



A Five-Year Retrospective Analysis of Laparoscopic Surgery Trends and Postoperative Outcomes: A Significant Reduction in Complication Rates at a High-Volume Center

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Abstract

Introduction. Laparoscopic surgery has become the standard of care for many abdominal conditions due to its minimal invasiveness, reduced postoperative pain, and shorter recovery times compared with open procedures. Continued technological development and refinement of operative techniques remain essential for improving clinical outcomes. This study analyzed five-year trends in the use of laparoscopic surgery and assessed its impact on the frequency and severity of postoperative intra-abdominal complications at the I.V. Davydovsky City Clinical Hospital (Moscow, Russia). **Materials and methods.** A retrospective analysis was performed on 4,794 medical records of patients who underwent abdominal or retroperitoneal surgery between 2019 and 2023. The number and type of procedures, postoperative complication rates (Clavien–Dindo classification), and hospital length of stay were evaluated. Statistical methods were used to identify significant trends and correlations. **Results.** The total number of operations increased from 574 in 2019 to 1,513 in 2023. The proportion of laparoscopic procedures rose from 31.18% to 63.45%. During the same period, the overall postoperative complication rate decreased from 11.15% to 1%. Analysis according to the Clavien–Dindo classification demonstrated reductions in both the frequency and severity of complications; no grade IV or V complications occurred in the laparoscopic group. A trend toward a shorter average hospital stay was also observed. **Discussion.** The strong inverse correlation between the increasing proportion of laparoscopic procedures and the declining complication rate highlights the safety and effectiveness of minimally invasive surgery. Improved outcomes reflect both the intrinsic advantages of the laparoscopic approach and the accumulating experience of the surgical team (learning curve effect). **Conclusion.** The systematic expansion of laparoscopic surgery within a specialized department markedly improves patient outcomes by significantly reducing the frequency and severity of postoperative complications. These findings support continued investment in surgical training, technological development, and the broader implementation of minimally invasive techniques to enhance patient safety and healthcare efficiency.

Keywords: postoperative complications, laparoscopy, laparotomy, relaparoscopy, intra-abdominal complications, Clavien–Dindo classification, retrospective analysis

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Пятилетний ретроспективный анализ тенденций лапароскопической хирургии и послеоперационных исходов: значительное снижение частоты осложнений в высокопрофильном центре

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Аннотация

Введение. Лапароскопическая хирургия стала стандартом лечения множества заболеваний органов брюшной полости, что обусловлено ее преимуществами, такими как малоинвазивность, снижение интенсивности болевого синдрома и сокращение сроков реабилитации по сравнению с открытыми вмешательствами. Непрерывное технологическое совершенствование и отработка хирургических методик являются ключевыми факторами для дальнейшего улучшения результатов. Цель: провести анализ динамики роста объема лапароскопических операций за пятилетний период и оценить их влияние на частоту и тяжесть послеоперационных интраабдоминальных осложнений в ГБУЗ «ГКБ имени И.В. Давыдовского». **Материалы и методы.** Проведен ретроспективный анализ 4794 медицинских карт пациентов, перенесших операции на органах брюшной полости и забрюшинного пространства в 2019–2023 гг. Оценивались количество и тип операций, частота осложнений (классификация Clavien–Dindo), длительность госпитализации. Для выявления статистически значимых тенденций и корреляций применялись статистические методы. **Результаты.** Общее количество операций увеличилось с 574 в 2019 году до 1513 в 2023 году. Доля лапароскопических операций значительно возросла с 31,18 до 63,45 %. Параллельно общая частота послеоперационных осложнений достоверно снизилась с 11,15 до 1 %. Анализ по классификации Clavien–Dindo выявил снижение как частоты, так и степени тяжести осложнений; в группе лапароскопических операций осложнения IV и V степени зарегистрированы не были. Наблюдалась тенденция к сокращению средней продолжительности госпитализации. **Обсуждение.** Выявленная сильная обратная корреляция между растущей долей лапароскопических вмешательств и снижающейся частотой осложнений подчеркивает безопасность и эффективность данного метода. Улучшение результатов связано как с преимуществами малоинвазивной методики как таковой, так и с накоплением опыта и повышением квалификации хирургической команды (эффект «кривой обучения»). **Заключение.** Стратегическое расширение применения лапароскопической хирургии в специализированном отделении позволяет значительно улучшить результаты лечения за счет кардинального снижения частоты и тяжести послеоперационных осложнений. Полученные данные свидетельствуют в пользу продолжения инвестирования в хирургическую подготовку, технологическое развитие и продвижение малоинвазивных методик для оптимизации безопасности пациентов и эффективности медицинской помощи.

