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Research Article

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Laparoscopic Appendectomy in the Treatment of Patients with Complicated Acute Appendicitis

I.S. Malkov[1] ✉, T.A. Mamedov[2], V.A. Filippov[1], S.V. Kurochkin[1, 2], I.F. Sharafislamov[1, 2]

Department of Surgery No. 2
[1] Kazan State Medical Academy, branch of the Further Professional Education Russian Medical Academy of Continuing Professional Education
36, Butlerova Str., Kazan 420012, Russian Federation
[2] City Clinical Hospital No. 7, Kazan
54, Chuikova Str., Kazan 420103, Russian Federation

✉ **Contacts:** Igor S. Malkov, Doctor of Medical Sciences, Professor, Head of the Department of Surgery of the Kazan State Medical Academy, branch of Further Professional Education of the Russian Medical Academy of Postgraduate Education. Email: ismalkov@yahoo.com

RELEVANCE Treatment of complicated forms of acute destructive appendicitis continues to be an urgent problem in emergency abdominal surgery.

AIM OF STUDY Improving the results of surgical treatment of patients with appendiceal peritonitis with laparoscopic appendectomy.

MATERIAL AND METHODS A retrospective analysis of the treatment of 150 patients with acute appendicitis complicated by local and diffuse peritonitis aged from 17 to 69 years was carried out. There were 77 (51.3%) women and 73 (48.7%) men. Depending on the treatment tactics used, two groups of patients were divided. In the main group (64 patients), the leading treatment method was laparoscopic appendectomy. In the comparison group (86 patients), traditional approaches were used, including open appendectomy with the McBurney approach in 72 patients (83.7%) and laparotomy for diffuse peritonitis in 14 (16.4%).

RESULTS The analysis of the surgical techniques used showed that in the main group, wound postoperative complications developed in 9 patients (14.1%). In the comparison group, postoperative complications developed in 32 patients (37.2%). For local non-limited peritonitis, the total duration of hospitalization after laparoscopic appendectomy performed in 49 patients was 6.7±1.4 days, and 8.6±2.1 days ($p<0.05$) in 72 patients who underwent open appendectomy. The duration of hospitalization was 8.2±2.7 days in case of diffuse peritonitis after laparoscopic appendectomy, sanitation and drainage of the abdominal cavity (15 cases), and 12.4±1.3 days ($p<0.05$) in 14 patients after laparotomy, appendectomy, sanitation and drainage of the abdominal cavity, intubation of the small intestine.

CONCLUSION Laparoscopic appendectomy may be the operation of choice for complicated forms of acute appendicitis according to developed indications. It should be performed by a surgeon experienced in endosurgical operations. To increase the efficiency of washing the abdominal cavity in case of diffuse peritonitis, it is recommended to use hardware sanitation. The capabilities of laparoscopic appendectomy make it possible to adequately perform the required amount of surgical treatment, minimize surgical trauma, and significantly reduce the rate of postoperative complications and the duration of hospital treatment compared to open appendectomy.

Keywords: acute appendicitis, periappendiceal abscess, peritonitis, laparoscopic appendectomy

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Affiliations

Igor S. Malkov	Doctor of Medical Sciences, Professor, Head of the Department of Surgery of the Kazan State Medical Academy, branch of the Further Professional Education of the Russian Medical Academy of Postgraduate Education; https://orcid.org/0000-0003-2350-5178, ismalkov@yahoo.com; 50%, research concept, text writing, editing
Tural A. Mamedov	Surgeon, Department of Surgery No. 2, Clinical Hospital No. 7, Kazan; https://orcid.org/0000-0003-1610-2813, tural_mm@mail.ru; 20%, data collection, text writing
Vyacheslav A. Filippov	Candidate of Medical Sciences, Associate Professor, Associate Professor of the Department of Surgery of the Kazan State Medical Academy, branch of the Further Professional Education of the Russian Medical Academy of Postgraduate Education; https://orcid.org/0000-0001-7440-4866, vyacheslav_f@mail.ru; 20%, text writing, editing

