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## Impact of minimally invasive procedures on hospital stay and disease staging in patients with colorectal cancer

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**Abstract.** *Introduction.* Accurate preoperative staging is essential for multimodal treatment planning in colorectal cancer (CRC). Because standard imaging modalities have limited sensitivity for detecting small peritoneal or pleural metastases, this study aimed to evaluate the impact of minimally invasive procedures on length of hospital stay (LOS) and disease staging in patients with CRC.

*Methods:* We conducted a single-center retrospective cohort analysis from December 2022 to July 2025. After strict exclusion criteria were applied, 26 surgical episodes corresponding to 25 unique patients with CRC were analyzed. Minimally invasive procedures, including diagnostic laparoscopy or video-assisted thoracoscopic surgery (VATS), were compared with open surgery. The primary outcome was LOS.

*Results:* Minimally invasive interventions (n=10) demonstrated a median LOS of 8.5 days (IQR, 5.2-13.0) versus 10.5 days (IQR, 7.0-18.0) for open surgery (p=0.289). Importantly, minimally invasive procedures directly altered the clinical stage or treatment strategy in 60% of cases within the minimally invasive group by histologically confirming distant metastases and preventing non-therapeutic laparotomies.

*Conclusions:* Although the reduction in LOS was not statistically significant due to varying surgical volumes, integrating minimally invasive procedures into the CRC staging algorithm is clinically justified. These procedures ensure precise staging and prevent unnecessary open surgical trauma.

**Keywords:** minimally invasive diagnostic, metastatic disease, colorectal cancer, treatment.

### Introduction

Colorectal cancer (CRC) is one of the most prevalent malignancies worldwide and a leading cause of cancer-related mortality [1]. The extent of disease at diagnosis largely determines prognosis and guides multimodal therapy [11]. Therefore, precise TNM staging remains central to treatment planning. In patients with locally advanced tumors (T3-T4) or suspected metastatic spread, accurate initial staging is critical, because overstaging may lead to unnecessarily extensive surgery, whereas understaging may result in missed opportunities for potentially curative treatment [2].

Standard imaging modalities, including computed tomography (CT) of the chest, abdomen, and pelvis, as well as pelvic magnetic resonance imaging (MRI) for rectal cancer, remain the primary methods for preoperative staging. However, these techniques have important limitations, particularly in detecting small-volume peritoneal metastases and early peritoneal or pleural dissemination. CT has limited sensitivity

for detecting small peritoneal implants metastases, leading to potential underestimation of disease extent and reduced accuracy of staging in patients with colorectal cancer. In clinical practice, the absence of radiologically detected metastases does not necessarily reflect the true extent of disease and may consequently influence surgical decision-making, including the appropriateness of major open surgical intervention [3,5]. Minimally invasive procedures are increasingly used for accurate staging. Diagnostic laparoscopy permits direct visual inspection of the peritoneal cavity and targeted biopsy of suspicious lesions, while video-assisted thoracoscopic surgery (VATS) allows visualization of the pleural space and histological confirmation of pleural metastases, as well as pulmonary metastasectomy when indicated [4,8]. In cases of suspected peritoneal metastases, diagnostic laparoscopy can provide refined staging by assessing tumor spread and calculating the Peritoneal Cancer Index (PCI) [7]. These strategies may reduce

the number of unnecessary laparotomies and shorten postoperative recovery, which is particularly important for patients who need to start systemic therapy without delay [12,13].

### Materials and Methods

This retrospective single-center cohort study was based on the electronic clinical database of the surgical inpatient unit of Kyiv Clinical Railway Hospital No. 3. The database initially included 123 hospitalization episodes of patients with neoplasms of the abdominal cavity, retroperitoneal space, and thoracic organs recorded between 13 December 2022 and 17 July 2025. Among these records, we identified an initial pool of 48 hospitalization episodes involving 28 unique patients with colorectal cancer (CRC).

To evaluate the direct impact of the surgical approach, strict exclusion criteria were applied. We excluded 22 episodes that involved non-surgical management, such as conservative treatment, admissions solely for systemic chemotherapy, or follow-up without intervention. Crucially, 3 patients from the initial cohort of 28 had only non-surgical admissions and were excluded entirely. Consequently, the final analyzed cohort consisted of 26 surgical episodes corresponding to 25 unique patients. To avoid duplication of demographic and disease-related characteristics, descriptive analyses of clinical variables were performed at the patient level ( $n = 25$ ). In contrast, analyses of hospital length of stay (LOS) and surgical outcomes were conducted at the hospitalization level ( $n = 26$ ), treating each surgical admission as an independent event.

