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# Complications Associated With Coloproctological Surgeries Using a 1940 nm Wavelength Laser

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**Aim:** to analyze complications arising from coloproctological surgeries using a 1940 nm wavelength laser, identify their causes, and propose preventive measures.

**Materials and methods.** 148 patients with stage 2–3 hemorrhoids underwent transdermal laser submucosal destruction of internal hemorrhoids using a diode-pumped fiber laser with a wavelength of 1940 nm and a power of 7.5 W in a pulsed-periodic mode (pulse — 500 ms, pause — 750 ms).

**Results.** Intraoperatively, bleeding from the internal hemorrhoid developed in 4.4 % (3/148) of patients. The cause was its trauma with a laser instrument and a violation of the integrity of the mucous membrane of the internal hemorrhoid. In this regard, hemorrhoidectomy was performed. The occurrence of intraoperative hematoma was diagnosed in 10.1 % (15/148) of patients and regarded as a complication. In all cases, the submucous hematoma was characterized by small sizes (3.0–4.0 cm) and did not increase during observation for 5–10 minutes. In the early postoperative period (on the first day after surgery), thrombosis of external hemorrhoids developed in 5.4 % (8/148) of patients, which regressed completely with conservative treatment. In the early postoperative period, 0.7 % (1/148) of patients were diagnosed with the development of an ulcerative mucosal defect in the area of the internal hemorrhoid, which healed with conservative therapy. According to our analysis, the main causes of complications are incorrect surgical technique and excessive laser energy exposure.

**Conclusion.** Laser methods are promising for minimally invasive treatment of anorectal diseases but require strict adherence to surgical techniques and control of energy parameters. Optimizing methodology and standardizing approaches will help reduce the frequency of complications and improve treatment safety.

**Keywords:** complications, minimally invasive treatment, hemorrhoids, laser destruction, anal fissure, laser vaporization, laser technology

**Conflict of interest:** the authors declare no conflict of interest.

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## Осложнения колопроктологических операций с применением лазера длиной волны 1940 нм

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**Цель:** провести анализ осложнений, возникающих при колопроктологических операциях с использованием лазера длиной волны 1940 нм, выявить их причины и предложить меры профилактики.

**Материалы и методы.** 148 пациентам с геморроем 2–3-й стадий выполнена трансдермальная лазерная подслизистая деструкция внутренних геморроидальных узлов с применением волоконного лазера с диодной накачкой, длиной волны 1940 нм и мощностью 7,5 Вт в импульсно-периодическом режиме (импульс — 500 мс, пауза — 750 мс).

**Результаты.** Интраоперационно у 4,4 % (3/148) пациентов развилось кровотечение из внутреннего геморроидального узла, причиной которого являлась его травматизация лазерным инструментом с нарушением целостности слизистой оболочки внутреннего геморроидального узла, в связи с чем была выполнена геморроидэктомия. Возникновение интраоперационной гематомы было диагностировано у 10,1 % (15/148) пациентов, расценено как осложнение, во всех случаях подслизистая гематома характеризовалась небольшими размерами (3,0–4,0 см) и при наблюдении в течение 5–10 минут не нарастала. В раннем послеоперационном периоде (на 1-е сутки после операции) у 5,4 % (8/148) пациентов развился тромбоз наружных геморроидаль-

ных узлов, который регрессировал полностью на фоне консервативного лечения. В раннем послеоперационном периоде у 0,7 % (1/148) пациентов диагностировано формирование «язвенного» дефекта слизистой в области внутреннего геморроидального узла, который зажил на фоне консервативной терапии. По результатам нашего анализа основной причиной осложнений является некорректная техника выполнения вмешательства и избыточное воздействие лазерной энергии.

**Заключение.** Лазерные методы являются перспективными для малоинвазивного лечения заболеваний аноректальной области, но требуют строгого соблюдения техники выполнения и контроля параметров энергии. Оптимизация методики и стандартизация подходов позволят снизить частоту осложнений и повысить безопасность лечения.

**Ключевые слова:** осложнения, малоинвазивное лечение, геморрой, лазерная деструкция, анальная трещина, лазерная вапоризация, лазерные технологии

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## Introduction

Laser-assisted surgery represents an advanced approach to the treatment of various diseases of the anorectal region, such as hemorrhoids, rectal fistula, anal fissure, and chronic inflammation of the epithelial coccygeal passage. The use of laser technologies allows to reduce the intensity of pain syndrome, accelerate the rehabilitation of patients, and reduce the number of postoperative complications [1].