Sergey V. Kurochkin — Head of the Radiologic Diagnostic Department of the State Autonomous Institution of Healthcare City Clinical Hospital No. 7 of Kazan; Associate Professor of the Department of Ultrasound Diagnostics of the Kazan State Medical Academy, branch of the Further Professional Education of the Russian Medical Academy of Postgraduate Education; https://orcid.org/0000-0002-8043-3871, kurochkin.70@bk.ru; 5%, data collection, text writing

Iskander F. Sharafislamov — Head of the Center for Radiologic Surgical Interventions of the State Autonomous Institution of Healthcare City Clinical Hospital No. 7 of Kazan; Assistant at the Department of Ultrasound Diagnostics of the Kazan State Medical Academy, branch of the Further Professional Education of the Russian Medical Academy of Postgraduate Education; https://orcid.org/0000-0002-0672-7521, sharusi@rambler.ru; 5%, data collection, text writing

AA – acute appendicitis
CT – computed tomography
LAE – laparoscopic appendectomy
PA – periappendicular abscess

BACKGROUND

The widespread use of endovideosurgical technologies at the end of the 20th and beginning of the 21st centuries made it possible to consider laparoscopic appendectomy (LAE) as the operation of choice for uncomplicated destructive appendicitis [1–6]. A comparative assessment of the results of treatment of patients after laparoscopic and traditional methods of treatment of acute appendicitis (AA) showed a significant reduction in the severity of postoperative pain and the frequency of postoperative complications, which is associated with less surgical trauma. In Russia, LAE has not become a universally preferred treatment method for complicated AA. The main arguments of skeptics are: the technical complexity of the currently existing surgical techniques of LAE, the lack of qualified specialists and trained personnel, the high percentage of conversions and the likelihood of intra-abdominal complications [7–11]. A nationwide survey of surgeons showed that the widespread use of LAE is also hampered by low motivation for the introduction of laparoscopic technologies [12].

Widespread peritonitis, according to most researchers, is an indication for midline laparotomy, elimination of the source of peritonitis, adequate sanation and drainage of the abdominal cavity, and nasointestinal decompression. However, among all cases of AA, patients with widespread appendiceal peritonitis, accompanied by paralytic intestinal obstruction and compartment syndrome, do not exceed 0.6% [13]. Therefore, in recent years, reports have appeared on the use of LAE for AA complicated by peritonitis and periappendiceal abscess (PA) [13–20]. The authors note that the laparoscopic technique makes it possible to determine the extent of the purulent process, carry out thorough targeted sanation and, if experienced, perform an appendectomy. In addition, the minimal area of peritoneal damage prevents the development of severe adhesions after surgical complications. However, the question of the advisability of performing LAE for such complications remains unresolved.

Taking into account the above, the goal of the study was formulated: to improve the results of surgical treatment of patients with AA complicated by peritonitis through the use of LAE.

MATERIAL AND METHODS

A retrospective analysis of the treatment of 150 patients with AA complicated by local and diffuse peritonitis, admitted to the Department of Surgery No. 2 of the State Autonomous Institution of Clinical Hospital No. 7 of Kazan from 2012 to 2022 at the age of 17 to 69 years, was carried out. There were 77 (51.3%) women, 73 (48.7%) men.

Depending on the treatment tactics used, two groups of patients were divided. In the main group (64 patients), the leading treatment method was LAE. In the comparison group (86 patients), traditional approaches were used, including open appendectomy, which was performed by surgeons who had insufficient experience in performing LAE for appendiceal peritonitis. Using the McBurney approach, appendectomy was performed in 72 patients (83.7%) and through laparotomy for widespread peritonitis in 14 (16.4%). There were no significant differences in the compared groups by age and gender (p >0.05). Most patients (n = 107, 71.3%) sought medical help in the first 48 hours from the moment of illness, of which in 14 cases (9.3%) patients were hospitalized upon re-application due

to increased abdominal pain and increased body temperature. Initially, patients either themselves refused the proposed hospitalization, or the emergency physician found no signs of AA.