The analyzed variables included age at admission, primary tumor location, documentation of TNM components [11], presence of metastatic involvement of the lungs, liver, or peritoneum, and type of surgical access. Minimally invasive access was defined as thoracoscopy and/or laparoscopy documented in operative reports, whereas open access was defined as thoracotomy and/or laparotomy. The primary outcome measure was LOS, calculated as the number of days from admission to discharge.

Accurate staging is essential for determining the optimal therapeutic strategy in patients with colorectal cancer [6]. Assessment of postoperative outcomes in clinical studies is commonly based on standardized classification systems, allowing consistent comparison between different surgical approaches [9].

Statistical analysis was performed using descriptive methods. Nonparametric comparisons of hospital stay between access groups were conducted using the Mann-Whitney U test. A two-sided  $p$  value  $<0.05$  was considered statistically significant.

No personal identifiers were included in the dataset; all data are presented in aggregated form.

### Results

The final surgical cohort included 25 unique colorectal cancer (CRC) patients accounting for 26 hospitalization episodes. The median patient age was 59.0 years (IQR 47.8-68.7). The primary tumor was located in the sigmoid colon (7 patients, 28.0%), splenic flexure (6, 24.0%), rectum (3, 12.0%), rectosigmoid junction (2, 8.0%), ascending colon (1, 4.0%), descending colon (1, 4.0%), cecum (1, 4.0%), and other/unspecified colon (4, 16.0%). Locally advanced disease (T3-T4) was documented in 15/25 (60.0%) unique patients. Distant metastases (M1) or suspected metastatic spread were noted in 11/25 (44.0%) patients, most frequently involving the lungs or peritoneum (Table 1). Notably, the presence or suspicion of distant metastases often led to the consideration of minimally invasive staging procedures before definitive surgery.

**Table 1.** Characteristics of the colorectal cancer (CRC) patient cohort

Characteristic	Value
Observation period	Dec 13, 2022 - Jul 17, 2025
Unique patients with colorectal cancer (CRC)	25
Unique surgical hospitalization episodes	26
Age, years (median, IQR)	59.0 (47.8-68.7)
Locally advanced disease (T3-T4) documented	15 (60.0%)
Presence of distant metastases (M1)	11 (44.0%)
Primary tumor location:	
- Sigmoid colon	7 (28.0%)
- Splenic flexure of colon	6 (24.0%)
- Rectum	3 (12.0%)
- Rectosigmoid junction	2 (8.0%)
- Colon [other/unspecified]	4 (16.0%)
- Ascending colon	1 (4.0%)
- Descending colon	1 (4.0%)
- Cecum	1 (4.0%)

Among the 26 hospitalization episodes with a clearly documented surgical approach, a detailed breakdown of interventions was performed (Table 2). The minimally invasive group ( $n=10$ ) consisted of VATS ( $n=5$ ), diagnostic laparoscopy ( $n=1$ ), and minimally invasive resections ( $n=4$ ). The open surgery group ( $n=16$ ) predominantly included major open resections and thoracotomies ( $n=15$ ) and an

exploratory laparotomy (n=1). Clinically significant postoperative complications occurred in 1 patient in the open group and 1 patient in the minimally invasive group.

Regarding disease staging, minimally invasive procedures played a pivotal role. In the minimally invasive cohort, diagnostic laparoscopy or VATS histologically confirmed previously suspected distant metastases in 50% of the cases. Furthermore, diagnostic laparoscopy allowed for an objective assessment of resectability without the immense trauma of an open incision, thereby changing the treatment strategy to immediate systemic therapy in patients with peritoneal carcinomatosis.

Minimally invasive procedures demonstrated a trend toward a shorter hospital stay compared with open surgery, although the difference was not statistically significant. The median length of hospital stay (LOS) was 8.5 days (IQR 5.2-13.0) in the minimally invasive group versus 10.5 days (IQR 7.0-18.0) in the open surgery group (p=0.289).

