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# Comparison of Laparoscopic Methods of Management of Appendix Stump

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## ABSTRACT

**INTRODUCTION:** Today, laparoscopic appendectomy (LAE) is the 'golden standard' of the treatment for acute appendicitis. However, the choice of the method of management of the appendix stump (AS) causes much debate.

**AIM:** Comparative analysis of invagination and ligation methods of management of the appendix stump in LAE.

**MATERIALS AND METHODS:** The analysis included data from 130 patients who underwent LAE. An analysis and comparison of the invagination and ligation methods of management of AS are presented.

**RESULTS:** There were no significant differences in the frequency of mild postoperative complications of LAE, severity of pain syndrome and length of hospital treatment. The difference was in the time of the surgical intervention, which was longer in the group of patients with AS managed using the invagination method. The frequency of infiltrates of the right iliac fossa was lower in the group of AS management using invagination method.

**CONCLUSION:** This clinical study demonstrated the effectiveness, safety and availability of the invagination method of AS management compared to the ligation method. A disadvantage of the invagination method is the requirements to the surgeon's practical skills and a significant increase in the length of the operation. The management of the AS by immersing it with the intracorporal suture into the cecum cupula can be recommended for use in the everyday surgical practice.

**Keywords:** acute appendicitis; laparoscopic appendectomy; appendix; vermiform process; appendix stump; method of management of appendix stump.

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# Сравнение лапароскопических способов обработки культи червеобразного отростка

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## АННОТАЦИЯ

**Введение.** В настоящее время лапароскопическая аппендэктомия (ЛАЭ) является «золотым стандартом» лечения острого аппендицита. Однако выбор способа обработки культи червеобразного отростка (ЧО) вызывает много споров.

**Цель.** Сравнить и оценить лигатурный и погружной способы обработки культи ЧО при ЛАЭ как наиболее доступные и применимые в современных реалиях.

**Материалы и методы.** В анализ были включены данные 130 пациентов, которым выполнялась ЛАЭ. Проведен анализ и сравнение погружного и лигатурного способов обработки культи ЧО.

**Результаты.** Значимых различий в частоте легких послеоперационных осложнений ЛАЭ, выраженности болевого синдрома и продолжительности срока стационарного лечения зарегистрировано не было. Отличие заключалось во времени оперативного вмешательства: оно было выше в группе пациентов, где обработку культи ЧО осуществляли погружным способом. Частота инфильтратов правой подвздошной ямки оказалась меньше в группе, где культу ЧО обрабатывали погружным способом.

**Заключение.** Данное клиническое исследование показало эффективность, безопасность и доступность погружного способа обработки культи ЧО по сравнению с лигатурным способом. Недостатком погружного способа обработки культи ЧО является требование к практическим навыкам хирурга и значительное увеличение продолжительности операции. Обработку культи ЧО путем ее погружения интракорпоральным швом в купол слепой кишки можно рекомендовать к применению в повседневной хирургической практике.

**Ключевые слова:** острый аппендицит; лапароскопическая аппендэктомия; аппендикс; червеобразный отросток; культя червеобразного отростка; способ обработки культи червеобразного отростка.

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## INTRODUCTION

Currently, an increasing number of practicing surgeons give preference to laparoscopic appendectomy (LAE) considering it the most reasonable surgery in the treatment for acute appendicitis [1–3]. This high-tech intervention combines the possibility of a full revision of the abdominal organs, a relatively lower frequency of postoperative complications (POC), faster rehabilitation of the patients [1, 2, 4] due to less traumatic access and a milder pain syndrome. This is especially important for obese patients and patients with an unclear diagnosis, since the traditional ‘open’ laparotomy access not only increases the duration of inpatient treatment, but is also often accompanied with various POCs.

On the other hand, according to literature data [5, 6], LAE is often followed by formation of the intra-abdominal infiltrates and abscesses. The frequency of these complications is associated with the key stage of the surgery — closure of the appendix stump (AS), the method of which has long been debated in the literature.

In practice, several methods of stump management are used: ligation, invagination, use of clips, of apparatus. Each of these methods has advantages and disadvantages [7, 8].

The *ligation method* is fast, relatively simple and cheap. However, according to a number of authors [7, 8], it leads to contamination of the free abdominal cavity through exposed mucous membrane, and to most frequent occurrence of intra-abdominal infiltrates and abscesses.

The *clip method* is even simpler and cheaper and has many supporters [7, 8], but its use is limited to cases of anomalies of the base of the appendix, where its width exceeds the width of the clip [7].

The *apparatus method*, being the safest and technically simple, nevertheless, requires the use of an endostapler, which makes this method most expensive [4, 5] and limits its widespread use.

The *invagination method* implies inversion of the appendix stump into the cecum, as it is done in the open appendectomy. This method should exclude the probability for contamination of the free abdominal cavity, minimize the percent of POCs, while remaining the most labor-intensive method requiring appropriate manual skills of the surgeon [2].