To date, there is no unified approach to the choice of wavelength and power of laser radiation in surgical treatment of diseases, but the trends are to reduce laser energy power (from 25 to 7.0–2.5 W) and increase wavelength (from 980 to 1940 nm) [2]. To achieve the highest efficiency and safety of intervention with the use of 1940 nm laser we analyzed the causes of occurring complications and methods of their elimination and prevention.

## Patients and methods

At the present time in National Medical Research Center of Coloproctology named after A.N. Ryzhikh, we accumulated experience of laser application in 148 patients with hemorrhoids of stages 2–3. All patients underwent transdermal laser submucosal destruction of internal hemorrhoidal nodes using a fiber laser with diode pumping, wavelength 1940 nm and power 7.5 W in pulse-periodic mode (pulse — 500 ms, pause — 750 ms).

Under the influence of laser radiation due to the effect of high temperature on tissues, denaturation of proteins occurs, as a result of which cavernous tissue is replaced by connective one. At the same time, laser treatment also affects the terminal branches of the superior rectal artery, which, ultimately, allows to eliminate the symptoms of hemorrhoidal disease [3].

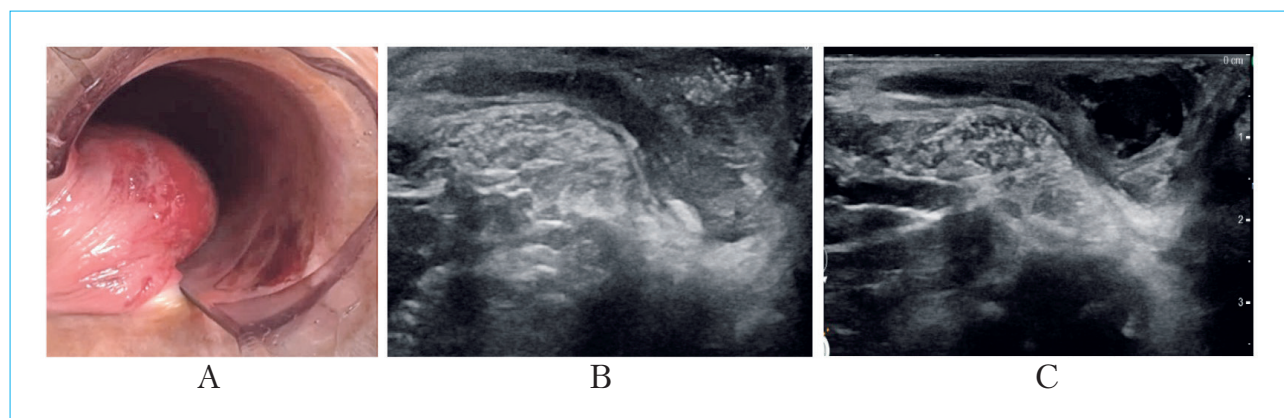
Intraoperatively, 4.4 % (3/148) of patients developed bleeding from the internal hemorrhoidal node, the reason for which was its traumatization by the laser instrument and violation of the integrity of the internal hemorrhoidal node mucosa, therefore hemorrhoidectomy was performed. In all three cases the complication occurred against the background of mechanical traumatization and was caused by insufficient control of the laser instrument during the intervention.

The prevention of this complication is the observance of the correct technique of laser instrument delivery strictly under the control of the pilot beam.

The occurrence of intraoperative hematoma was diagnosed in 10.1 % (15/148) of patients, it was considered as a complication, in all cases submucosal hematoma was characterized by small size (3.0–4.0 cm) and did not grow during 5–10 minutes of observation, in no case the hematoma was opened.

We noted that in some cases the increase in the size of the internal hemorrhoidal node during laser exposure occurs without a characteristic bluish tint, however, we also attributed these observations to hematomas, assuming that these changes are due to the effect of explosive boiling with the formation of bubble effect.

Intraoperative ultrasound cannot distinguish between a “true” hematoma and a hematoma caused by the effect of laser energy on the cavernous tissue of the internal hemorrhoidal node. The reason for the development of “true” submucosal hematoma in 3/15 patients is the damage of the hemorrhoidal vein and insufficient effect of the transmitted laser energy (Fig. 1). Under the influence of laser energy as a result of explosive bubble boiling process the so-called “false” submucosal hematoma developed in 12/15 patients (Fig. 2).