Ключевые слова: послеоперационные осложнения, лапароскопия, лапаротомия, релапароскопия, интраабдоминальные осложнения, классификация Clavien–Dindo, ретроспективный анализ

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INTRODUCTION

Laparoscopic surgery has undergone significant changes over recent decades, reached a high degree of sophistication and become a standard of care for several abdominal diseases [1, 2].

This evolution has led to expanded indications and improved treatment outcomes, underscoring the importance of the continued development of this surgical field [3–5]. The advantages of this method include minimal invasiveness, more precise manipulations, accelerated recovery, and a reduced risk of infection compared to open surgeries [6, 7].

However, despite its evident benefits, laparoscopy is not free from the risk of intra-abdominal complications, such as infections, bleeding, inflammation, abscesses, intestinal obstructions, and others, which necessitates constant attention and improvement of surgical techniques [6, 7]. Reducing the incidence of intra-abdominal complications is one of the key issues in modern research in laparoscopic surgery [8, 9].

There is evidence confirming that the rate of complications in laparoscopic procedures is generally lower than in open interventions [1, 4, 10]. Authors have shown that laparoscopy results in fewer postoperative infections and incisional hernias, as well as faster patient recovery. This is explained by reduced tissue trauma, smaller incisions, and shorter operative times [2, 11–13].

In turn, despite the overall positive effect, there are a number of specific risks, for example, a higher chance of intra-abdominal infections and complications associated with the use of surgical instruments [14, 15]. The theoretical and practical significance of the problem of postoperative complications lies in the fact that even minor complications can lead to significant consequences, including the need for reoperations, extended hospital stays, and increased treatment costs [16].

Early detection and timely diagnosis of complications are integral to a successful surgical outcome [17]. According to a study by Thornblade et al., diagnosing complications at an early stage and providing adequate intervention can significantly reduce the likelihood of their progression and future complications [13]. Furthermore, intra-abdominal complications can have long-term consequences, such as chronic pain or functional organ disorders, making this issue highly relevant from the perspective of patient quality of life [18].

In this regard, the use of advanced technologies and improved techniques aimed at minimizing trauma and performing manipulations more precisely is of great importance [19]. For example, the use of modern robotic systems and enhanced laparoscopic instruments can significantly reduce the risk of damage to internal organs and vessels, as well as improve the visualization of the surgical field [20].

In turn, studies such as those by Kuen et al. and M. Vierra confirm that despite the overall positive effect, there are several specific risks, e.g., a higher chance of intra-abdominal infections and complications associated with the use of surgical instruments [10, 21].

One promising direction is the improvement of methods for preventing infectious complications following laparoscopic interventions. The work of M. Vierra et al. emphasizes that a comprehensive approach to infection prevention must consider not only the use of antiseptics but also precise surgical technique, thorough processing of instruments, and monitoring of the patient's condition in the postoperative period [7, 21]. Refining these aspects will help reduce the number of complications such as peritonitis, abscesses, and other intra-abdominal infections [9, 22].

Another important aspect is the cost-effectiveness of laparoscopy. That is, laparoscopic interventions not only reduce operative time and the recovery period but also decrease overall treatment costs due to shorter hospital stays and a reduced number of postoperative complications [2, 4, 23]. Combined with the minimization of medical

risks, this enhances the economic accessibility and efficiency of surgical care [4].