Thus, the choice of the method of closure of the appendix stump depends on the professionalism of the surgeon and a compromise between safety and cost. In our work, we compared the invagination and ligation methods of the appendix stump closure as most accessible and applicable in modern realities.

The **aim** of this study to compare and assess the ligation and invagination methods of management of the appendix stump in laparoscopic appendectomy.

## MATERIALS AND METHODS

An observation study of 130 patients who underwent LAE for one of the forms of acute appendicitis was conducted at the Ryazan City Clinical Emergency Care Hospital. Patients signed informed consent to hospitalization and surgical treatment. No additional interventions were conducted outside the standard medical care; the clinical data were processed in the depersonalized form.

**Inclusion criteria:** one of the forms of acute appendicitis, age 18–80 years, signing the standard form of Informed consent to medical care at the City Clinical Emergency Care Hospital.

**Exclusion criteria:** age under 18 or over 80 years; refusal of surgical treatment; body mass index over 40 kg/m<sup>2</sup>; presence of peritonitis involving more than three areas of the abdominal cavity; presence of interintestinal abscesses, retroperitoneal phlegmon, pylephlebitis; anesthetic risk IV and V according to the classification of the American Society of Anesthesiologists (ASA).

The patients were divided into comparison groups according to the method of closure of the appendix stump in LAE. The **first (main) group** (n=60, 46.2%; 38 women, 22 men) underwent LAE with closure of the appendix stump by applying two ligatures without immersing it in the cupula of the cecum (Figure 1, a). The **second (control) group** (n=70, 53.8%; 46 women, 24 men) underwent LAE with ligation of the appendix stump with one ligature and invagination it into the cupula of the cecum (Figure 1, b).

The mean age of the patients ranged from 18 to 70 years and was 45.4±11.9 years in the main group and (47.0±12.2) years in the control group ( $p > 0.05$  for Student's t-test). The body mass index was (28.2±5.1) kg/m<sup>2</sup> in the main group and (29.1±4.8) kg/m<sup>2</sup> in the control group ( $p > 0.05$  for Student's t-test). The groups were also comparable in gender composition ( $p > 0.05$  for Pearson's  $\chi^2$ -test). There were no differences in comorbidity between the compared groups (Mann–Whitney test was used;  $U_{emp.}=64 > U_{cr.}=52$ : the null hypothesis was not refuted, the differences between the compared groups were statistically insignificant,  $p > 0.05$ ).

The majority of patients of both groups had degree II of operative risk in ASA classification; patients with risk degree III appeared the least numerous; patients with degree IV and V of anesthetic risk were not included in the study (Table 1).

When comparing groups of patients with acute appendicitis by the character, prevalence of morphological alterations and location of the appendix, no statistically significant differences were found between the groups (Tables 2, 3).

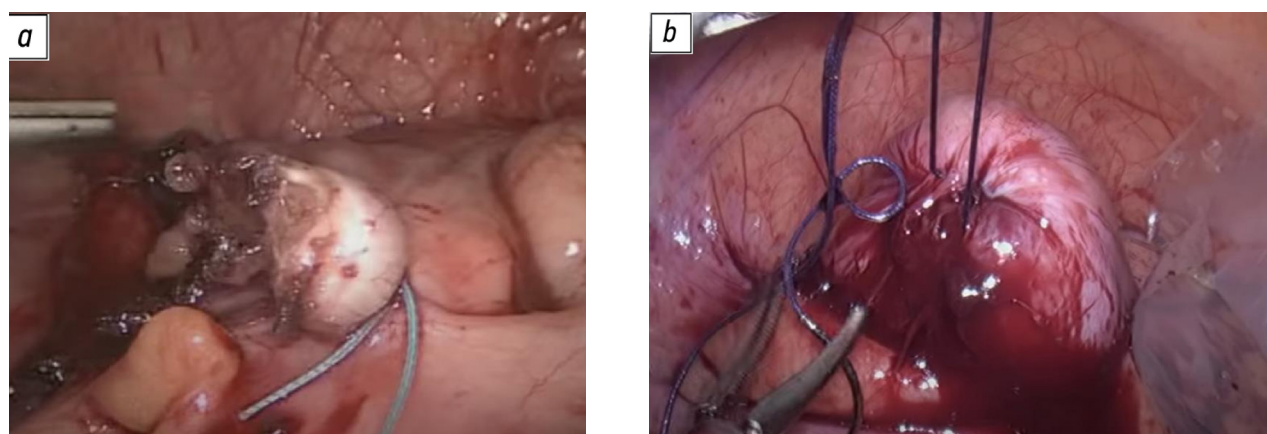


Fig. 1. Compared methods of management of the appendix stump: *a* — ligation method; *b* — invagination method.