The severity of the physical condition, the degree of risk of anesthesia and surgery were assessed based on the classification of the American Association of Anesthesiologists (2020), which takes into account the physical status of patients. All patients in the general sample had *ASA* I *E*, *ASA* II *E*, which is explained by the predominance of young and middle-aged patients.

The examination of patients with AA was comprehensive and included clinical laboratory, radiation (ultrasound examination - ultrasound, computed tomography, CT) research methods and laparoscopy. X-ray examination of the abdominal cavity was not performed. To clarify the diagnosis, CT was performed in 27 cases. However, the frequency of use of instrumental diagnostics in the study groups was different. Ultrasound of the abdominal organs was performed using *Philips-iU* 22, *SonoScape devices S* 8 and *SSI* 6000 using linear and convex sensors. In the main group, ultrasound was performed on all patients upon admission to the emergency department. The feasibility of using ultrasound was confirmed in the diagnosis of PA. In 150 patients presented in the study materials, PAs were excluded.

The method was also used on the 3rd day of the postoperative period to monitor the course of the wound process and early diagnosis of intra-abdominal complications. Scanning was performed in the supine and left lateral position. We searched for free fluid, limited fluid accumulations, as well as hyper- and hypoechoic formations in the surgical area and adjacent areas. In the comparison group, ultrasonography was performed on all women (n = 44), as well as in case of diagnostic difficulties (n = 15, 17.4%). No preliminary preparation for the study was carried out. Special techniques included dosed compression of the abdominal wall. The diagnosis of AA was established on the basis of direct and indirect signs in 88 patients (72%), which was confirmed during surgery.

CT with intravenous contrast was performed on a *Philips Brilliance* 64 and *Ingenuity* 128 device with a radiation dose of up to 64 mSv. Iodine-containing water-soluble contrast in a volume of about 100 ml was administered through a peripheral venous catheter installed in the cubital fossa using an automatic injector at a rate of 3-5 ml/sec. The slice thickness was 2.5–5 mm, with subsequent transverse, frontal, and sagittal reconstructions performed. Contrast enhancement was assessed in three phases: arterial, portal venous and delayed. The indications for its use were: the difficulty of diagnosing PA and choosing a method of its treatment: open appendectomy or only transcutaneous drainage under ultrasound control. CT was performed in 18 patients (28.1%) of the main group and in 9 (10.9%) of the comparison group.

Diagnostic laparoscopy in the main group was performed in all patients as the first stage of endosurgical intervention under endotracheal anesthesia. During the study, the clinical diagnosis was established or clarified, and the technical capabilities and feasibility of performing LAE were determined. In the comparison group, laparoscopic examination was performed only in diagnostically difficult cases (n = 15, 18.3%). To assess the prevalence of peritoneal exudate, we were guided by diagnostic algorithm developed at the N.V. Sklifosovsky Research Institute of Emergency Medicine, according to which the lower and upper levels of the abdominal cavity were divided into six areas. These are the small pelvis (1), right (2) and left (3) lateral canals; right subhepatic space (4); right (5) and left (6) subphrenic spaces [14]. According to the nature of the peritoneal exudate, including local and widespread forms of peritonitis, purulent occurred in 103 cases, purulent-fibrinous in 47 patients. The severity of generalized peritonitis according to the Mannheim peritoneal index in the main and comparison groups did not exceed score 22. For prophylactic purposes, during laparoscopic surgery, all patients were intravenously administered antibiotics of the third generation cephalosporin group + metronidazole.

Appendectomy was performed antegrade in 52 patients (81.2%), retrograde in 8 (12.5%), and in a combined manner in 4 (6.3%). The mesentery of the appendix was divided using bipolar coagulation, ligation with extracorporeal Roeder's knot, or the *LigaSure device*.

