Objective physiological parameters (ECG, blood pressure, rheologic characteristics of the blood) in animals treated by plasma extraction were virtually indistinguishable from controls. Observation on the animals for 1 week showed that they tolerated the operation quite satisfactorily. The method of continuous plasma extraction using immobilized solvents is thus practicable, in principle, for the removal of hydrophobic compounds from blood.

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EXPERIMENTAL EVERTED MECHANICAL INTESTINAL SUTURE

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In the last two decades instruments for mechanical suture have been introduced on a wide scale in abdominal surgery. Most Soviet suturing instruments (the NZhKA-60, PKS-25, KTs-28, SPTU) and their American counterparts (YIA, EEA) are designed to form anastomoses with an invested suture. Besides their undoubted advantages, these instruments also have certain disadvantages due to the character of the suture they form: difficulty in examining the region of anastomosis, making it difficult to assess whether the suture has been correctly applied, and that hemostasis is satisfactory, the need to introduce the working part of the instrument into the lumen of the organs to be sutured, making the operation less aseptic, and the possibility of development of stenosis in the region of anastomosis [3, 5, 6, 8].

The SK-60 and SZhK-60 instruments, developed by the All-Union Research and Testing Institute for Medical Engineering, Ministry of Health of the USSR, jointly with the Professional Surgical Clinic, I. M. Sechenov First Moscow Medical Institute, for use in operations for enteroenterostomy and gastroenterostomy by means of an everted staple suture [1], are free from these disadvantages. The first report of the experimental and clinical use of the SK-60 instrument was published by Shkrob et al. [4]. These workers used the instrument for enteroenterostomy and they buried the mechanical suture line with knotted sutures.

The possibility of forming anastomoses between the hollow viscera of the gastrointestinal tract by means of a single row of mechanical sutures, including those of the everted type, has been widely discussed in recent years and definite advantages of mechanical suture in a single row without peritonization have been described [2, 7]. The possibility and desirability of using the SK-60 and SZhK-60 mechanical suturing instruments for enteroenterostomy by means of an everted intestinal suture without peritonization of the mechanical suture line accordingly calls for urgent solution.

EXPERIMENTAL METHOD

In experiments on 15 mongrel dogs 32 anastomoses were performed. They included 18 on the small intestine, 11 on the large intestine, and three between the large and small intestines; 23 anastomoses were of the end-to-end and nine of the side-to-side type. The state of the anastomoses was analyzed during the operation, immediately after suture, during repeated operations on the animals at a later stage, and at autopsy. The animals were killed after 3,

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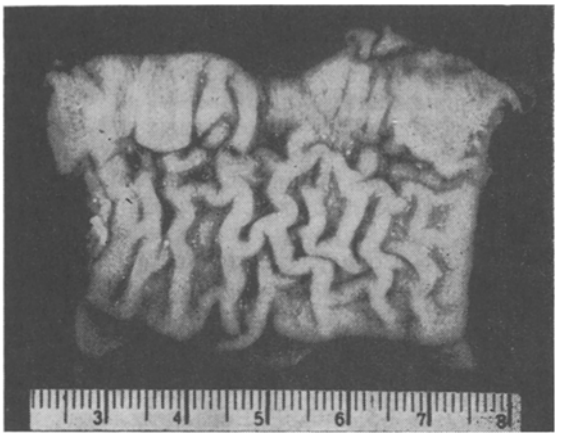

Fig. 1. End-to-end anastomosis between two segments of large intestine (1 month). Anastomosis line hardly visible, some staples can be seen cutting out.

Fig. 2. Side-to-side anastomosis between two segments of small intestine (1.5 years). Anastomosis line is smooth and no staples are present.

7, and 14 days and 1, 3, 6, 12, and 18 months. All anastomoses were examined roentgenologically to determine the position of the staples and were subjected to histotopographic investigation (staining with hematoxylin and eosin and by Van Gieson's method) to study regeneration processes.

All anastomoses were formed with a single row of everted staple sutures by means of the SK-60 and SZhK-60 instruments without peritonization of the mechanical suture line. The principles of action of these two instruments are similar. They form a single row of sutures with the staples arranged longitudinally. By means of these instruments anastomoses can be formed aseptically without introducing the working part of the apparatus into the lumen of the organs to be sutured and they ensure reliable hemostasis. Tissue trauma is minimal. During formation of the anastomosis the intestine is reliably sutured around the whole of its perimeter except at the extreme ends of the hemiperimeters, where regions 2-4 mm long remain unsutured (as is stipulated by the scheme of formation of the anastomosis), and where one or two interrupted knotted sutures are applied. In one case the anastomosis failed in the region sutured manually because of a technical defect (the ligature did not pass through the mucosa and submucosa). There were no other complications.

