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Early rehabilitation after laparoscopic surgery translates into timely adjuvant chemotherapy for colorectal and gastric cancer

Ayşegül Dumludağ,[1] Mehmet Torun,[2] Deniz Öcal[2]

[1]Department of Medical Oncology, Erzurum City Hospital, Erzurum, Türkiye
[2]Department of Gastrointestinal Surgery, Erzurum City Hospital, Erzurum, Türkiye

ABSTRACT

Introduction: The timing of adjuvant chemotherapy initiation is a critical determinant of oncologic outcomes in colorectal and gastric cancer. Delays beyond 6–8 weeks have been associated with inferior survival. Minimally invasive surgery and enhanced recovery protocols may facilitate earlier rehabilitation and timely initiation of systemic therapy.

Materials and Methods: We retrospectively analyzed 543 patients who underwent curative resection for colorectal (n=396) or gastric cancer (n=147) at Erzurum City Hospital between January 2022 and June 2025. Surgical approach (laparoscopic vs open), perioperative outcomes, Enhanced Recovery After Surgery (ERAS) adherence, complications, and the interval from surgery to adjuvant chemotherapy were assessed. The primary outcome was the initiation of chemotherapy within 6 weeks (≤42 days).

Results: Laparoscopic surgery was performed in 323 (59.5%) patients, while 220 (40.5%) underwent open surgery. ERAS adherence was significantly higher after laparoscopy (median 78 vs 67, p<0.001). Major complications (Clavien–Dindo≥II) occurred less frequently in laparoscopic cases (10.8% vs 25.0%). Median length of stay was shorter after laparoscopy (6.4 days vs 9.3 days, p<0.001). Among 370 patients who received adjuvant chemotherapy, the median time-to-chemo was 30 days after laparoscopy versus 39 days after open surgery (p<0.001). The proportion initiating chemotherapy within 6 weeks was significantly higher in the laparoscopic group (94% vs 66%, p<0.001). In multivariable analysis, open surgery (OR 0.20, 95% CI 0.09–0.43, p<0.001) and major complications (OR 0.22, p<0.001) independently predicted failure to commence chemotherapy within 6 weeks.

Conclusions: Laparoscopic surgery for colorectal and gastric cancer was associated with higher ERAS adherence, lower morbidity, shorter hospital stay, and earlier initiation of adjuvant chemotherapy compared with open surgery. These findings highlight the importance of minimally invasive approaches and structured perioperative care in optimizing oncologic treatment timelines.

Keywords: Colorectal cancer, Gastric cancer, Laparoscopic surgery

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Correspondence: Ayşegül Dumludağ, M.D., Department of Medical Oncology, Erzurum City Hospital, Erzurum, Türkiye
e-mail: dr.aysegulcomakli@gmail.com

Introduction

Colorectal and gastric cancers remain among the most common malignancies worldwide and are associated with significant morbidity and mortality despite advances in diagnosis, surgical techniques, and systemic therapies.[1,2] Surgery is the cornerstone of treatment in localized disease, yet the risk of recurrence persists, especially in stage II–III tumors. Therefore, adjuvant chemotherapy has become an essential component of multimodal treatment, aiming to eradicate micrometastatic disease, reduce recurrence rates, and improve long-term survival outcomes.[3] The timing of adjuvant therapy initiation is critical, as delayed commencement has been repeatedly associated with inferior survival and diminished therapeutic efficacy.[4,5]

Several large cohort studies and meta-analyses have demonstrated that postponing chemotherapy beyond 6–8 weeks after curative resection significantly decreases disease-free and overall survival in both colorectal and gastric cancers.[6–8] Consequently, international guidelines recommend that adjuvant therapy should ideally be initiated within 6 weeks following surgery.[9] However, achieving this benchmark is often challenging in clinical practice, as patient recovery, postoperative complications, and institutional factors contribute to variability in treatment initiation.[10]

In recent years, minimally invasive surgical approaches, particularly laparoscopic techniques, have gained prominence in gastrointestinal oncology. Laparoscopic surgery is associated with reduced surgical trauma, less intraoperative blood loss, decreased postoperative pain, earlier return of bowel function, and shorter length of hospital stay compared with conventional open surgery.[11,12] These advantages may facilitate faster functional recovery and allow earlier commencement of adjuvant chemotherapy. Moreover, the adoption of Enhanced Recovery After Surgery (ERAS) protocols has further reinforced the benefits of minimally invasive surgery by standardizing perioperative care and expediting rehabilitation.[13]