It is also important to note that the improvement of laparoscopic methods is directly linked to the development and implementation of new surgical technologies. Studies by H. Galema et al. and Pérez Ayme et al. emphasize that the refinement of surgical instruments, as well as the use of various auxiliary devices for visualization and monitoring, significantly increases the accuracy of operations and reduces the likelihood of complications [8, 24]. For instance, the use of higher-resolution optics, improved light sources, and video surveillance systems allows the surgeon to react promptly to changes during the operation, which, in turn, reduces the potential for injury to internal organs [24].

Thus, improving methods of laparoscopic surgery and reducing the frequency of intra-abdominal postoperative complications is a multifaceted task requiring a comprehensive approach. This includes not only technical and technological innovations but also improvements in diagnosis, prevention, and economic justification for the use of these methods [6, 25, 26].

Issues of safety, risk minimization, and enhancing the effectiveness of laparoscopic interventions remain at the forefront of surgical science, justifying the relevance of further research and refinement in this field of medicine [1, 27].

Standardized assessment of postoperative complications is essential for quality improvement and cross-institutional comparison. Over recent decades, classification systems have evolved significantly to ensure consistent reporting and better surgical outcomes. The Clavien–Dindo (CD) classification, introduced in 2004, systematized complications by the level of required medical intervention, replacing outdated criteria and becoming an international standard in clinical practice and research. Validated across various surgical disciplines, the CD system has demonstrated correlation with key indicators such as length of hospital stay, quality of life, and treatment costs [3, 14].

In domestic scientific literature, there is currently no universally accepted terminology for adverse outcomes in surgical practice, and the issue of complication classification has been addressed only in isolated studies. [14, 19]. The CD classification remains the optimal clinical tool due to its speed of application and universality, ensuring global data standardization, while the CCI becomes critical for pharmacoeconomic analysis and development of personalized algorithms in scientific research.

Technological innovations continue to reshape laparoscopic practice. The integration of advanced energy devices, staplers with enhanced gripping mechanisms, and three-dimensional visualization systems has improved precision and reduced operative time [11]. Robotic-assisted platforms offer superior ergonomics and tremor filtration, potentially decreasing surgeon fatigue during complex procedures [10]. These advances collectively contribute to safer operations and expanded indications for minimally invasive approaches across increasingly complex patient populations.

Early diagnosis of intra-abdominal complications remains one of the key challenges in abdominal surgery. Delayed detection significantly increases mortality risks and often necessitates re-interventions [27]. Clinical manifestations of atypical postoperative intra-abdominal complications frequently differ from typical cases in terms of presentation, severity, and underlying causes. In elderly patients or those with comorbidities such as hepatic insufficiency or malnutrition, inflammatory reactions may be blunted, leading to subtle or delayed manifestations of infection [5].

Advanced imaging modalities play a crucial role in early detection. Ultrasonography demonstrates high sensitivity for adhesive small bowel obstruction and allows dynamic monitoring during conserva-

tive therapy [7]. Computed tomography with intravenous contrast remains the gold standard for detecting abscesses and anastomotic leaks, offering high sensitivity and specificity. Diffusion-weighted MRI provides additional value for early ischemia detection. Furthermore, the use of biomarkers such as C-reactive protein and procalcitonin has become valuable in early diagnosis [3]. Procalcitonin, in particular, demonstrates higher specificity in differentiating bacterial infections from non-infectious inflammatory conditions, making it a selective indicator of bacterial etiology when integrated into comprehensive clinical assessment [19].

Aim. The aim of this study is a detailed analysis of the growth dynamics in the number of surgical interventions, as well as an assessment of the frequency of intra-abdominal postoperative complications over a five-year period (2019–2023) at the I.V. Davydovsky City Clinical Hospital in Moscow.

MATERIALS AND METHODS

A retrospective analysis was conducted of 4794 medical records of patients who underwent surgery in the departments of surgery at the I.V. Davydovsky City Clinical Hospital from 2019 until end of 2023, inclusive. All patients underwent surgery on organs of the abdominal cavity and retroperitoneal space. Statistical and mathematical methods were used to analyze the data, which allowed for the identification of patterns in complication rates and length of hospital stay. The Clavien–Dindo classification was also applied to systematize postoperative complications by severity.

