COURSE OF MORPHOLOGICAL CHANGES IN THE RECTUS ABDOMINUS MUSCLE DEPENDING ON SURGICAL APPROACH TO THE BILIARY TRACT

N. N. Volobuev, V. P. Tumanov, and A. V. Kosenko

UDC 616.366-003.7-089.12]-07

KEY WORDS: morphology; muscle; access.

In the century-long history of biliary surgery more than 70 different operative approaches have been suggested [1]. However, in modern surgical practice three of them are most frequently used: oblique-transverse incisions of the Kocher and Fedorov types, which compete with the upper midline, and, less frequently, with Lawson–Tait's pararectal approach.

However, the upper midline incision for laparotomy which is the least traumatic, does not provide adequate exposure in one-third of patients for exploration of the extra hepatic biliary passages [3]; in 3.9% of cases it is complicated by eventration in the early postoperative period, and in 11.3% of cases by the subsequent development of postoperative hernias. Meanwhile the classical approaches of Kocher and Fedorov, while in most cases they provide optimal technical conditions for operation, are quite traumatic and may be followed by a number of postoperative complications: eventration (in 1.3% of cases), suppuration of the operation wound (in 3.3%), pneumonia (in 2.9%), and subcostal hernias that are difficult to cure (in 14.1%). With modern anesthesia and muscle relaxants operations can be performed on the biliary tract through any approach. Nevertheless, the unfavorable functional and morphological consequences of the inevitable trauma to neurovascular structures, muscles, and aponeuroses of the anterior abdominal wall cannot be ignored.

One abdominal incision which provides adequate access to organs of the subhepatic space without any substantial injury to anatomical formations of the anterior abdominal wall is the so-called medial sliding approach. This consists essentially of an upper right paramedian incision through the "skin triad" and the anterior wall of the rectus sheath. The latter is separated mainly by blunt dissection from the linea alba and from the posterior wall of its own sheath, and is retracted laterally as far as possible. The posterior wall of the rectus sheath is divided longitudinally 2.5-3 cm medially to the lateral border of the muscle. In this way no nerve or large vessel of any kind is injured. This ensures favorable conditions for healing of the operation wound, and has no significant effect on respiratory function, which is particularly important in elderly overweight patients. Since the course of the wound canal is broken, it is an important means of preventing eventration and hernia formation. Our experience with the use of this approach has left a most favorable impression. However, in order to evaluate it from all aspects, it was decided to undertake a comparative study of the course of the morphological changes arising in neurovascular and muscular formations of the abdominal wall after different operative approaches to the extrahepatic biliary passages.

EXPERIMENTAL METHODS

Experiments were carried out on rabbits weighing 1.5-3 kg. The animals were divided into four groups with 25 rabbits in each group. A subcostal approach of the Fedorov type was used on the rabbits of group 1, a pararectal approach on those of group 2, a medial sliding approach on group 3, and an upper midline approach on group 4. The operations were performed under sterile conditions under local anesthesia with 0.25% procaine solution. The three or four intercostal nerves (T9-T12) with arteries of the same name, and also the

Crimean Medical Institute. A. V. Vishnevskii Institute of Surgery, Academy of Medical Sciences of the USSR, Moscow. (Presented by Academician of the Academy of Medical Sciences of the USSR D. S. Sarkisov.) Translated from Byulleten' Éksperimental'noi Biologii i Meditsiny, Vol. 101, No. 5, pp. 631-633, May, 1986. Original article submitted July 22, 1985.