Table 1. Comparative characteristics of groups according to operative risk classification of the American Society of Anesthesiologists

Operative risk \ Group	Ligation method	Invagination method	Total
n	60	70	130
Degree I, n (%)	24 (40.0)	29 (41.4)	53 (40.8)
Degree II, n (%)	32 (53.3)	35 (50.0)	67 (51.5)
Degree III, n (%)	4 (6.7)	6 (8.6)	23 (7.7)

Note: Mann–Whitney test;  $U_{emp.}=32 > U_{cr.}=29$ ,  $p > 0.05$

Table 2. Comparative characteristics of groups by character and prevalence of morphological alterations

Morphological form of appendicitis \ Group	Ligation method	Invagination method
n	60	70
Catarrhal appendicitis, n (%)	7 (11.7)	6 (8.6)
Phlegmonous appendicitis, n (%)	49 (81.7)	56 (80.0)
Gangrenous appendicitis, n (%)	5 (8.3)	8 (11.4)
Appendicular infiltrate, n (%)	15 (25.0)	17 (24.3)
Appendicular abscess, n (%)	3 (5.0)	4 (5.7)
Local peritonitis, n (%)	10 (16.7)	13 (18.6)

Note: Mann–Whitney test;  $U_{emp.}=44 > U_{cr.}=31$ ,  $p > 0.05$

The patients of both groups were operated on within the first six hours of hospitalization. All interventions were performed on the same equipment, by surgeons with the experience in laparoscopic surgery > 7 years. In this case, the same treatment of the mesoappendix was

performed: the latter was removed within the unchanged tissues. Drainage of the abdominal cavity was performed only in case the peritonitis phenomena were present. In the absence of pathological changes in the peritoneum, drainage of the abdominal cavity was not performed.

**Table 3.** Comparative characteristics of groups by location of appendix

Location of appendix	Group	Ligation method	Invagination method
n		60	70
Classic, n (%)		48 (80.0)	53 (75.7)
Retrocecal, n (%)		7 (11.7)	9 (12.9)
Retroperitoneal, n (%)		5 (8.3)	8 (11.4)

Note: Mann–Whitney test;  $U_{emp.}=59 > U_{cr.}=51, p > 0.05$

Before discharge, the patients underwent obligatory US of the abdominal cavity and a complete blood count. The patients were discharged upon clinical recovery, normalization of the laboratory parameters, and absence of alterations of the abdominal organs on US examination.

Statistical processing of variables was performed using the parametric Student's t-test, Mann–Whitney U-test, processing of qualitative features by calculating Fisher's exact test and Pearson's  $\chi^2$  test. For processing non-parametric features, Wilcoxon test was calculated. The level of reliability at  $p < 0.05$  was considered statistically significant.

## RESULTS

Different methods of managing the AS influenced the length of hospital treatment as follows: the mean length of hospital treatment after appendectomy with invagination of the AS was  $(3.2 \pm 1.1)$  days, and was somewhat longer after ligation of the stump —  $(4.3 \pm 1.4)$  days ( $p \geq 0.05$  for Fisher's test). The method of managing the AS did not demonstrate an effect on the length of hospital stay.

The level of pain scored on a visual analogue scale of 1 to 10 [9] where 1 is the minimal pain sensation, and 10 corresponds to maximal pain, in 6 hours after the surgery in patients of the main and control groups was  $(2.41 \pm 2.12)$  and  $(2.46 \pm 1.98)$  respectively ( $T_{emp.}=4 > T_{cr.}=2, p \geq 0.05$ ). There was no need to prescribe narcotic analgesics in patients of either of the groups. A day after surgery, the pain syndrome was that minimal that no patients needed analgesics.

The duration of the operation was expectedly longer in the group where the AS was inverted into the cupula of the cecum  $(75.1 \pm 19.8)$  min versus  $(54.8 \pm 14.2)$  min in the group with stump ligation;  $p < 0.05$  for Student's t-test). Here, significant differences between the compared groups already appear, which is quite logical, since using the invagination method of the stump closure *adds another stage to the operation* — laparoscopic

application of a purse-string suture to the cupula of the cecum, which takes about 15–20 minutes to complete.

Intraoperative and iatrogenic complications were not observed in any of the groups. All surgeries were performed laparoscopically, there were no conversions. Mild POCs (nausea, vomiting, hyperthermia, suppuration of the postoperative wound) were present in a statistically equal ratio (17 (24.3%) patients in the main group and 14 (23.3%) patients in the control group) and stopped either on their own or after conservative therapy. Such complications are quite common after any laparoscopic intervention and are caused by surgical injury and the effect of drugs used for anesthesia.