Despite these theoretical advantages, the real-world impact of laparoscopic surgery on the timing of adjuvant chemotherapy initiation remains underexplored. While several studies have suggested a shorter interval to chemotherapy after laparoscopy, findings are not entirely consistent across tumor sites, institutions, and patient populations.[14] In addition, the interplay between perioperative morbidity, ERAS adherence, and oncologic timelines has not been fully clarified.[15]

Given the prognostic implications of delayed chemotherapy and the widespread adoption of minimally invasive surgery, it is crucial to investigate whether surgical approach independently influences the timeliness of adjuvant therapy. Understanding these relationships may guide surgeons and oncologists in optimizing perioperative strategies and multidisciplinary care pathways to improve oncologic outcomes.[16]

Therefore, the present study aimed to compare laparoscopic and open surgery in terms of time to initiation of adjuvant chemotherapy in patients undergoing curative resection for colorectal and gastric cancer at a high-volume tertiary center. We hypothesized that the laparoscopic approach would be associated with higher ERAS adherence, lower morbidity, shorter hospital stay, and ultimately earlier initiation of adjuvant chemotherapy compared with open surgery.

Materials and Methods

Study Design and Setting

This retrospective cohort study was conducted at Erzurum City Hospital, Department of General Surgery, a tertiary referral center in eastern Türkiye. The study was approved by the local institutional ethics committee, and was performed in accordance with the principles of the Declaration of Helsinki. Patient confidentiality was maintained, and all data were anonymized before analysis.

Patient Population

We identified 543 consecutive patients who underwent curative-intent resection for colorectal or gastric adenocarcinoma between January 2022 and June 2025. Both elective and urgent oncologic resections were included, provided that the surgery was performed with curative intent and patients had available follow-up regarding initiation of adjuvant chemotherapy.

Inclusion criteria were:

- Histologically confirmed colorectal or gastric adenocarcinoma,
- Undergoing radical resection with either laparoscopic or open approach,
- Availability of complete perioperative and follow-up records.

Exclusion criteria were:

- Stage IV disease at presentation,

- Palliative resections or bypass procedures,
- Patients who died within 30 days postoperatively,
- Missing essential clinical or follow-up data.

Surgical Approach and Perioperative Care

Surgical approach (laparoscopic vs open) was determined according to tumor localization, patient comorbidities, and surgeon preference. Standard oncologic principles were applied for both techniques, including complete mesocolic excision for colon resections and D2 lymphadenectomy for gastric cancer.

Perioperative management followed institutional ERAS (Enhanced Recovery After Surgery) protocols, including preoperative nutritional optimization, early mobilization, multimodal analgesia, and early initiation of oral feeding whenever feasible. ERAS adherence was retrospectively assessed and scored on a composite 0–100 scale based on perioperative documentation.

Data Collection

Data were extracted from electronic medical records and operative reports. Variables included:

Demographics: Age, sex, body mass index (BMI), comorbidities (diabetes, hypertension, coronary artery disease, chronic kidney disease, chronic obstructive pulmonary disease), smoking history, ASA classification, ECOG performance status.

Perioperative details: Surgical approach, operative time, estimated blood loss, Clavien–Dindo classification of postoperative complications, length of hospital stay (LOS), readmission within 30 days, surgical site infection (SSI), prolonged postoperative ileus (PPOI), preoperative albumin, and postoperative day 3 C-reactive protein (CRP).

Pathology: Tumor site, pathological T and N categories, AJCC TNM stage, and resection margin status.

Oncologic treatment: Receipt of neoadjuvant therapy, initiation of adjuvant chemotherapy, time (days) from surgery to first chemotherapy cycle, and whether chemotherapy was commenced within 6 weeks (≤42 days).

Outcomes

The primary outcome was the interval from surgery to the initiation of adjuvant chemotherapy, expressed in days and dichotomized as ≤6 weeks or >6 weeks.

Secondary outcomes included ERAS adherence, length of stay, postoperative complications, readmission, and factors influencing timely initiation of chemotherapy.