Videolaparoscopy and endosurgical interventions were performed using a mobile device and instruments from ˝*Karl Storz*˝ (Germany), “Endomedium”, “NPF MFS”, “PPP” (Russia).

The distribution of patients by clinical and morphological forms of AA is presented in Table. 1.

Table 1

Clinical and morphological forms of complicated appendicitis in patients of the study groups

Form of appendicitis	Main group (*n* =64)	Group comparisons (*n* =86)	Pearson chi-square
Phlegmonous, complicated by local unconfined peritonitis	42 (65.6%)	61 (70.9%)	0.480
Gangrenous, complicated: a) local unconfined peritonitis; b) widespread peritonitis	 7 (7.1%) 15 (15.1%)	 11 (8.1%) 14 (10.4%)	 0.19 1.206
Total:	22 (32.3%)	25 (31.1%)	*p* >0.05

According to the criterion for assessing the significance of differences, Pearson Chi-square in the main group and the comparison group, depending on the clinical and morphological form of AA, did not reveal statistically significant differences ($p > 0.05$). Therefore, overall the groups appear relatively homogeneous.

RESULTS

A relatively low (72%) sensitivity of ultrasonography in diagnosing AA was noted. However, the feasibility of its use was confirmed in the diagnosis of PA. We searched for free fluid, limited fluid collections, as well as hyper- and hypoechoic formations in the surgical area and adjacent areas (Fig. 1).

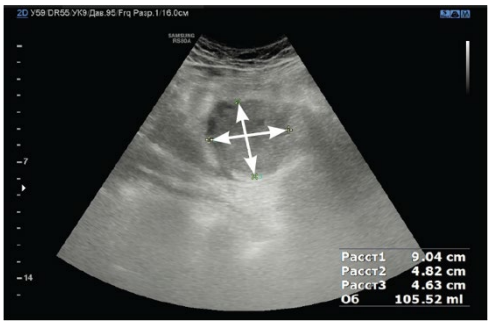

Fig. 1. Echosonographic sign of appendicular abscess (white arrows)

CT provided significant assistance in diagnosing intra-abdominal complications of destructive AA. The method in most cases made it possible not only to visualize appendix and determine its inflammatory changes, but also to more clearly (unlike ultrasound) differentiate the anatomical structures of the abdominal cavity (Fig. 2).

In all cases, an enlarged edematous appendix and the presence of free fluid in the abdominal cavity were visualized.

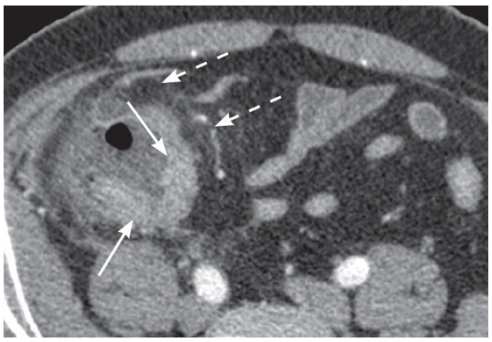

Fig. 2. Patient Z., 70 years old. Contrast-enhanced computed tomography of the abdomen, portal phase. Axial slice. Posteromedial location of the edematous and tortuous appendix (white arrows). The presence of a periappendicular inhomogeneous masses with unevenly thickened contrasting walls, liquid contents and gas bubbles (dashed arrows)

Videolaparoscopy made it possible to verify the diagnosis, assess the prevalence and nature of peritoneal exudate, the severity of intestinal dilatation and its motor activity, and select the optimal treatment tactics.