Suppuration of the postoperative wound is associated with the peculiarities of extraction of the appendix through the abdominal wall, which is often followed by its infection and subsequent suppuration [10]. This complication can be minimized by using a container for extraction, which is, however, not always used. In the study, in both groups, the appendix was extracted in the same way, using a polyvinyl chloride bag, no statistical differences were observed.

In the main group, where the stump was only ligated without subsequent invagination, in 4 patients (6.7%) the postoperative period was complicated with infiltrate of the right iliac region, which required additional conservative treatment, antibacterial treatment (a combination of ceftriaxone and metronidazole) and prolongation of hospitalization to  $(11 \pm 1.8)$  days. In the control group, infiltrate was diagnosed in only one patient. Processing of the results of this study using Fisher's exact test showed statistical significance of the frequency of abdominal infiltrates after appendectomy and its dependence on the method of closure of the appendix stump ( $F=5.993$ , which is greater than the tabular F value at a significance level of  $p < 0.05$ ). The frequency of other complications does not depend on the method of the stump closure (calculation using Fisher's exact test,  $p \geq 0.05$ ). We did not have abdominal abscesses or failure of the appendix stump in any of the groups. Accordingly, no repeat operations were required (Table 4).

In the absence of pathological alterations of the peritoneum, we consider the drainage of the abdominal cavity unreasonable, therefore, no drainage of the abdominal cavity was performed in this situation. However, 20 patients of the first group and 24 of the

second needed drainage. The drains were removed in  $(1.8 \pm 0.6)$  days in patients of the first group and  $(1.9 \pm 0.4)$  days of the second. The analysis was performed using Fisher's exact test,  $p \geq 0.05$  (Table 5).

**Table 4.** Comparative characteristics of groups by frequency of early postoperative complications

Complication	Group	Ligation method	Invagination method
n		60	70
Nausea, vomiting, n (%)		3 (5)	1 (1.4)
Hyperthermia, n (%)		11 (18.3)	9 (12.9)
Suppuration of postoperative wound, n (%)		3 (5.0)	4 (5.7)
Infiltrates of abdominal cavity, n (%)		4 (6.7)	1 (1.4)

**Table 5.** Comparative characteristics of groups by frequency of abdominal cavity drainage and time of drainage removal

Parametrs	Group	Ligation method	Invagination method
n		60	70
Drainage of abdominal cavity, n (%)		20 (33.3)	24 (40)
Time of drainage removal, $M \pm SD$ , days		$1.8 \pm 0.6$	$1.9 \pm 0.4$

Clinical forms of appendicitis, presence of peritonitis, anatomical and topographic peculiarities, concomitant pathology factors that influence the course of the postoperative period, equally affect it in both groups and also affect the results of the study, the comparison groups are statistically homogeneous in these factors.

After clinical recovery, normalization of laboratory parameters, absence of pathological changes on US of the abdominal cavity, all patients were discharged in a satisfactory condition for outpatient follow-up care.

## DISCUSSION

Thus, the data obtained in the study, in general, once again indicate a high effectiveness of LAE as a 'gold standard' in the treatment of patients with acute appendicitis irrespective of the methods of the AS management. The absence of statistical differences between the comparison groups shows that the method of management of the AS influences the results of LAE.

Such factors as the length of hospital stay, the level of postoperative pain and the need for narcotic analgesics, were in no way dependent on the method

of AS management. The difference *was manifested in prolongation of the duration of the procedure*, which was expected in the group where the stump was closed by the invagination method. However, the frequency of abdominal infiltrates the complications most often faced by surgeons during LAE was lower in the group where the stump was closed by invagination.

Although many patients may not develop complications after surgery, we think that an increase in the operative time by 15–20 minutes is a reasonable price to pay for reducing the risk of postoperative complications. Therefore, in cases, where it is possible to invaginate the stump, it is better to invaginate it, especially in situations such as long stumps, stumps on a wide base or doubts in the stump viability.

We think that the frequency of infiltrate formation in the right iliac region after appendectomy with otherwise equal conditions is associated with two factors a method of mobilization of the appendix and a method of stump management. Since in both groups the mesentery of the appendix was removed within the unchanged tissues, there is no effect of this factor on the frequency of infiltrates. Leaving the stump of the appendix



non-invaginated with open mucosa probably leads to contamination of the right iliac fossa, which increases the likelihood of infiltrates.

## CONCLUSION

This clinical study showed the effectiveness, safety and accessibility of the invagination method of management of the appendix stump compared to the ligation method.

## ADDITIONAL INFORMATION

**Author contributions.** S.V. Tarasenko — scientific guidance, concept and design of the study, editing; D.O. Tyulenev — collection of material, writing the text, selection of literature; A.A. Kopeykin — selection of literature, editing; O.V. Zaytsev — editing. All authors approved the manuscript (the publication version), and also agreed to be responsible for all aspects of the work, ensuring proper consideration and resolution of issues related to the accuracy and integrity of any part of it.

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