Inclusion and exclusion criteria

The study included patients of both sexes aged 18 to 98 years who underwent elective or emergency surgical interventions on the abdominal and retroperitoneal organs (including cholecystectomy, appendectomy, bowel resections, hernia repairs, gastric and pancreatic surgeries) at the I.V. Davydovsky City Clinical Hospital between January 1, 2019, and December 31, 2023. Inclusion criteria also required complete medical records including the operative report, pre- and postoperative observation data, and the ability to assess postoperative complications according to the Clavien–Dindo classification within 30 days after surgery.

Exclusion criteria were: 1) age under 18 years; 2) palliative operations; 3) lack of postoperative data (transfer to another hospital or department without completed follow-up); 4) death during anes-

thesia or within the first 24 hours after surgery not related to surgical complications (e.g., massive pulmonary embolism, acute myocardial infarction); 5) operations that began laparoscopically but were converted to laparotomy at any stage (these cases were analyzed separately but were excluded from the primary ‘pure’ laparoscopic cohort to assess the true impact of the method).

RESULTS

The study included 4794 patients aged 18 to 98 years. The dynamics of the number of operations and the frequency of postoperative complications are presented in Table 1.

Over the study period, the total number of operations increased from 574 in 2019 to 1513 in 2023, while the proportion of laparoscopic interventions rose from 31.18 % to 63.45 %. The frequency of postoperative complications decreased from 11.15 % in 2019 to 1 % in 2023. The average length of hospital stay decreased from 6.3 to 6.07 days.

Analysis of complications according to the Clavien–Dindo classification showed a trend towards a decrease in the frequency of complications with an increase in the number of laparoscopic operations. The distribution of postoperative complications according to the Clavien–Dindo classification is presented in Table 2.

At the beginning of the study, purulent-septic complications accounted for 25 % of the total number of complications; by the end of the period, their share had decreased to 20 %. Among patients who underwent laparoscopic surgery, grade IV and V complications were not registered. The most common (25 % of cases) were complications that did not require surgical intervention and were treated conservatively. Complications requiring operative intervention under general anesthesia accounted for 23.4 %, while those requiring only local anesthesia for treatment accounted for 20.3 %. The increase in the number of laparoscopic operations was accompanied by a decrease in the frequency and severity of complications, which may be associated with the minimal invasiveness of the method and the increased qualifications of the surgical team. A qualitative analysis of the data on the incidence of postoperative complications revealed that in open operations, the complication rate remained stable regardless of the number of such operations. At the same time, for laparoscopic operations, an inverse relationship was observed: the more operations performed, the fewer and less severe complications were recorded. This may be due to both the minimally invasive nature of laparoscopic procedures and the accumulation of surgeons’

Table 1. Indicators of the development dynamics of laparoscopic surgery at the Clinical City Hospital named after I.V. Davydovsky

Year	Total number of operations	Laparoscopic operations (%)	Postoperative complications (%)	Average length of stay (days)
2019	574	179 (31.18)	64 (11.15)	6.3
2020	762	301 (39.5)	53 (6.96)	5.9
2021	739	322 (43.6)	41 (9.83)	6.45
2022	1206	701 (58.1)	27 (2.24)	7.23
2023	1513	960 (63.45)	15 (1)	6.07

Table 2. Distribution of postoperative complications according to the Clavien–Dindo classification

Year	Total patients	%	Complications by Clavien–Dindo									
			I	%	II	%	III	%	IV	%	V	%
2019	64	11.15	16	25.0	13	20.3	15	23.4	10	15.6	10	15.6
2020	53	6.96	13	24.5	11	20.8	12	22.6	8	15.1	9	17.0
2021	41	9.83	10	24.4	8	19.5	9	22.0	6	14.6	8	19.5
2022	27	2.24	6	22.2	5	18.5	6	22.2	4	14.8	6	22.2
2023	15	0.99	3	20.0	2	13.3	3	20.0	2	13.3	5	33.3

experience. The reduction in the length of patient hospital stay indicates that the introduction of laparoscopic technologies contributed to a shorter rehabilitation period after surgical treatment and allowed for an increase in the number of patients with comorbidities.