0007-4888/86/0005-0701$12.50

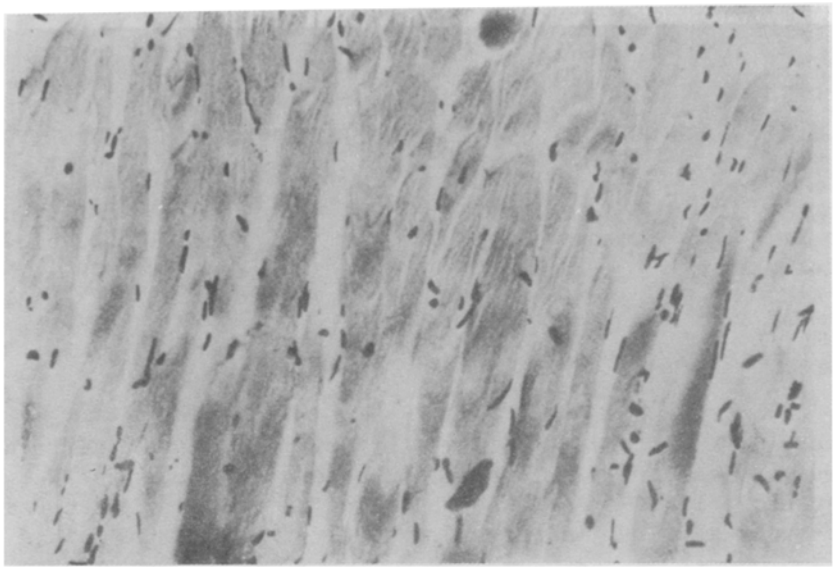

Fig. 1. Longitudinal section through rectus abdominis muscle fibers (7 days after operation). Medial sliding incision. Uniform staining with eosin. Interstitial edema. Hematoxylin and eosin, 76 × 120.

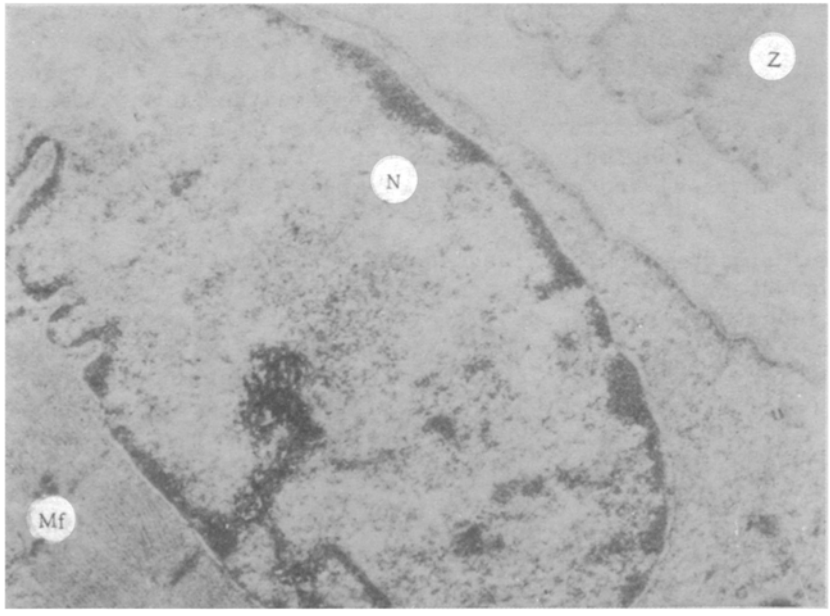

Fig. 2. Ultrastructure of muscle fiber of rectus abdominus muscle is preserved. Medial sliding incision, 7 days after operation. N) Nucleus, Z) Z-band; Mf) myofilaments. 35.000×.

superior epigastric vessels are inevitably divided when Fedorov's incision is used, and three intercostal nerves (T9-T11) with the arteries of the same name are divided by a pararectal incision. With the medial sliding and upper midline approaches, the main sources of innervation and blood supply remained outside the zone of the incisions. After the completion of the laparotomy the postoperative wounds were closed in layers, and 150,000 U of streptomycin in 0.25% procaine solution was injected into the region of the incision to prevent suppurative infection. The time from operation to taking the material was 2 h, and 7, 30, 90, and 180 days. Five animals were investigated at each time. On removal of the animal from the experiment, pieces of tissue measuring 1.5 × 1.5 cm were excised from the middle third of the rectus abdominus muscle. Material was fixed for light microscopy in 12% neutral formalin solution and then embedded in paraffin wax or frozen in a freezing microtome. Sections were stained with hematoxylin and eosin, by Van Gieson's method, by the Bielschowsky—Gros impregnation method, by Brachet's method, and with toluidine blue at various pH values. Material for electron-microscopic study was fixed immediately after removal in 2.5% glutar-