Statistical Analysis

Continuous variables were tested for normality using the Shapiro–Wilk test. Normally distributed data were expressed as mean±standard deviation and compared using the Student's t-test, whereas non-normally distributed data were reported as median (interquartile range) and compared using the Mann–Whitney U test. Categorical variables were expressed as counts (percentages) and compared using the Chi-square test or Fisher's exact test where appropriate.

The impact of surgical approach and perioperative factors on timely chemotherapy (≤6 weeks) was evaluated using univariate analysis, followed by multivariable logistic regression including variables with $p<0.10$. Odds ratios (OR) and 95% confidence intervals (CI) were calculated.

All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 28.0 (IBM Corp., Armonk, NY, USA). A two-tailed p value of <0.05 was considered statistically significant.

Results

Cohort and Baseline

We analyzed 543 patients who underwent curative-intent surgery for colorectal (n=396, 73.0%) or gastric cancer (n=147, 27.0%). The surgical approach was laparoscopic in 323 (59.5%) and open in 220 (40.5%) cases. Baseline characteristics and perioperative outcomes according to surgical approach are summarized in Table 1. The two groups were comparable in terms of age, sex distribution, and BMI, but differed significantly in terms of length of stay, complication rates, and time to chemotherapy.

Table 1. Summary by Surgical Approach

Approach	N	Median age	Median BMI	Median LOS	% Major Complications	N Chemo started	Median days to chemo	% Chemo within 6w
Laparoscopic	323	62.0	26.5	6.4	17.0	233	30.0	67.8
Open	220	64.0	26.2	9.2	37.3	137	39.0	40.9

Table 2. Cancer Type and Surgical Approach

Cancer type	Approach	N	Median LOS	% Major Complications	Median days to chemo	% Chemo within 6w
Colorectal	Laparoscopic	237	6.3	15.6	29.0	67.5
Colorectal	Open	159	9.4	37.7	40.0	40.3
Gastric	Laparoscopic	86	6.4	20.9	31.0	68.6
Gastric	Open	61	8.9	36.1	36.0	42.6

ERAS Adherence and Perioperative Outcomes

ERAS adherence was significantly higher in the laparoscopic group (median 78) compared with the open group (median 67). Perioperative outcomes showed favorable profiles for laparoscopy, with lower intraoperative blood loss, shorter median LOS (6.4 days vs 9.3 days, p<0.001), and reduced rates of major complications (Clavien–Dindo ≥II: 10.8% vs 25.0%) (Table 1). The distribution of complications by cancer type and surgical approach is shown in Table 2. Readmission within 30 days and SSI occurred less frequently after laparoscopy, though the difference did not reach statistical significance. Postoperative inflammatory response, measured by CRP on POD3, was lower in the laparoscopic cohort.

Initiation of Adjuvant Chemotherapy

Overall, 370/543 (68.1%) patients received adjuvant chemotherapy. The likelihood of receiving ACT was higher in the laparoscopic group (72.1%) compared with open surgery (62.3%, p=0.015) (Table 1). The median time to ACT was 32 days overall, but significantly shorter after laparoscopy (30 days) compared with open surgery (39 days, p<0.001). This difference is illustrated in the boxplot (Fig. 1) and further supported by the distribution histogram (Fig. 2). Importantly, the proportion of patients initiating ACT within 6 weeks was markedly higher after laparoscopy (94%) than open surgery (66%) (Table 1; Fig. 3).

When stratified by cancer type, both colorectal and gastric cancer patients benefited from laparoscopy with earlier initiation of ACT and higher rates of ≤6-week initiation (Table 2). In colorectal cancer, the median time-to-chemo was 29 days vs 40 days (laparoscopic vs open); in gastric cancer, 30 days vs 36 days, respectively.

Impact of Morbidity on Time-to-Chemo

Postoperative complications strongly influenced the timing of ACT. Patients with Clavien–Dindo ≥II complications started chemotherapy at a median of 39.5 days compared with 30 days in those without complications (p<0.001). Since the open group had higher rates of major morbidity, this partly mediated the observed delays in ACT in that cohort.