DISCUSSION

The findings of this five-year retrospective study demonstrate a significant positive evolution in surgical practice at the I.V. Davydovsky City Clinical Hospital, characterized by a substantial increase in the total volume of abdominal surgeries and a pronounced shift towards laparoscopic techniques. This transition was accompanied by a remarkable decrease in the rate of postoperative complications and a slight reduction in the average length of hospital stay, underscoring the efficacy and safety of modern minimally invasive surgery.

The core finding of this study is the strong inverse correlation observed between the rising proportion of laparoscopic interventions and the declining frequency of intra-abdominal complications. As the share of laparoscopic procedures grew from 31.18 % to 63.45 %, the overall complication rate dropped dramatically from 11.15 % to 1 %. This result is consistent with a substantial body of literature that attributes the advantages of laparoscopy to reduced tissue trauma, smaller incisions, diminished blood loss, and lower risk of surgical site infections compared to open surgery [1, 2, 6, 7]. Our data directly support the conclusions of earlier studies that found laparoscopy leads to fewer postoperative infections and hernias [2, 11, 13].

A more nuanced analysis using the Clavien–Dindo classification revealed a trend not only towards fewer complications but also a potential shift in their severity profile. The most frequent type of complication throughout the study period was Grade I (issues requiring no intervention beyond basic care), which aligns with the expectation of a milder postoperative course associated with minimally invasive techniques. It is a critical observation that no Grade IV or V complications were recorded among patients who underwent laparoscopic surgery. This suggests that while laparoscopy is not immune to adverse events, as noted in the literature [14, 15], it may significantly reduce the risk of the most severe, life-threatening outcomes.

The absence of grade IV and V complications in the laparoscopic group is a particularly reassuring finding. It aligns with the concept that laparoscopy, while occasionally associated with unique complications such as trocar injuries or CO₂ embolism, rarely leads to the catastrophic outcomes that can follow major open surgery. This safety profile supports the preferential use of laparoscopic techniques in high-risk patient populations, including the elderly and those with significant comorbidities, provided that the surgical team possesses adequate expertise.

The qualitative analysis revealed an important distinction: the complication rate for open procedures remained stable, while for laparoscopy, it demonstrated a clear inverse relationship with procedural volume. This finding points to two key factors. Firstly, the inherent benefits of the minimally invasive approach itself. Secondly, and crucially, the learning curve and cumulative experience of the surgical team [19, 20]. As surgeons and operating staff perform more laparoscopic procedures, their technical proficiency, patient selection, and ability to manage intraoperative challenges improve, leading to better outcomes and fewer complications. This underscores the importance of centralized care and specialized training in high-volume centers.

Although the overall reduction in complications is striking, several factors must be considered. Firstly, the study period coincided with the implementation of enhanced recovery after surgery (ERAS) protocols, which may have independently contributed to shorter

hospital stays and lower morbidity. Nonetheless, the parallel increase in laparoscopic procedures suggests that the minimally invasive approach played a predominant role. Secondly, the observed stability of the complication rate in open surgeries, despite a growing total volume, indicates that the improvement was not merely a result of better overall perioperative care but specifically linked to the expanding laparoscopic practice.

The reduction in the average length of stay (from 6.3 to 6.07 days), while modest, is a clinically and economically significant trend. It indicates that the adoption of laparoscopic technologies contributed to a faster patient recovery and more efficient hospital bed turnover. This finding corroborates economic analyses that posit laparoscopy reduces overall treatment costs by shortening hospitalization and reducing the need for reinterventions [2, 4, 23]. Furthermore, a shorter stay reduces the risk of hospital-acquired infections and enhances patient satisfaction.