**Table 2.** Baseline characteristics and procedural details of surgical episodes (n = 26).

Characteristic	Minimally invasive (n=10)	Open surgery (n=16)
Median Age, years (IQR)	53.5 (46.4-58.3)	65.7 (53.0-71.7)
Locally advanced disease (T3-T4)	6 (60.0%)	10 (62.5%)
Presence of distant metastases (M1)	5 (50.0%)	7 (43.8%)
Primary tumor location, n		
- Sigmoid colon	3	4
- Splenic flexure of colon	2	4
- Rectum	0	4
- Rectosigmoid junction	1	1
- Colon (other/unspecified)	2	2
- Ascending colon	1	0
- Descending colon	1	0
- Cecum	0	1
Type of procedure, n		
- VATS	5	0
- Diagnostic Laparoscopy	1	0
- Minimally Invasive Resection	4	0
- Open Resection / Thoracotomy	0	15
- Open Exploratory Laparotomy	0	1
Postoperative complications, n	1	1

**Table 3.** Length of hospital stay (LOS) by surgical approach (n = 26)

Parameter	Minimally invasive (n=10)	Open surgery (n=16)	p-value
LOS, mean $\pm$ SD (days)	9.6 $\pm$ 5.6	12.2 $\pm$ 6.4	-
LOS, median (IQR) (days)	8.5 (5.2-13.0)	10.5 (7.0-18.0)	0.289
Range (min-max) (days)	4-21	3-24	-

## Discussion

In this retrospective clinical cohort, most patients with colorectal cancer (CRC) had locally advanced disease, reflecting the common clinical scenario of late-stage diagnosis and the need for accurate staging in multimodal treatment planning [1,2]. We found substantial heterogeneity in disease-stage documentation: formal TNM records underreported metastatic disease compared with narrative reports of lung, liver, or peritoneal metastases. In such cases, minimally invasive staging plays a crucial role in confirming suspected disease. Diagnostic laparoscopy and VATS can identify metastatic spread that may be missed on imaging, thereby guiding appropriate treatment decisions [2,4,8].

Standard CT and MRI have limited sensitivity for small peritoneal implants, which can lead to understaging [3]. As shown in prior studies, laparoscopic “first-look” staging in patients at high risk of peritoneal disease or with equivocal imaging allows direct assessment of tumor spread, calculation of the Peritoneal Cancer Index, biopsy of lesions, and avoidance of non-therapeutic laparotomy in cases of unresectable disease [4,7]. From an oncologic surgery perspective, this approach reduces surgical trauma, lowers the risk of delaying systemic therapy, and improves the overall treatment pathway [2,12].

Our refined analysis demonstrated that although minimally invasive procedures showed a trend toward a shorter length of hospital stay (LOS) (8.5 vs. 10.5 days), this difference did not reach statistical significance (p = 0.289). As reviewers correctly pointed out, LOS is a multifactorial metric that must be interpreted with caution. The lack of a significant difference in our cohort is likely driven by the extent of the intervention, varying indications, and baseline patient characteristics. For instance, patients in the open surgery group were notably older (median age, 65.7 vs. 53.5 years) and underwent major resections, which inherently require longer recovery times.

However, the true clinical value of the minimally invasive approach lies not only in the number of

**Table 4.** Role of minimally invasive procedures in the staging algorithm for colorectal cancer (CRC)

Clinical situation	Limitation of CT/MRI	Minimally invasive approach	Clinical effect
Suspicion of peritoneal metastases (high-risk T3-T4 or equivocal CT findings)	Underestimation of small peritoneal metastases and overall disease spread	Diagnostic laparoscopy with targeted biopsy and assessment of peritoneal spread	Avoids unnecessary exploratory laparotomy; clarifies stage; guides systemic/locoregional therapy; shortens LOS
Equivocal pulmonary nodules in colorectal cancer (CRC) needing tissue diagnosis	Inability to confirm the metastatic nature of lung nodules by imaging alone	Video-assisted thoracoscopic surgery (VATS) for biopsy or atypical resection	Provides histological confirmation; clarifies stage; supports treatment modification; shortens LOS

(Note: This table represents a practical framework proposed by the authors based on the synthesis of current literature and the findings of this study, rather than a direct outcome of the statistical analysis.)

hospital days but also in its substantial impact on disease staging. In our cohort, VATS and laparoscopy provided definitive histological confirmation of metastases and allowed surgeons to assess resectability accurately. For example, relying on open exploratory laparotomy for a patient with total peritoneal carcinomatosis carries unjustified surgical trauma. Diagnostic laparoscopy avoids this, thereby facilitating a timely shift toward systemic therapy [10,12].

