COMPARISON OF MORPHOLOGICAL CHANGES IN OVARIAN WOUNDS WHEN STEEL AND PLASMA SCALPELS ARE USED

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An important aspect of the study of healing of ovarian wounds following operations on these organs is the degree to which the times of healing depend on the character of surgical intervention on the ovarian tissue. Differences in the course of healing when different methods are used depend mainly on the response of the ovary itself, which itself is predetermined by the state of the microcirculation, the extent of the inflammatory process, and the character of the developing scar.

In recent years reports have been published of the use of a plasma scalpel in surgery [2-10, 13, 14]. A plasma jet is produced by the action of an electric field on an inert gas (helium or argon), as a result of which it is heated to 3000-15,000°K and ionized. When the plasma comes in contact with biological tissues, the latter undergo pyrolysis and evaporation. The power of the plasma jet may amount to several kilowatts, and is some 10 times greater than the power of a laser scalpel. Advantages of the plasma scalpel over other thermal instruments include the high speed cutting of the tissues, effective coagulation of blood vessels, the aseptic nature of the cut and coagulated surfaces, and the shallowness of thermal necrosis (from 300-600 μ to 1 mm). Another important feature is that during cutting and coagulation a very small quantity of smoke is formed, and no special device is required to remove it. The wound need not be dried during coagulation. Neither blood nor smoke nor any liquid medium is an obstacle for the plasma jet, which can coagulate arteries up to 3.5 mm in diameter, and up to 7.5 mm in the liver. The plasma jet has no mutagenic action on tissue, and its use does therefore not involve any special protection for the personnel [7]. The laser scalpel involves the risk of reflection of the beam onto the retina, but the plasma jet has no such risk [3]. Views have been expressed on advantages of the plasma scalpel over a steel scalpel during operations on the liver, kidney, spleen, stomach, and intestine, and for evaporation of mitastoses and division of muscles [5-9]. There have been no investigations into the use of a plasma scalpel in surgery of the ovaries. The use of the traditional operative technique on the internal reproductive organs often leads to the development of adnexitis with the formation of adhesions in the pelvis minor [1, 11].

The aim of the present investigation was to compare the results obtained by using steel and plasma scalpels under conditions of experimental trauma to ovarian tissue.

EXPERIMENTAL METHOD

Experiments were carried out on 25 mature rabbits weighing 3-4 kg. Intravenous injection of 2% hexobarbital solution (20 mg/kg body weight) was used for anesthesia, after which a midline laparotomy was performed. For hemostasis, the ovarian ligament was compressed by an intestinal clamp and the ovary was incised in the transverse direction as far as the hilus. The appendages on the left were divided by a steel scalpel, those on the right by a plasma scalpel (SUPR-M apparatus, on cutting mode). Hemostasis was secured by insertion of two or three capron sutures (when the plasma scalpel was used, bleeding was negligible and sutures often were inserted only to make the data more representative). For subse-

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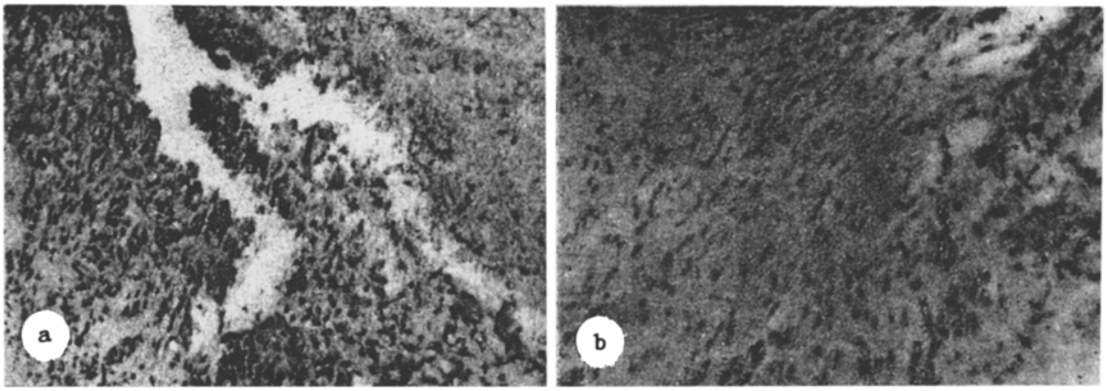

Fig. 1. Ovarian wound resulting from incision with a steel scalpel. a) Zone of inflammation and initial manifestation of proliferation of loose connective tissue (14th day); b) zone of fibrous connective tissue at site of ovarian trauma (30th day). Hematoxylin-eosin. 120×.

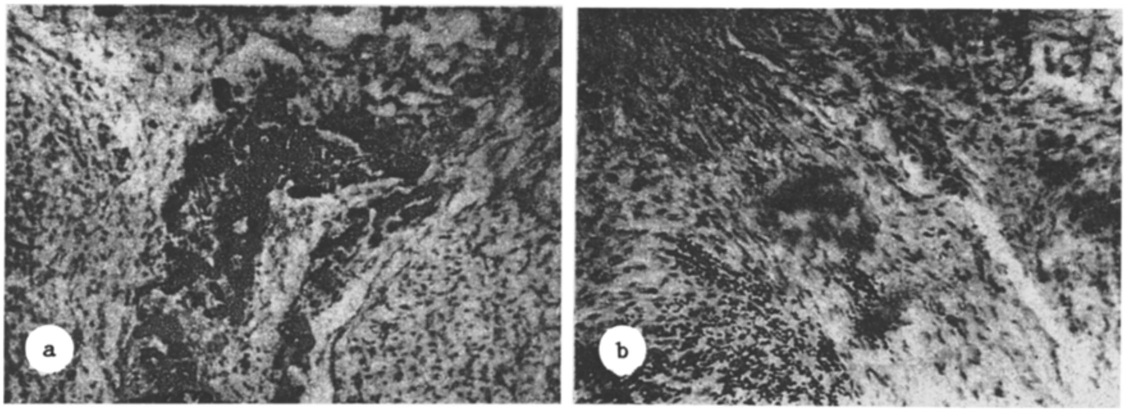

Fig. 2. Ovarian wound caused by incision by plasma scalpel. a) Zone of carbonization with areas of tissue destruction (7th day); b) fibrous connective tissue at site of trauma (21st day). Hematoxylin-eosin. 120×.

