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Impact of Intraoperative Ultrasonography on Metastatic Lymph Node Detection in Laparoscopic Gastric Cancer Surgery

Mide Kanseri Cerrahisinde İntraoperatif Ultrasonografinin Metastatik Lenf Nodu Tayinindeki Yeri

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Abstract

Objectives: Laparoscopic D2 lymphadenectomy in gastric cancer surgery is technically demanding due to the close anatomical relationship with major vascular structures and the pancreatic parenchyma. This study investigated whether intraoperative ultrasonography (IOUS) influences early surgical and short-term oncologic outcomes in patients undergoing laparoscopic total gastrectomy.

Material and Methods: In this single-center retrospective comparative cohort study, between November 2023 and November 2025, a total of 78 patients underwent laparoscopic D2 lymph node dissection with IOUS guidance, of whom 31 underwent total gastrectomy. These patients were compared with 28 patients who underwent laparoscopic total gastrectomy and D2 lymph node dissection without IOUS between November 2021 and November 2023. The two groups were evaluated with respect to demographic characteristics, early perioperative outcomes, postoperative complications, and the total number of lymph nodes dissected and the number of metastatic lymph nodes.

Results: A total of 59 patients with gastric cancer were included in the analysis: 28 in the non-IOUS group and 31 in the IOUS group. No significant differences were observed between the groups with respect to demographic characteristics, clinical variables, or preoperative laboratory parameters (all $p>0.05$). Intraoperative complication rates (14.3% vs. 9.7%), postoperative complication profiles, requirements for erythrocyte suspension transfusion, operative time (median 200 minutes), intensive care unit stay, and total length of hospital stay were comparable between groups ($p>0.05$). There was no significant difference in the total number of dissected lymph nodes ($p=0.773$). The number of metastatic lymph nodes was low in both groups, and there was no significant difference associated with the use of IOUS ($p=0.605$).

Conclusion: IOUS may be considered a supportive technique that contributes to anatomical delineation and surgical safety during laparoscopic gastric cancer surgery. Further studies with larger patient cohorts are warranted to clarify its potential impact on oncological outcomes.

Keywords: Gastric cancer, intraoperative ultrasonography, laparoscopic lymphadenectomy, laparoscopic gastrectomy

Öz

Giriş / Amaç: Mide kanseri cerrahisinde laparoskopik D2 lenfadenektomi, majör vasküler yapılar ve pankreas parankimi ile yakın komşuluğu nedeniyle teknik olarak zorlayıcıdır. Bu çalışmada, laparoskopik total gastrektomi uygulanan hastalarda intraoperatif ultrasonografi (İU) kullanımının erken postoperatif cerrahi ve onkolojik sonuçlara etkisini değerlendirmeyi amaçladık.

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Gereç ve Yöntem: Kasım 2023-Kasım 2025 tarihleri arasında 31'i total gastrektomili olmak üzere toplam 78 hastaya İU eşliğinde laparoskopik D2 lenf nodu diseksiyonu uygulanmıştır. Bu 31 hasta Kasım 2021-Kasım 2023 arasında İU yardımsız laparoskopik total gastrektomi ve D2 lenf nodu diseksiyonu uygulanan 28 hasta ile karşılaştırılmıştır. İki grup demografik özellikler, perioperatif erken sonuçlar, komplikasyonlar, diseke edilen total ve metastatik lenf nodu sayıları açısından değerlendirilmiştir.

Bulgular: Çalışmaya İU uygulanmayan 28 hasta ve İU uygulanan 31 hasta olmak üzere toplam 59 mide kanseri hastası dahil edildi. Gruplar arasında demografik, klinik ve preoperatif laboratuvar parametreleri açısından anlamlı bir fark saptanmadı (tümü için p>0,05). İntraoperatif komplikasyon oranları (%14,3 vs. %9,7), postoperatif komplikasyon dağılımı, eritrosit süspansiyonu transfüzyon gereksinimi, operasyon süresi (medyan 200 dk), yoğun bakım yatış süresi ve toplam hastanede kalış süresi gruplar arasında benzerdi (p>0,05). Diseke edilen lenf nodu sayısı açısından gruplar arasında anlamlı fark izlenmedi (p=0,773). Metastatik lenf nodu sayıları her iki grupta da düşük olup, İU kullanımı ile anlamlı bir farklılık saptanmadı (p=0,605).