Based on the information obtained during diagnostic laparoscopy, criteria were determined to allow LAE to be performed:

1. Absence of pronounced infiltrative changes in the base of the cervical region and the dome of the cecum.

2. Accumulation of purulent exudate with fibrin, easily removed with a manipulator, limited to 3–5 anatomical areas.

3. Increased intestinal motor activity under mechanical influence. Since it is difficult to assess the degree of intestinal motor disorders during laparoscopy, we used a visual criterion to determine the response of the smooth muscles of the intestinal wall to mechanical stress. A pulsating stream from the BRUSAN apparatus was used as such a stimulus. The absence of a motor reaction of the intestine during 3–5 minutes of observation indicated deep

functional disorders. In this case, dilatation and significant interstitial edema of the intestinal wall were always noted. In such cases, laparotomy and nasointestinal decompression were performed.

4. Mannheim peritoneal index values not exceeding score 22.

In total, there were 77 attempts to perform LAE for complicated forms of AA in the main group. However, the possibilities of the endovideosurgical method were limited in cases of perforation of the base of the cervical region due to inflammatory infiltration of the dome of the cecum (2), atypical (retrocecal/retroperitoneal) location of the appendix (2), severe adhesions (1), PA (3), in 5 cases the spread of purulent exudate to the upper floor of the abdominal cavity was verified (areas 4, 5, 6). Despite the fact that LAE for complicated forms of AA was performed in all cases by surgeons with experience in endosurgical interventions, the conversion rate was 16.9%. Their significant share in complicated forms of AA was associated, first of all, with insufficiently informative methods of preoperative diagnosis, as well as the desire to prevent severe intra-abdominal complications. Thus, the main group included 64 patients who underwent LAE.

In the presence of purulent exudate, it was first evacuated and the abdominal cavity was sanitized using the BRUSAN apparatus. Otherwise, infected exudate may flow through the side channels into the subphrenic space. The device is inserted through a 5.0 mm or 10.0 mm trocar, depending on the severity of fibrin deposits on the parietal and visceral peritoneum. For this purpose there are two nozzles of different diameters. The design solution of this device was based on the principle of a simultaneously functioning 2-channel system of inflow and outflow of fluid, which ensures operation of the device in 3 modes: irrigation, aspiration, and irrigation and aspiration. The simultaneous operation of two channels eliminates splashing of the washing liquid throughout the peritoneum, its spread to adjacent intact areas, as well as suction of the nozzle, which is often observed when a traditional electric suction is used. The supply of washing liquid can be continuous or pulsating. The effect of a pulsating jet on the intestinal wall plays the role of a kind of hydromassage, stimulating its motor activity (Fig. 3).

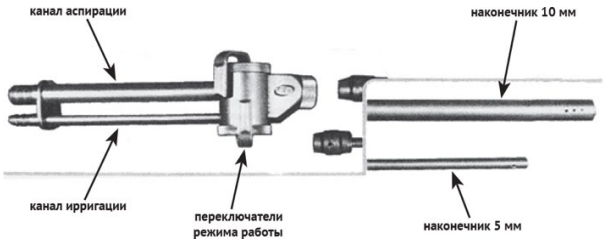

Fig. 3. Irrigation-aspiration apparatus BRUSAN

This device can also be successfully used for open surgical interventions.

Intraoperative complications in the form of bleeding of varying intensity from the short infiltrated mesentery of the appendix occurred in 6 cases. To stop them, additional electrocoagulation (n =4) and clipping (n =2) were used.

The management of patients after LAE had a number of features:

1. Antibacterial therapy was continued in all cases.

2. If the postoperative period was favorable, drain was removed after 12 hours in patients operated on for local peritonitis, and they were allowed to get up and take liquid food. If the operation was performed for diffuse peritonitis, the drainage was also removed after 12 hours, and the patient was allowed to get out of bed. After sanitation of the abdominal cavity, only one drain was installed in the small pelvis. Early activation of patients after LAE is seen as one of its main advantages. Infusion therapy and drug stimulation of the intestines were continued. Individuals at high risk of thromboembolic complications were prescribed anticoagulant therapy. Fluids were allowed 24 hours after surgery. When intestinal motor activity was restored, they switched to taking liquid and semi-liquid food.