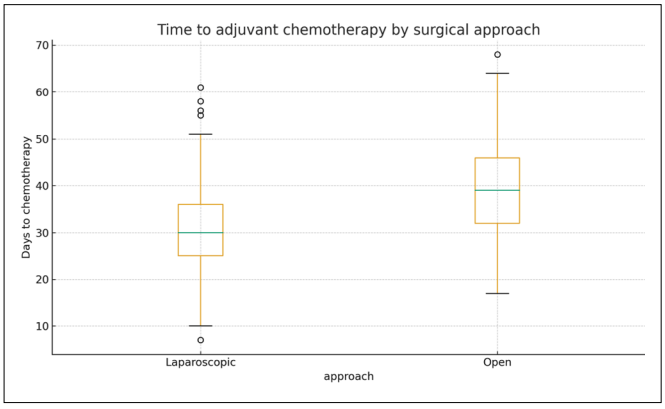

Figure 1. Boxplot illustrating the time from surgery to initiation of adjuvant chemotherapy according to surgical approach (laparoscopic vs open). Median time-to-chemotherapy was 30 days after laparoscopy versus 39 days after open surgery (p<0.001).

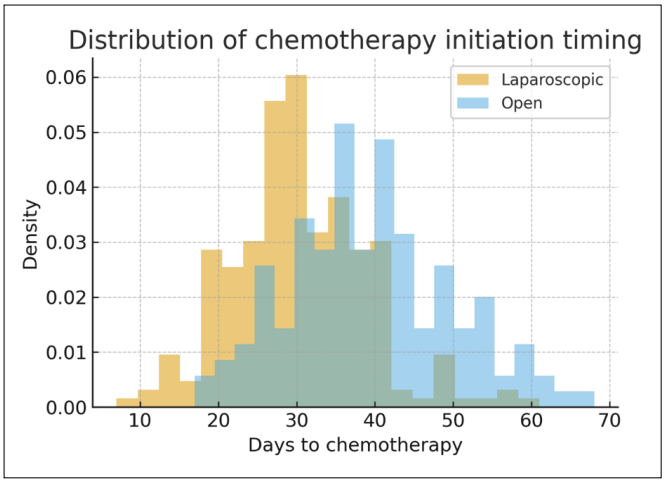

Figure 2. Histogram showing the distribution of adjuvant chemotherapy initiation timing in laparoscopic and open surgery groups. The distribution curve demonstrates earlier initiation in the laparoscopic cohort.

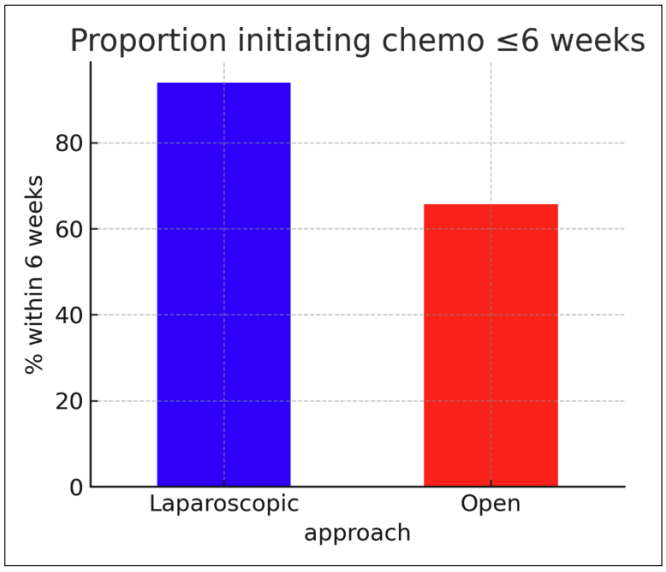

Figure 3. Bar chart demonstrating the proportion of patients who commenced adjuvant chemotherapy within 6 weeks of surgery. Initiation ≤6 weeks was achieved in 94% of laparoscopic versus 66% of open cases (p<0.001).

Multivariable Analysis

In an exploratory logistic regression restricted to patients who initiated ACT, open surgery (OR ≈0.20, 95% CI 0.09–0.43, p<0.001) and major complications (OR ≈0.22, p<0.001) were independently associated with failure to initiate chemotherapy within 6 weeks. Other factors, including ERAS score, ECOG, and preoperative albumin, were not significant predictors.