**Figure 1.** “True” submucosal hematoma: A – intraoperative picture (result of laser-induced damage to the hemorrhoidal vein); B – intraoperative ultrasound examination; C – ultrasound examination on day 1 after surgery

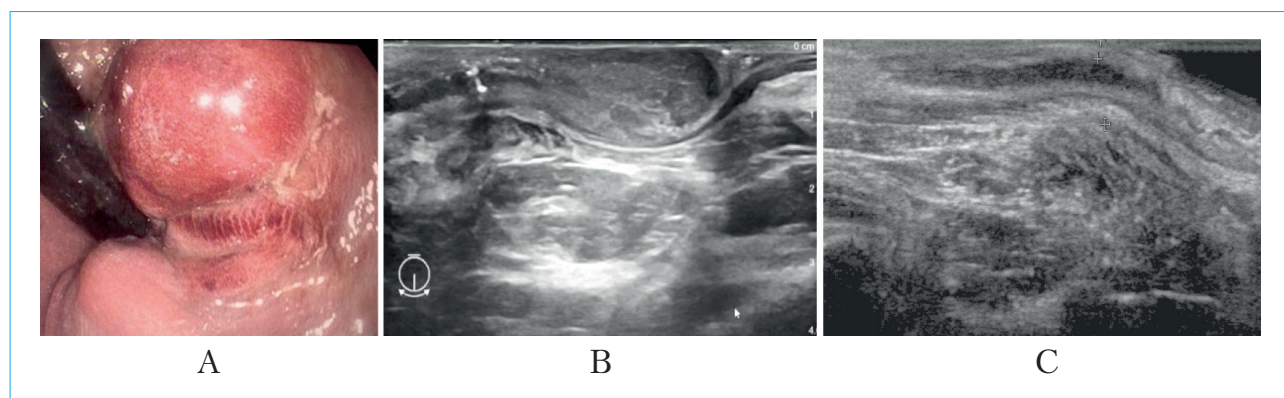
**Рисунок 1.** «Истинная» подслизистая гематома: А – интраоперационная картина (результат повреждения геморроидальной вены под влиянием лазерного воздействия); В – интраоперационное УЗИ; С – УЗИ на 1-е сутки после вмешательства

In the projection of laser destruction of the internal hemorrhoidal node a fluid formation of irregular shape with heterogeneous content, of medium echogenicity, avascular in color Doppler mapping is determined (Fig. 1A). In case of a “false” hematoma, a complete regression of the above-described changes is noted on the next day (Fig. 2C).

In case of hematoma, it is necessary to make sure that there is no hematoma growth by visual inspection and transrectal ultrasound examination. Such hematomas respond well to conservative therapy; most often complete regression occurs on day 3–5. We have not found any cases of hematoma growth, but in cases of hematoma growth it is necessary to perform its opening.

In the early postoperative period (1 day after surgery), 5.4 % (8/148) of patients developed thrombosis of external hemorrhoidal nodes, which, in our opinion, is associated with the effect of laser energy on the external hemorrhoidal node. This complication requires conservative treatment and regresses completely. For the purpose of prevention, it is necessary to exclude the impact of laser radiation on the external hemorrhoidal node.

In the early postoperative period, 0.7 % (1/148) of patients were diagnosed with the formation of “ulcerative” mucosal defect in the area of internal hemorrhoidal node, which is associated with the thermal effect of laser on the mucous membrane of hemorrhoidal node, leading to irreversible changes.



**Figure 2.** “False” submucosal hematoma: A – intraoperative picture (process of explosive bubble boiling of tissues as a result of laser radiation); B – intraoperative ultrasound examination; C – ultrasound examination on day 1 after the surgery, hematoma not identified

**Рисунок 2.** «Ложная» подслизистая гематома: А – интраоперационная картина (процесс взрывного пузырькового кипения тканей как результат лазерного излучения); В – интраоперационное УЗИ; С – УЗИ на 1-е сутки после вмешательства, гематома не определяется

Despite the use of a wavelength of 1940 nm, where the laser penetration depth is 0.5–0.7 mm, thermal effects are relevant, which can cause irreversible changes. This complication was managed by conservative therapy. The aim of prevention is to control the amount of energy transmitted.

According to the results of a single-factor analysis performed in our clinic, an increase in the risk of postoperative complications was found when the amount of energy transferred per hemorrhoidal node increased [4]. However, no cases of acute paraproctitis were detected during the entire observation period.