Based on these findings and current guidelines, it is reasonable to incorporate minimally invasive procedures into the colorectal cancer (CRC) staging algorithm (Table 4). This includes diagnostic laparoscopy with biopsy for suspected peritoneal metastases and VATS for suspicious lung lesions. This approach allows clinicians to avoid unnecessary laparotomies, achieve accurate staging, and promptly tailor systemic therapy. Although the present study was not designed to evaluate oncologic outcomes, the observed reduction in hospital stay may have important clinical implications for timely initiation of systemic therapy.

#### Limitations

This study has several limitations that must be acknowledged. First, the retrospective, single-center design and the relatively small sample size (n=26 surgical episodes) inherently limit the statistical power, particularly for detecting significant differences in length of hospital stay (LOS). Second, there is potential selection bias regarding the clinical decision to perform minimally invasive staging

procedures rather than immediate open surgery, as this was influenced by surgeon preference and individual patient characteristics. Third, to assess healthcare resource utilization accurately, the analysis was partially conducted at the level of hospitalization episodes rather than strictly at the level of unique patients, which introduces methodological complexity. Fourth, the study focuses exclusively on perioperative outcomes, diagnostic yield, and staging accuracy, without evaluating long-term oncological outcomes or overall survival. Finally, heterogeneity in disease-stage documentation—specifically, the discrepancy between narrative surgical reports and formal TNM coding – may have influenced the retrospective assessment of clinical stage.

#### Conclusions

This study highlights the clinical rationale for integrating minimally invasive procedures into the staging and treatment pathway for patients with colorectal cancer (CRC). Although no statistically significant difference in length of hospital stay (LOS) was observed between the cohorts—largely due to differences in surgical volume, patient age, and intervention types—the minimally invasive strategy is vital for accurate staging. Diagnostic laparoscopy and VATS provide crucial histological confirmation of metastatic spread when conventional imaging is equivocal, effectively preventing unnecessary major laparotomies. These findings support the routine use of minimally invasive staging to minimize surgical trauma and expedite the initiation of systemic therapy in advanced CRC.

#### Article Declarations

**Raw Data and Materials.** The raw data and materials supporting the findings of this study are available from the corresponding author upon reasonable request.

**Study Limitations.** This study has several limitations, including the limited sample size and the single-center nature of the study, which may restrict the generalizability of the findings. Further studies with larger cohorts are needed to confirm the obtained results.

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**Patient consent:** was waived due to the retrospective nature of the study.

**Conflict of Interest:** None declared. Not required due to the retrospective nature of the study and the use of anonymized data.

**AI Statement.** Artificial intelligence tools were used only for language editing, grammar correction, and improvement of the clarity of the manuscript. The authors reviewed and approved the final version of the text and take full responsibility for the content of the article.

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## Вплив малоінвазивних втручань на тривалість госпіталізації та стадіювання захворювання у пацієнтів із колоректальним раком

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**Анотація.** *Вступ.* Точне передопераційне стадіювання є критично важливим для планування лікування колоректального раку (КРР). Оскільки стандартні методи візуалізації мають обмежену чутливість щодо виявлення дрібних перитонеальних або плевральних метастазів.

*Мета.* Метою дослідження було оцінити вплив малоінвазивних втручань на тривалість госпіталізації та стадіювання захворювання у пацієнтів із КРР.

*Матеріали та методи.* Проведено одноцентровий ретроспективний когортний аналіз за період із грудня 2022 року до липня 2025 року. До основного аналізу було включено 26 хірургічних епізодів, що відповідали 25 унікальним пацієнтам із КРР. Малоінвазивні втручання, зокрема діагностичну лапароскопію або відеоасистовану торакокопічну хірургію (VATS), порівнювали з відкритими операціями. Первинною кінцевою точкою була тривалість госпіталізації.

*Результати.* Медіана тривалості госпіталізації для малоінвазивних втручань (n=10) становила 8,5 дня (IQR, 5,2-13,0) порівняно з 10,5 дня (IQR, 7,0-18,0) для відкритих операцій (p=0,289). Важливо, що малоінвазивні втручання безпосередньо змінили клінічну стадію або стратегію лікування у 60% випадків у межах відповідної групи шляхом гістологічного підтвердження віддалених метастазів, що дозволило уникнути нетерапевтичних лапаротомій.

*Висновки.* Хоча зменшення тривалості госпіталізації не досягло статистичної значущості, інтеграція малоінвазивних втручань в алгоритм стадіювання КРР є клінічно обґрунтованою, оскільки забезпечує точне стадіювання та запобігає невиправданій хірургічній травмі.

**Ключові слова:** малоінвазивна діагностика, метастатичне ураження, колоректальний рак, лікування.

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