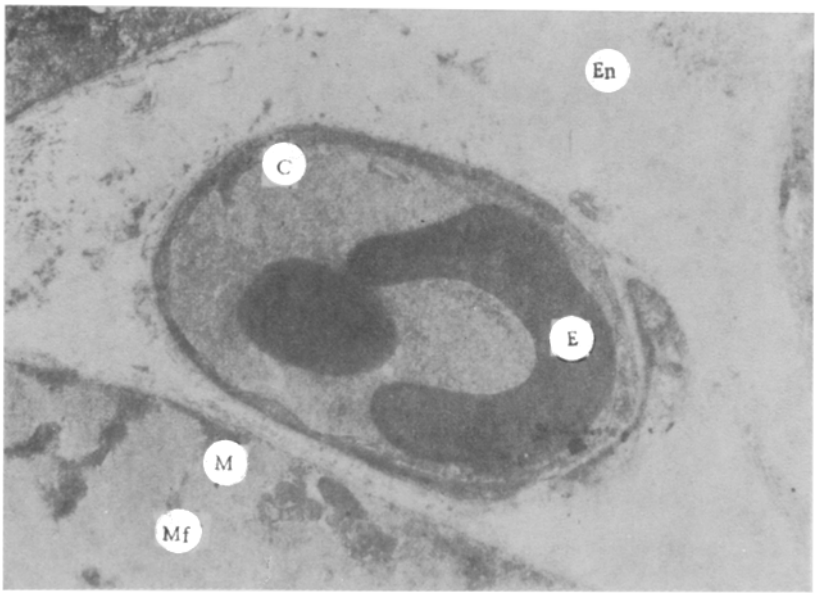

Fig. 3. Capillary (C), with erythrocytes (E) in its lumen, located in endomysium (En). Ultrastructure undisturbed; 7 days after operation through medial sliding incision. 3000×.

aldehyde solution in phosphate buffer, pH 7.4, in which it was cut into fragments 1 mm in diameter, which were then postfixed in OsO_4 solution. Blocks were embedded in Araldite. Ultrathin sections of the muscle were stained in a drop of 2% uranyl acetate solution and in 50% alcohol, and counterstained with lead citrate. The sections were examined in the JEM 100B electron microscope.

RESULTS

During the first few hours after the operation by Fedorov's approach and the pararectal incision, edema and swelling of individual muscle fibers and their nuclei and signs of intravascular stasis were observed. The staining properties of the muscle fibers remained unchanged.

When an upper midline and medial sliding approach was used, slight edema of individual muscle fibers and their nuclei, which were more marked nearer to the line of incision, were observed at this time. The structure of the muscle fibers was undisturbed and their staining properties remained unchanged.

On the 7th day after Fedorov's incision and the use of a pararectal approach, signs of atrophy of individual muscle fibers were observed, namely a considerably decrease in their diameter compared with normal, the structure of the fibers became indistinct, the cross striation disappeared from some of them, interstitial edema of the muscles increased, and their nuclei became more palely stained. Irregular staining of individual muscle fibers with eosin was observed. Some of the muscle fibers were in a state of overcontraction. Many fusiform fibroblasts and loosely packed fibrous structures appeared. On impregnation with silver many destructively changed myelinated and unmyelinated nerve fibers were clearly visible. The axons of many myelinated fibers were fragmented or vacuolated. The myelin sheath was of usual thickness but contained many granules. The nuclei of the Schwann cells usually were oval in shape.

After a medial sliding incision complete preservation of the structure of the muscle fibers was observed. Their staining properties remained unchanged. Myelinated and unmyelinated fibers showed no signs of destruction. Slight interstitial edema of the muscle tissue persisted. No connective-tissue cells were present (Fig. 1).

With the upper midline approach the muscle fibers stained readily with eosin. Their staining properties were undisturbed. There was no edema. No evidence of atrophy or destruction of muscle or nerve tissue could be found.

On the 30th day after operation with Fedorov's approach and with the pararectal incision, atrophy of the muscle fibers and a decrease in their diameter were clearly visible.