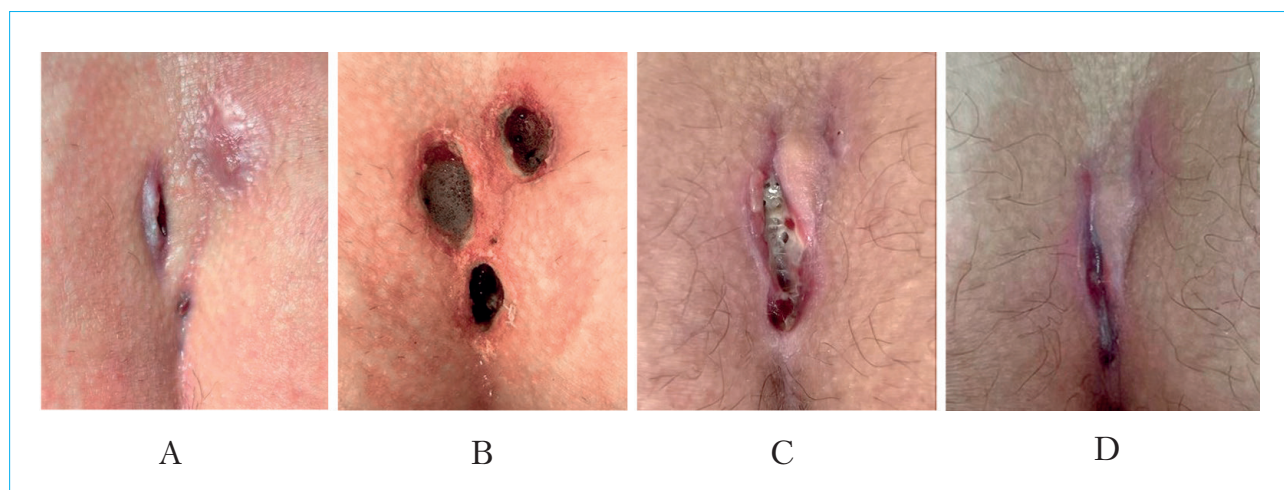
Minimally invasive treatment of chronic inflammation of the pilonidal sinus – laser coagulation of the epithelial coccygeal tract, known as SiLaC (Sinus Laser Coagulation) – is becoming increasingly common [5]. The intervention is performed by laser coagulation of the fistulous passage walls with preliminary curettage, removal of hair and inflammatory detritus. In National Medical Research Center of Coloproctology named after A.N. Ryzhikh we are conducting a study including 68 patients who underwent a combination of pit-picking and laser coagulation of the fistula tract of pilonidal sinus using a laser with a wavelength of 1940 nm, power of 9 W in continuous mode. Dermopunch was used to excise the primary foramen, followed by mechanical treatment with a Folkman spoon and laser treatment of the fistulous passage walls. The technique of performance corresponds most of all to the combination of two methods described earlier (pit picking, SiLaC). Intraoperatively in 1 (1,4 %) patient there was a bleeding that required wider access for visualization and laser treatment of the bleeding area. It is possible to stop bleeding with laser treatment but

if there is a need, it is necessary to expand the size of the wound.

In the postoperative period, necrosis of the skin bridge occurred in 1 (1.4 %) patient due to the close location (1.0–0.5 cm) of the primary and secondary orifices. No additional surgical interventions were required. By performing daily dressings, complete healing of the postoperative wound was observed already on day 40 (Fig. 3). The prevention of this complication will be the choice of alternative intervention techniques in case of close proximity of the orifices.

Laser methods have been described in the treatment of rectal fistulas. In our Center laser thermal obliteration of fistulous passage was performed in 23 patients with trans- and extrasphincteric fistulas of rectum. The wavelength of the diode laser was 1470 nm, a radial light guide in continuous mode with a power of 12 W was used.

In the postoperative period in the laser group in two patients the development of acute paraproctitis was noted in connection with which the opening and drainage was performed. Later, due to non-healing of the fistulous passage in both cases, one of the patients underwent excision of the fistula with sphincter suturing, the second patient had the fistula eliminated by ligature method. Possible reasons for the development of this complication are inadequate outflow of exudate through the wound canal and also faster obliteration of the distal part of the wound canal, while the wound canal is preserved in the middle or proximal segment. In order to prevent this complication, excision of the distal part of the fistulous passage to a depth of 1.5 cm and careful postoperative monitoring of the wound channel are recommended [6].



**Figure 3.** Necrosis of the skin bridge: A – preoperatively; B – day 2; C – day 21; D – day 40

**Рисунок 3.** Некроз кожного мостика: А – до операции; В – 2-е сутки; С – 21-е сутки; D – 40-й день

Laser vaporization of anal fissure is an equally important promising minimally invasive treatment method. At National Medical Research Center of Coloproctology named after A.N. Ryzhikh, as part of a pilot study, 25 patients with chronic anal fissure with sphincter spasm underwent laser vaporization using a 1940 nm wavelength, 7.5 W laser in pulsed-periodic mode. No complications were noted in the early postoperative period at this time of observation.

