CHARACTERISTICS OF HEMATOLOGICAL CHANGES DURING OPERATIVE RESECTION OF THE LIVER USING A PLASMA SCALPEL

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The ever widening practical application of the plasma scalpel in surgery demands a study of both local and general reactions of the body to this procedure [1, 2].

We have studied the trend of hematological parameters most closely related to the protective-adaptive and reparative reactions of the body to operative trauma [3, 4].

Experiments were carried out on 14 rabbits. The results of investigations accompanying operations performed in the usual way, with a steel scalpel (seven rabbits) were compared with cases when resection of the liver was performed with a plasma scalpel (also seven rabbits). The operations were performed under hexobarbital anesthesia (30 mg/kg body weight). After laparotomy in the usual way the left lobe of the liver (10% of its mass) was resected.

Resection of part of the liver, temporarily excluded from the circulation, was almost bloodless. In both experiment and control, the amount of blood lost did not exceed 1 ml, or 0.6% of the total blood mass of a rabbit with a mean body weight of 2.5 ± 0.5 kg. The wound in the abdominal wall was sutured with silk in layers. Healing took place in the course of 3-4 weeks without complications.

Blood was tested before the experiment, and again 1, 3, 7, 14, 21, and 30 days and 2 and 3 months after the operation. The hemoglobin concentration and erythrocyte count were determined in blood samples. The total and differential leukocyte counts and the hematocrit index also were determined. The most important parameters were calculated. The cytomorphology of the animals' bone marrow was studied. The myelogram and the total number of myelokaryocytes were counted. To obtain more illustrative results, the method of "areas" [5] was used, enabling the trends of absolute values of the differential leukocyte count and the myelogram to be represented graphically.

The experimental results showed that in the course of the operation the animals developed a protective-adaptive hematological response, the realization of which involved mechanisms of redistribution and also the hematopoietic organs, especially the bone marrow. This response in the control group was very moderate in character. For instance, 1 day after the operation, when performed with an ordinary steel scalpel, a mild leukocytosis, neutrophilia with a shift to the left, and eosinopenia developed (Fig. 1a, top). By the 3rd day the leukocytosis was rep ace by normocytosis. Later irregular changes took place in the total number of leukocytes and the leukocyte formula. At the end of the 2nd week the erythrocyte count was significantly lowered, on average by $0.85 \cdot 10^{12}$ cells/liter ($p < 0.01$).

It will also be clear from Fig. 1 that neutrophilia in the peripheral blood corresponded to karyocytopenia in bone marrow puncture specimens (Fig. 1A, bottom). On the 1st day the number of myelokaryocytes fell on average by 2.57 times ($p < 0.05$) on account of hypoplasia of the neutrophilic and, in particular, the erythroblastic series. After 2 weeks the number of myelokaryocytes was restored. Starting with the 3rd day the number of lymphocytes in the myelogram increased significantly.

Thus in the group of animals undergoing operations with an ordinary steel scalpel, changes characteristic of surgical stress developed: neutrophilic leukocytos is, a shift to the left, and eosinopenia, with short-term karyocytopenia in the bone marrow, accompanied by absolute lymphocytosis. Normalization of the leukocyte count and myelogram began at the end of the 2nd week after the operation.

In the group of animals undergoing operations with a plasma scalpel, more marked changes occurred, although in general the trend of these changes was the same as in the experiments of series I. It will be clear from Fig. 1 (top) that a more

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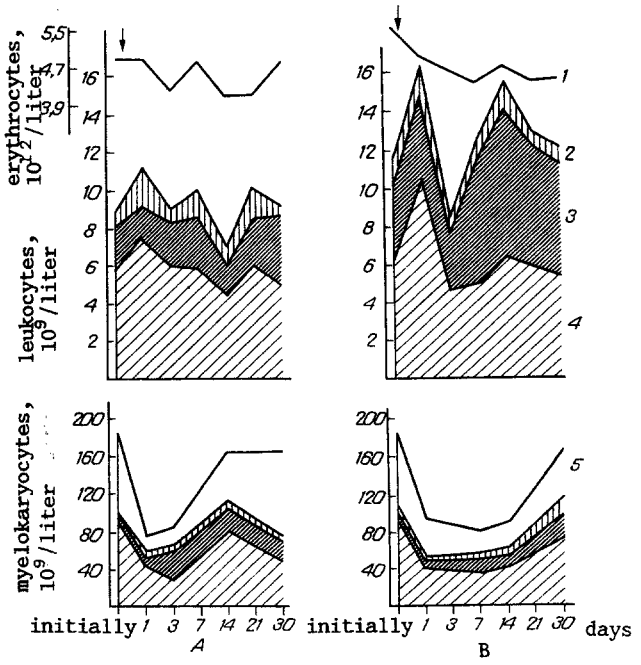

