×; c, d, e, f) 400×. Staining by Nissl's method (a, b, c, d) and hematoxylin and eosin (e, f).

EXPERIMENTAL RESULTS

In animals of the control group, considerable bleeding took place after the formation of an incised wound of the brain. On microscopic investigation of the wound its edges had uneven, lacerated outlines (Fig. 1b). Many desquamated and deformed cells and also fresh erythrocytes were found on the wound surface. Hyperchromic nerve and glial cells (Fig. 1d) were observed in the depth of the tissues at a distance of up to 9 mm from the wound edges (Fig. 1d). The intercellular spaces were structured and were intensely stained. After wounding with the MCC, bleeding was absent and the outlines of the wound canal were smooth and covered with a coagulation film about 100 μm thick (Fig. 1a). Beyond it there were two or three rows of shrunken nerve cells, followed by nerve and glial cells which were almost free from changes (Fig. 1c). The well preserved appearance of the blood capillaries at a depth of 200 μm and more distant from the wound edges was noteworthy.

Infliction of an incised wound of the liver by scalpel was accompanied by profuse bleeding, deformation of hepatocytes, and their desquamation into the lumen of the wound channel (Fig. 1f). Lipid drops accumulated in the marginal zone of the wound. After infliction of a liver wound by MCC hemorrhage was absent or was immediately stopped by adjusting the heat mode of the coagulotome. The wound surface was covered with a thin coagulation film, on which individual coagulated erythrocytes could be seen here and there. At a depth of about 0.1 mm from the wound edge there was a very slight decrease in the intensity of staining of the hepatocytes (Fig. 1e).

The results show that thermal dissection of tissues under cryoprotection leads to much less damage to the tissue elements of the brain and liver than infliction of incised wounds by an ordinary steel scalpel, and ensures satisfactory hemostasis. Unlike suggested surgical instruments intended for thermal dissection of tissues, the MCC can carry out preliminary cooling of biological tissues. The cooling process in this case is controlled automatically and its depth is determined by the functional state of the tissues. Cooling and coagulation are balanced in depth, so that minimal trauma to

the tissues is achieved, and according to data in the literature [4], this is a favorable situation for spontaneous cleansing of the wound through the action of tissue hydrolases, against the background of a mild inflammatory reaction. Automatic control of the combined action of cold and heat rules out the possibility of tissue overheating in the zone of the wound canal. Meanwhile, if laser and plasma scalpels are used, tissue hyperthermia inevitably arises in the region of dissection, and this is evidently one of the main causes of local postoperative complications, leading to healing of wounds by secondary intention in 40% of cases [2].

The thermal characteristics of the MCC are responsible for its noncarcinogenicity and they enable the method of thermal dissection under cryoprotection to be used in operations for cancer.

On the basis of the results, the MCC can thus be regarded as a promising instrument for surgical operations on the brain and liver.

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MINERAL MATRIX PHOSPHATE EXCHANGE IN INTACT BONES AFTER SINGLE AND MULTIPLE FRACTURES

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Phosphates are among the basic chemical components of the mineral matrix of bone tissue, and accordingly their determination in bone tissue reflects the degree of its mineralization [2]. After trauma the mineral content in bone tissue is reduced not only in the region of injury, but also in bones adjacent (intact) to the injured segment [4-7]. However, no detailed investigations of this problem have yet been undertaken.

The aim of this study was to establish the dynamics of changes in the phosphate content of the mineral matrix in intact bone tissue after single and multiple fractures of the long bones.

EXPERIMENTAL METHOD

Experiments were carried out on 122 male rats weighing 180-220 g, including 63 with a single fracture (of the middle third of the right femur), 51 with multiple fractures (middle third of both femora and both tibiae), and eight intact animals, which served as the control group. The method of producing a traumatic injury was described previously [1]. Phosphates in the mineral matrix were determined by Fiske and Subbarow's method [3]. Only the humeri were investigated in rats with multiple fractures. In rats with single fractures, besides the humeri, both tibiae and the left femur also were investigated. The animals were withdrawn from the experiment daily for 60 days after trauma, i.e., a time series was

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