3. On the 3rd day, all patients had laboratory parameters monitored and echosonography was performed for the purpose of early non-invasive diagnosis of postoperative complications.

4. If symptoms of an “unfavorable postoperative course” appeared (intestinal paresis for more than 3 days, low-grade fever, leukocytosis, severe pain, fluid accumulation in the abdominal cavity according to ultrasound), an abdominal CT scan with contrast was

performed and indications for urgent relaparoscopy were established. Based on the information received, further treatment tactics were determined. Thus, one relaparoscopy was performed on demand due to early postoperative adhesive small intestinal obstruction that developed on the 6th day, laparoscopic adhesiolysis and restoration of intestinal passage were performed.

The main criterion for the effectiveness of the treatment tactics used is the frequency of postoperative complications. In the main group they developed in 9 patients (14.1%), most of them were grades I and II. These included seromas that did not require removal of sutures from the surgical wound (5), and inflammatory infiltrate (1) at the site of the 3rd trocar. More severe complications (III *a* –III *b*) were represented by wound purulent-inflammatory complications, in which sutures were removed in 2 patients; early adhesive intestinal obstruction, which required relaparoscopy to resolve, occurred in 1 case. After LAE, no development of intra-abdominal abscesses was observed, even with widespread peritonitis. This is largely due to adequate sanitation of the abdominal cavity.

In the comparison group, postoperative complications developed in 32 patients (37.2%). At the same time, complications of I and II degrees occurred in 18 patients. These included long-term postoperative intestinal paresis (more than 3 days after surgery) in 2 patients, urinary tract infection in 1, phlebitis of the superficial veins of the leg in 2, inflammatory infiltrates in 2, seromas that do not require removal of sutures from the surgical wound, in 11. Wound purulent-inflammatory complications requiring removal of sutures from the surgical wound (III *a* –III *b*) were observed in 14 cases. Factors contributing to their development were contact of the surgical wound with peritoneal exudate and a destructively altered cervical region, the traumatic nature of surgical intervention, and inadequate sanitation of the abdominal cavity (Table 2).

Table 2

Postoperative complications according to the Clavien-Dindo classification (2004)

Severity of complications	Main group (*n*=64)	Group comparisons (*n*=86)	Pearson chi-square
Grade I–II	6 (9.4%)**	18 (20.9%)**	3.645
Grade III *a* –III *b*	3 (4.7%)**	14 (16.3%)**	4,906
Total:	9 (14.1%)*	32 (37.2%)*	9,898

Notes: * — p<0.05; ** — p>0.05

For local peritonitis, the total duration of hospitalization after LAE performed in 49 patients was 6.7±1.4 days, in 72 patients who underwent open appendectomy the duration of hospital stay was 8.6±2.1 days (p <0.05). In case of diffuse peritonitis after LAE, sanitation and drainage of the abdominal cavity (15 cases), the duration of hospitalization was 8.2±2.7 days, in 14 patients of the comparison group after median laparotomy, appendectomy, sanitation and drainage of the abdominal cavity the duration of hospital stay was 12.4±1.3 days (p <0.05).

CONCLUSIONS

1. Laparoscopic appendectomy may be the operation of choice for complicated forms of acute appendicitis according to developed indications. It should be performed by a surgeon experienced in endosurgical operations.

2. To increase the efficiency of washing the abdominal cavity in diffuse peritonitis, it is recommended to perform sanation with devices.

3. The capabilities of laparoscopic appendectomy make it possible to adequately perform the required volume of surgical treatment, minimize surgical trauma, significantly reduce the rate of postoperative complications compared with open appendectomy from 37.2 to 14.1% (p <0.05) and the duration of hospital treatment for local peritonitis from 8.6±2.1 to 6.7±1.4 days (p <0.05) and with diffuse peritonitis from 12.4±1.3 to 8.2±2.7 days (p <0 .05).

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