## Discussion

Nowadays laser technologies are actively used as a minimally invasive method of treatment of anorectal diseases, they allow to reduce the intensity of pain syndrome and stimulate the processes of tissue regeneration, which allows to shorten the rehabilitation period. However, laser application does not exclude the risk of early postoperative complications.

When comparing the complications identified by us, most of them are consistent with the literature data.

A study by A.G. Khitryan et al. showed that after using the transnodal method of laser destruction in patients with stage 2–3 hemorrhoids, complications developed in the early postoperative period: bleeding that required stopping was noted in 2 (3.2 %) patients; acute thrombosis of external hemorrhoids developed in 1 (1.6 %) patient, which was stopped conservatively; acute paraproctitis was diagnosed in 2 (3.2 %) patients, for which incision and drainage were performed. The authors attribute these complications to the displacement of the laser instrument lateral to the internal hemorrhoidal node, resulting in insufficient visualization of anatomical structures during the operation [7]. According to other studies, the incidence of complications such as thrombosis and paraproctitis is significantly reduced with the correct technique of the procedure and careful compliance with the necessary preoperative and postoperative recommendations [8].

The first experience of application of laser destruction of hemorrhoidal nodes was described in 2007 by A.F. Karaholilo lu. 106 patients with hemorrhoids of the stage 1–2 underwent intervention by transnodal access using a laser with a wavelength of 980 nm, power of 15 W, in pulse mode. Intraoperatively, 0.9 % (1/106) developed hemorrhoidal bleeding, which was eliminated by stitching the hemorrhoidal node. In 1.9 % of patients (2/106) a submucosal hematoma developed in the early postoperative period, which did not require treatment. After one year of follow-up,

recurrence of the disease symptoms was noted in 11 % of patients [9].

In the treatment of pilonidal sinus using SiLaC technique with the use of 1470 nm wavelength laser with 10 W power by M. Dessily et al., it was noted that out of 200 patients in the postoperative period complications developed in 30 patients. Secondary infection of the postoperative wound area that required antibiotic therapy was detected in 8.5 % of patients (17/30), abscess development, which was opened and drained, – in 1 % (2/30). Hematoma developed in 1.5 % (3/30) of patients, and did not require additional interventions. In addition, 8 % of patients (4/30) had fibrin formation in the area of primary orifices, which prevented wound drainage: in these cases, wound curettage was performed. The recurrence rate of pilonidal sinus was 15.2 % [10].

M. Abdelnaby et al., in the framework of a randomized study performed treatment of pilonidal sinus in 62 patients by SiLaC method using 1470 nm laser with 13 W power. The intervention technique did not differ from the technique first proposed by M. Dessily. In the postoperative period 3.2 % (2/62) had minor bleeding, 9.7 % (6/62) had pus-like discharge in the area of the postoperative wound. These complications correspond to I–II degree of severity according to the Clavien – Dindo classification [11].

In a prospective study by A.F. Pappas et al., the same laser device was used in the treatment of pilonidal sinus in 237 patients in a similar technique to M. Dessily. In 7 % of patients (17/237) the development of secondary infection of the postoperative wound area was noted, which did not require repeated surgical intervention, and the disease recurrence rate was 7.5 % [12].

Our experience in using laser technologies in the treatment of colorectal diseases allows us to conduct a detailed analysis of complications, which in turn allows us to better understand the mechanisms of their occurrence, identify the most vulnerable stages of intervention and risk factors, and develop detailed recommendations for preventing complications and improving the safety of treatment. This approach contributes not only to reducing the number of complications, but also to improving the effectiveness of minimally invasive techniques, making them more predictable and safer for the patient. All this is aimed at further study of laser technologies in coloproctology, determining a common standard of application of wavelength and power of laser radiation. Further studies should include a significant number of patients with various diseases of the anorectal region, which will allow to evaluate the effectiveness,

feasibility of their application compared to classical methods of treatment.

## Conclusions

Thus, the use of laser technologies as a minimally invasive method does not exclude the development of complications such as bleeding, submucosal hematoma, acute thrombosis of hemorrhoids, necrosis and secondary infection of the

postoperative wound. It is important to note that careful preparation for surgery, as well as strict adherence to all medical protocols and standards of patient management at the intervention stage, are extremely important to minimize these risks. Nevertheless, we should strive to achieve unified approaches to the treatment of anorectal diseases using laser technology, and further research will help us improve patient treatment outcomes and minimize the risk of complications.

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