Fig. 1. Erythrocyte and leukocyte counts (top) and myelogram (bottom) after resection of liver by steel (a) and plasma (b) scalpel. Abscissa, time of investigation (in days); ordinate, number of leukocytes and myelokaryocytes (in 10^9 liter) and number of erythrocytes (in 10^{12}/liter). 1) Erythrocytes, 2) monocytes, 3) lymphocytes, 4) neutrophils, 5) erythroblasts.

marked neutrophilic leukocytosis developed on the 1st day. The total number of leukocytes in the blood was increased on average by 40.5% ($p < 0.01$). There was a more marked shift to the left, and eosinopenia. The degree of leukocytolysis was intensified. The number of leukocytes destroyed increased by 2.5 times ($p < 0.02$).

Later, after some decrease on the 3rd day, the total number of leukocytes in the blood increased once again. This second wave of leukocytosis was due to an increase in the number of lymphocytes in the blood on account of redistribution of the lymphocytes and their migration from the lymphoid organs. On average the absolute number of lymphocytes in the blood was increased under these circumstances by 97.0% ($p < 0.05$). It is important to emphasize that in the control we observed neither intensification of leukocytolysis nor this second wave of absolute lymphocytosis in the blood.

Erythrocytopenia in animals of the experimental group was much more marked. For instance, on the 7th day the erythrocyte concentration in the peripheral blood fell on average by $1.2 \cdot 10^{12}$ cells/liter ($p < 0.02$). Under these circumstances we observed a small shift toward spherocytosis and physiological hyperchromia of the erythrocytes. On the 1st day after the operation, for instance, the index of sphericity of the erythrocytes decreased by 33.0% ($p < 0.02$). The color index rose on average from 0.65 ± 0.03 to 0.84 ± 0.06 ($p < 0.05$).

The study of bone marrow puncture material revealed a more lasting contraction of the erythroid series. Anemia in this series of experiments could be observed after 2 and 3 months, whereas in the control, normalization of erythropoiesis began as early as 1 month after the operation.

Just as in the experiments of series I karyocytopenia of the bone marrow took place, due to contraction of the neutrophilic and, in particular, the erythroid series. Meanwhile the myelogram showed a clearly defined absolute lymphocytosis and monocytosis.

Hypoplasia of the erythroid series, flooding of the bone marrow with lymphocytes and monocytes, as well as absolute lymphocytosis in the peripheral blood, are all evidence of an immunological readjustment in the body; in the experimental group, this readjustment was more dynamic. Fluctuations of the parameters studied reached a high amplitude, and their duration was comparatively long.

Comparison of Fig. 1 a and b shows that restoration of the red and white cell counts in the experimental group occurred later. For instance, 1 month after the operation marked erythrocytopenia was still present, and the blood and bone marrow cell counts showed absolute lymphocytosis and monocytosis.

The myelokaryocyte count began to recover 2 weeks later than in the control. In the experimental group, complete normalization did not occur, even as late as 2-3 months after the operation.

We thus discovered the basic principles governing the hematological reaction associated with resection of the liver in rabbits. In general this reaction can be reduced to neutrophilic leukocytosis, erythrocytopenia, and myelokaryocytopenia, with lymphocytosis and monocytosis superposed on it.

Our results are evidence of the comparatively high intensity of this response when a plasma scalpel was used during the operation. As we have already stated, under these circumstances a second wave of leukocytosis developed, due to an increase in the number of lymphocytes in the blood.

The greater magnitude and duration of the hematological and myelomorphological changes and the closer involvement of the bone marrow in this response will be noted. We regard these features as the result of the comparatively greater degree of trauma associated with this method of dividing the tissues.

The plasma scalpel, which is a high-temperature jet of gas, causes instant evaporation and charring of the tissues, and on account of this and other reasons, it is a biologically more meaningful stimulus, evoking more "natural" hematological changes. This fact alone may be of clinical importance, by facilitating the task of interpreting the results of investigations of the blood in such cases.

The plasma scalpel stimulates the protective leukocytic reactions, and the field of its application may therefore be extended to the treatment of indolent and suppurative wounds and burns; its use in combined radiation injuries, etc., may also be indicated.

On the physiological plane, we showed conclusively once again that the character of the hematological response of the body is largely dependent on the type and qualitative features of the traumatizing factor.

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