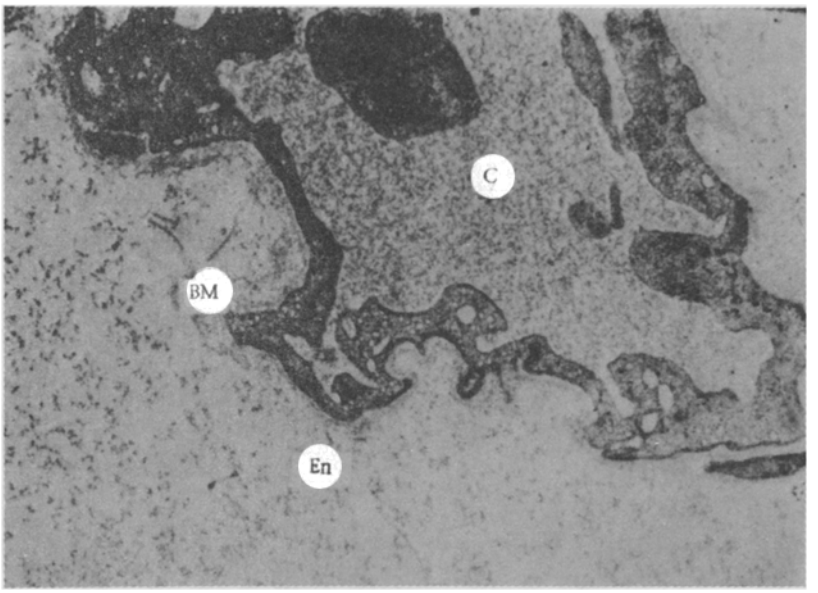

Fig. 4. Edema and compression of capillary (C) in endomysium (En) of striated muscle. Basement membrane (BM) reduced in density and has a folded appearance; 7 days after operation, Fedorov's incision. 35,000×.

Connective tissue began to proliferate at the site of the distintegrating muscle fibers, and numerous fusiform fibroblasts were observed among the connective-tissue fibers. Nerve fibers whose axons were broken into fragments of different length and thickness, and were vacuolated, could be seen.

After a medial sliding approach diffuse staining of the muscle fibers with eosin was observed, but no interstitial edema was present. The structure of the muscle fibers was unchanged and their staining properties undisturbed. The structure of the nerve fibers also was undisturbed. No connective-tissue cells were present.

After the upper midline incision all pathological changes connected with operative trauma and manifested previously as moderate interstitital edema had disappeared by this time.

On the 90th day after Fedorov's incision or the pararectal approach progressive atrophy of muscle fibers was observed, followed by their disappearance and replacement by a wide layer of connective tissue. Sometimes empty membranes of muscle fibers, with disturbed configuration, were found. In most cases, among destructively changed nerve fibers newly formed delicate nerve fibers, surrounded by a thin membrane and with round nuclei, were seen. After the medial sliding and upper midline incisions no pathomorphological changes could be observed in the rectus muscle or its neurovascular structures. On the 180th day after operation through Fedorov's and the pararectal incisions, muscle atrophy was pronounced. Not only single muscle fibers had undergone destruction, but also whole muscle bundles, which were totally replaced by dense fibrous connective tissue. Frequently nerve fibers, broken into fragments of different lengths, were found in the mass of connective tissue and between structurally changed muscle fibers. By this time after the medial sliding and upper midline incisions, the normal structure of the muscle fibers was observed, with no evidence of atrophy or destruction.

Electron-microscopic investigation of biopsy specimens of muscle tissue taken after the medial sliding incision revealed a normal ultrastructure of the muscle fiber, capillaries, and nerve fibers (Figs. 2 and 3). Incidentally, with the upper midline incision, signs of ill-defined hydropic destruction of the muscle fiber were observed. This was the case in the early postoperative period, and the signs of destruction disappeared in the later stages after the operation.

After Fedorov's and the pararectal incision, destructive ultrastructural changes were observed at various times. Both trophic and contractile systems were damaged. The connective-tissue membrane of the muscle fiber and its transverse septum, the Z-band, also were involved in the pathological process. The nuclear apparatus of the sarcomeres appeared

functionally highly active in character. After incisions of these types, nearly all structural elements composing the capillary wall were affected in the capillary system of the muscle (Fig. 4). Later (after 30 days) thickening of the connective-tissue cells with active infiltration by fibroblasts and high activity of satellite cells were noted.

The data on comparative morphological changes after the use of different operative approaches to the extrahepatic biliary tract thus provide conclusive evidence of the advantages of the medial sliding laparotomy, which combines sufficiently wide topographic-anatomical room for maneuver, with minimal trauma to muscular and neurovascular formations of the anterior abdominal wall.

LITERATURE CITED

1. V. M. Buyanov and L. V. Kozlova, Klin. Khir., No. 11, 64 (1981).
2. V. V. Rodionov et al., Khirurgiya, No. 10, 84 (1979).
3. A. Yu. Sozon-Yaroshevich, Anatomical-Clinical Factors Determining Surgical Access to Internal Organs [in Russian], Leningrad (1954).
4. M. I. Shalaev et al., Khirurgiya, No. 9, 67 (1977).