Fig. 3

Fig. 4

Fig. 3. Side-to-side anastomosis between two segments of large intestine (14 days). Region of scar (arrows) covered with normal mucosa. Van Gieson, magnification 5 ×.

Fig. 4. End-to-end anastomosis between two segments of small intestine (3 months). Scar (arrows) free from signs of inflammation and covered with normal mucosa. Van Gieson, magnification 5 ×.

EXPERIMENTAL RESULTS

Immediately after suture a low anastomosis lip (about 2-3 mm high) was obtained; the everted portions of intestine were composed mainly of the seromuscular layer and as a rule the mucosa was almost invisible. No diastasis of the mucosa occurred and the region of anastomosis did not swell above the intestinal surface.

The region of the anastomosis was completely free from adhesions, or only single adhesions were present at various times of the investigation. Patency of the intestine was preserved. No stenosis of the intestine was found in the region of anastomosis. On the 3rd day the everted parts of the intestine, 2 mm high, were edematous and hyperemic, with petechial hemorrhages. No diastasis of the mucosa was seen and there was no anastomotic ridge. On the 7th day the everted region could not be identified. Starting with the 14th day the region of the anastomosis was difficult to distinguish from the side of either the mucosa or the serosa. After 1 month to 1 year, cutting out staples could be seen from the side of the mucosa (Fig. 1), but after 1.5 years no staples were present (Fig. 2).

Roentgenologic investigation of the anastomoses showed that all staples were regular and B-shaped. On the 3rd-7th day the line of staples was still regular, but on the 14th day the regular arrangement of the staples was disturbed, with gradual migration into the lumen of the intestine. After 3-6 months only half of the staples were present, and after 1 year only single staples were present. After 18 months no staples could be detected in the region of anastomosis. No significant differences were found in the times of migration of the staples between end-to-end and side-to-side anastomoses.

Histotopographic investigation on the 3rd day revealed moderate disturbances of the circulation in the everted edges of the intestine but no necrosis of the mucosa. No disturbance of the blood supply or signs of inflammation could be found in the walls of the intestine

adjacent to the anastomosis. In the region of contact between the mucosal surfaces a thin band of fibrin with a few polymorphonuclear leukocytes was present. There was no diastasis along the suture line. Adaptation of the suture tissues was good.

On the 7th day the layers of the intestinal wall were exactly apposed and no everted portions of intestine were present. The scar, 1 mm thick, was epithelized and avascular, and the staples were surrounded by a thin connective-tissue capsule. On the 14th day the scar, 1-2 mm thick, was covered with normal mucosa. No inflammatory changes were present (Fig. 3).

After 3-6 months the scar was thin, collagenized, and covered with normal mucosa (Fig. 4). After 12-18 months the region of anastomosis was virtually indistinguishable. No significant differences were observed in the course of repair processes between anastomoses in the small and large intestine or between end-to-end and side-to-side anastomoses.

The results showed that mechanical suture with staples formed by the SK-60 and SZhK-60 instruments is very reliable. In the absence of a peritonizing row of sutures, the slightest defect in operation of the suturing instrument (incorrect bending of the staple, trauma to the tissues, failure to suture all layers of the intestinal wall, and so on) would inevitably lead to the development of breakdown of the sutures forming the anastomosis. The method of formation of intestinal anastomoses by the SK-60 and SZhK-60 instruments is sufficiently aseptic and the sutures are airtight, for no complications affecting the peritoneal cavity (peritonitis, abdominal abscesses, marked adhesions) were observed. In one case anastomosis between two segments of small intestine broke down in the region sutured manually. Hemostasis was good and it was always possible to verify this visually. With a single row of everted staple sutures regeneration proceeded rapidly with minimal inflammatory changes in the region of the anastomosis: the region of anastomosis was epithelized on the 7th day and the normal mucosa was fully restored on the 14th day. Migration (cutting out) of the staples began on the 14th day and ended toward the 18th month, without any accompanying inflammatory changes in the region of the anastomosis. Later, because the everted areas of the intestine projected only a little above the surface, the action of intraintestinal pressure smoothed the region of the anastomosis and ensured accurate apposition of the layers of the intestinal wall. No stenosis of the intestinal lumen was found in the region of anastomosis.

By means of the SK-60 and SZhK-60 instruments for mechanical suture intestinal anastomoses can thus be formed under aseptic conditions, with minimal trauma to the sutured organs, and with accurate apposition and close contact of the sutured tissues, and reliable and verifiable hemostasis. The introduction of a single row of everted mechanical sutures without peritonization gives rise to minimal adhesions, ensures a sufficiently airtight anastomosis, rapid repair, and healing by first intention, without subsequent stenosis in the region of anastomosis.

In practice, the use of single-row everted mechanical sutures will evidently prove most useful for anastomosis of segments of intestine with a small diameter, where peritonization of the mechanical suture line could lead to substantial stenosis of the intestinal lumen in the region of anastomosis.

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