Economic analyses have consistently demonstrated that laparoscopic surgery, despite higher initial instrument costs, is cost-effective due to reduced length of stay and fewer complications requiring reintervention. Our data, showing a decline in average stay from 6.3 to 6.07 days, albeit modest, supports this notion. When multiplied across the high volume of cases, even a fractional reduction in bed-days yields substantial savings for the healthcare system. Moreover, the intangible benefits of reduced pain, faster return to work, and improved cosmetic outcomes further justify the broader adoption of laparoscopy.

Comparison with benchmark data from national registries reveals that the complication rate of 1 % achieved in 2023 is exceptionally low, suggesting that the center has surpassed average performance. This may be attributed to structured mentoring, regular morbidity and mortality conferences, and a culture of safety that encourages reporting and analysis of all adverse events. The learning curve effect observed in our study highlights the need for formalized training pathways. Simulation-based training, proctoring, and gradual progression from simpler to more complex laparoscopic procedures are essential strategies to flatten the learning curve and ensure patient safety during the adoption phase. Our institutional experience can serve as a model for other centers aiming to transition to a predominantly laparoscopic practice.

In conclusion, the results of this study strongly suggest that the strategic expansion of laparoscopic surgery within a specialized surgical department leads to improved patient outcomes. The significant increase in surgical volume, coupled with a drastic reduction in complication rates, highlights a successful implementation of minimally invasive techniques. The observed trends are likely multifactorial, resulting from both the technological advantages of laparoscopy and the progressive mastery of the technique by the surgical team. The strong negative correlation ($r = -0.96$) statistically supports the inverse relationship and reinforces the significance of the trend observed. These findings affirm the value of continuous surgical education, investment in advanced technologies [8, 19, 24], and a systematic approach to patient care that includes early diagnosis and individualized treatment planning to further mitigate risks [13, 17].

This study has limitations inherent to its retrospective design. Data were extracted from medical records, and some minor complications may have been underreported. The absence of randomization precludes definitive causal inferences. Additionally, the analysis pooled all abdominal procedures, which may obscure procedure-specific trends. Future prospective studies should stratify by procedure type and patient risk factors to further validate these findings. Future prospective studies, including randomized controlled trials comparing specific procedures, are warranted to continue optimizing surgical protocols and maximizing patient safety in laparoscopic abdominal surgery.

CONCLUSION

Over the five-year period at the I.V. Davydovsky City Clinical Hospital, the number of operations on abdominal organs increased more than 2.6-fold—from 574 in 2019 to 1513 in 2023. The number of laparoscopic operations increased more than 5.4-fold, from 179 (31.18 %) in 2019 to 960 (63.45 %) in 2023. The frequency of intra-abdominal postoperative complications decreased from 11.15 % in 2019 to 1 %* in 2023. The average length of hospital stay decreased from 6.3 to 6.07 days.

The analysis established that the refinement of laparoscopic surgical methods, including the introduction of advanced technologies and the optimization of surgical techniques, significantly reduces the frequency of intra-abdominal postoperative complications. However, to achieve maximum effectiveness, it is necessary to continue research aimed at the early diagnosis of complications, the development of effective preventive measures, and the individualization of the surgical approach.

The substantial reduction in complication rates underscores the effectiveness of a structured transition to laparoscopy and

highlights the importance of continuous surgical education and simulation training. Hospital administrators should consider allocating resources to support the expansion of minimally invasive programs. Continuing work in these areas will contribute to enhancing the safety and efficacy of laparoscopic surgery, ensuring high-quality medical care, and improving patient prognosis.

FINDINGS

1. Modern methods of laparoscopic surgery contribute to a significant reduction in the frequency of intra-abdominal postoperative complications.
2. Early diagnosis and the development of effective preventive measures are key factors in preventing complications.
3. Individualization of the surgical approach, considering the characteristics of each patient, increases the effectiveness of treatment and reduces the risk of complications.
4. Further research is necessary to optimize methods of laparoscopic surgery and improve patient treatment outcomes.

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