quent sampling of ovarian tissue, a lethal dose of hexobarbital was injected intravenously. The animals (five rabbits in a group) were withdrawn from the experiment after 3, 7, 14, 21, and 28-30 days. During relaparotomy, the intensity of adhesion formation was assessed in accordance with the classification of Knightly and co-workers [12], and this was followed by histological examination of the ovarian tissue.

Material for histological and histochemical analysis was prepared by the traditional method. Sections were stained with hematoxylin-eosin, picrofuchsine-fuchselin, and iron-hematoxylin by Heidenhain's method. The PAS reaction after Shabadash, and the Feulgen and Einarson reactions were carried out.

EXPERIMENTAL RESULTS

During relaparotomy adhesions were found in 47 ovaries, in most cases to the II-IV degree. When a steel scalpel was used for the operations on the ovaries, the adhesions were most frequently of the III-IV degree, whereas after the use of a plasma scalpel, they were more frequently of the II-III degree.

Analysis of the histological data showed a definite sequence of developing morphological changes in the ovaries when an ordinary scalpel was used. During the first 3 days, disturbances of the hemodynamics developed in the focus of intervention, in the form of congestion of the microcirculatory vessels, and prestasis and stasis of erythrocytes in them. Correspondingly, small foci of hemorrhage and destruction appeared in the ovarian tissue in foci of unequal blood filling, and by the 7th day this zone of inflammation was clearly demarcated from tissues adjacent to the wound. Tissue destruction was characterized by a band of necrosis with death of cellular and fibrous structures. In the zone of necrosis widespread foci of hemorrhage could be seen. The demarcation zone of inflammation was characterized by the formation of areas of concentration of leukocytes, lymphocytes, and histiocytes as well as solitary macrophages, around the foci of congestion of the capillaries. The focus of destruction underwent organization with proliferation of loose connective tissue, rich in blood vessels of sinusoidal type.

Starting with the 14th day, in place of the loose connective tissue the formation of fibrous connective tissue was observed, and by the 30th day this was converted into a definitive scar, poor in cells (Fig. 1a, b).

In ovaries cut by the plasma scalpel the same sequence of developing morphological changes was noted: from hemodynamic disturbances (congestion, prestasis, stasis in microcirculatory vessels), to the formation of a demarcation zone of inflammation and replacement of the traumatic foci by ovarian tissue. On the 3rd-7th days after treatment with the plasma scalpel three zones of injury were discovered in the ovaries: a zone of destruction (represented by amorphous tissue with destruction of cells and vessels), a zone of circulatory disorders (with mild hemodynamic disturbances, edema, and virtual absence of foci of hemorrhage), and a demarcation zone of inflammation (consisting mainly of a narrow rim of cells of lymphocyte type with occasional leukocytes). The intensity of the reaction and the size of the lesion were rather smaller in cases when the plasma scalpel was used in all zones than when the traditional operative technique was used. In the course of time, at the site of injury by the 14th day disturbances of the hemodynamics were virtually nonexistent, and by the 21st day a definitive scar had formed at the site of the loose connective tissue (Fig. 2a, b). The traumatic focus in ovarian tissue healed by connective tissue invasion of the destructive focus.

Similar observations were made by other investigators using a plasma scalpel. Nechai and co-workers [4], for instance, noted the same sequence of stages in development of the sclerotic process. However, the times of healing of gastric wounds after the use of plasma and ordinary scalpels were identical. Meanwhile Skobelkin and co-workers 19] observed acceleration of the proliferative phase of repair. We also found shortening of the healing times. The hemostatic effect of the plasma jet must also be mentioned. On microscopic examination of the ovarian tissue, marked spasm of the arterioles was observed in the zone adjacent to the traumatic focus, and in turn this led to considerable reduction of the hemodynamic disturbances and hemorrhages. A hemostatic effect also was observed by Savel'ev and co-workers [7], who showed by their researches that the coagulation properties of the plasma jet enable the duration of an operation to be reduced through mobilization of the organs without ligation of their vessels. It has also been shown that wound healing takes place without complications because of the condition of asepsis, the shallowness of thermal injury, and also, evidently, the power of adsorption of the carbon particles formed on the wound surface.

The investigation thus reveals distinguishing features of the action of a plasma scalpel, namely the less damaging action of the procedure on ovarian tissue, the more rapid course of wound healing, diminution of the inflammatory reaction in response to the procedure and, as a result, the milder nature of the adhesion process after operations using this technique. An important consideration is that when the plasma scalpel is used the number of hemostatic sutures inserted into the injured organ can be reduced, and this in turn helps to reduce the severity of the inflammatory reaction. This experimental study showed that the clinical use of the plasma scalpel for operations on the ovaries is not only possible, but justified.

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