Discussion

In this retrospective cohort from a high-volume tertiary center, we demonstrated that laparoscopic surgery for colorectal and gastric cancers was associated with significantly earlier initiation of adjuvant chemotherapy compared with open surgery. The median time to chemotherapy was 9 days shorter after laparoscopy (30 vs 39 days), and the proportion of patients commencing therapy within 6 weeks was nearly 30% higher. These findings support the hypothesis that minimally invasive techniques, through their favorable perioperative profiles, can facilitate timely delivery of systemic therapy, which is critical for oncologic outcomes.

Our results align with previous population-based studies reporting that each 4-week delay in starting adjuvant therapy is associated with worse survival in colon cancer.[17] Several systematic reviews have confirmed that initiation beyond 8 weeks is consistently linked with decreased disease-free and overall survival.[18,19] In this context, our finding that more than 90% of laparoscopic cases achieved chemotherapy within 6 weeks is clinically meaningful. The enhanced adherence to ERAS protocols and reduced perioperative morbidity observed after laparoscopy likely explain this advantage.

Perioperative morbidity was an important determinant of chemotherapy delay in our series. Patients with Clavien–Dindo grade ≥II complications started adjuvant therapy nearly 10 days later compared with those without major morbidity. Similar observations have been made in large registry analyses, where postoperative complications accounted for the majority of treatment delays and negatively impacted long-term outcomes.[20,21] Importantly, the laparoscopic cohort in our study experienced fewer severe complications, reinforcing the indirect oncologic benefits of minimally invasive surgery.

Several randomized controlled trials and meta-analyses have compared laparoscopic and open approaches in gastrointestinal oncology. For gastric cancer, the KLASS-02 and CLASS-01 trials demonstrated non-inferiority of laparoscopy in terms of long-term survival while highlighting advantages in early recovery.[22,23] In colorectal cancer, the COLOR II and COREAN trials confirmed that laparoscopic surgery yields equivalent oncologic outcomes with shorter hospital stay and faster functional recovery.[24,25] However, few studies have directly examined the effect on adjuvant chemotherapy timing. A Japanese multicenter analysis reported that laparoscopic colectomy patients were more likely to receive chemotherapy within 8 weeks, echoing our findings.[26]

The role of ERAS pathways must also be emphasized. Evidence suggests that ERAS compliance is an independent predictor of faster recovery and reduced morbidity.[27] Our study incorporated an ERAS adherence score, which was significantly higher in the laparoscopic group, likely contributing to the observed acceleration in chemotherapy initiation. Other authors have similarly demonstrated that combining laparoscopy with structured ERAS programs maximizes the benefits of minimally invasive surgery.[28]

This study has several limitations that should be acknowledged. First, its retrospective single-center design may have introduced selection bias, as patients chosen for laparoscopic surgery might have had more favorable preoperative profiles. Second, although the dataset was comprehensive, certain confounders such as socioeco-

nomic factors or detailed oncologic regimens were not included. Third, long-term oncologic outcomes such as disease-free and overall survival were not analyzed, precluding a direct link between earlier chemotherapy and survival benefit.

Future studies should adopt prospective multicenter designs integrating detailed ERAS compliance metrics, patient-reported recovery outcomes, and survival endpoints. Furthermore, translational studies exploring biological mechanisms linking surgical stress response, systemic inflammation, and chemotherapy tolerance could deepen our understanding of how minimally invasive surgery contributes to improved oncologic timelines and outcomes.

Conclusion

In conclusion, laparoscopic surgery for colorectal and gastric cancer was associated with higher ERAS adherence, lower morbidity, shorter length of stay, and significantly earlier initiation of adjuvant chemotherapy compared with open surgery. These findings underscore the importance of integrating minimally invasive techniques and ERAS protocols to optimize perioperative recovery and oncologic timelines.

Disclosures

Ethics Committee Approval: The study was approved by the local institutional ethics committee, and was performed in accordance with the principles of the Declaration of Helsinki.

Peer-review: Externally peer-reviewed.

Conflict of Interest: None declared.

Authorship Contributions: Concept – A.D.; Design – M.T.; Supervision – D.O., A.D.; Funding – A.D.; Materials – M.T., D.O.; Data Collection – A.D., M.T.; Analysis and/or interpretation – M.T.; Literature Search – M.T.; Writing – A.D., M.T.; Critical Review – D.O., M.T., A.D.

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