Tartışma / Sonuç: Sonuç olarak İU, laparoskopik mide kanseri cerrahisinde anatomik ayırım ve cerrahi güvenliğe katkı sağlayabilecek yardımcı bir yöntem olarak değerlendirilebilir. Daha geniş hasta serileri ile yapılacak çalışmalar, onkolojik sonuçlara etkisini daha net ortaya koyacaktır.

Anahtar Kelimeler: Mide kanseri, intraoperatif ultrasonografi, laparoskopik lenfadenektomi, laparoskopik gastrektomi

Introduction

Gastric cancer is the fifth most commonly diagnosed malignancy worldwide and ranks fourth among cancer-related causes of death (1). Surgical resection remains the cornerstone of curative treatment, and complete tumor removal with adequate lymph node dissection is one of the most critical determinants of long-term survival (2,3). Therefore, gastrectomy combined with systematic lymphadenectomy constitutes an essential component of current treatment strategies for resectable gastric cancer.

In recent years, laparoscopic gastrectomy has gained increasing acceptance due to its comparable oncological outcomes to open surgery and its more favorable early postoperative recovery profile (4). However, the lack of tactile feedback in the laparoscopic approach may complicate intraoperative decision-making during perivascular lymph node dissection (5). This limitation has increased interest in adjunctive imaging modalities that may enhance surgical safety.

Intraoperative ultrasonography (IOUS) provides real-time imaging with high resolution in differentiating vascular structures and soft tissues. Although IOUS is widely used in hepatobiliary and pancreatic surgery, its contribution to lymph node dissection in gastric cancer surgery has not yet been clearly established (6). Therefore, this study aimed to evaluate the impact of IOUS on early postoperative surgical and oncological outcomes in patients undergoing laparoscopic total gastrectomy.

Materials and Methods

Study Design and Patient Selection

Although the study was initially planned as a prospective investigation, it was converted to a retrospective cohort design due to insufficient patient recruitment. Patients who underwent laparoscopic surgery for gastric adenocarcinoma at the Surgical Oncology Department of Ankara University Faculty of Medicine were included.

Between November 2023 and November 2025, 78 patients underwent laparoscopic D2 lymph node dissection with IOUS guidance, 31 of whom underwent total gastrectomy. Between November 2021 and November 2023, these 31 patients were compared with 28 patients who underwent laparoscopic total gastrectomy with D2 lymph node dissection without IOUS.

Inclusion criteria were:

- age ≥18,
- histopathologically confirmed gastric adenocarcinoma, and
- curative-intent gastrectomy.

Exclusion criteria were:

- presence of distant metastasis at diagnosis,
- palliative surgery,
- missing clinical or laboratory data,
- loss to follow-up.

Patients were divided into two groups according to the use of IOUS: the IOUS group and the non-IOUS group.

Demographic characteristics, comorbidity burden assessed by the Charlson comorbidity index (CCI), tumor-related variables, and laboratory parameters (serum albumin level, lymphocyte count, and neutrophil count) were recorded. Perioperative data and postoperative outcomes were systematically collected. Postoperative complications were graded according to the Clavien-Dindo classification (7).

Intraoperative and postoperative outcomes included operative time, requirement for erythrocyte suspension transfusion, intensive care unit (ICU) stay, total length of hospital stay, total number of dissected lymph nodes, and total number of metastatic lymph nodes. The two groups were compared with respect to postoperative outcomes and surgical complications.

Written informed consent was obtained from all participants, and the study was approved by the Institutional Ethics Committee of Ankara University Faculty of Medicine (approval no: İ01-07-23, date: 12.01.2023).

Surgical Technique and IOUS

All procedures were performed by an experienced surgical team. Total gastrectomy was performed in all included patients. The fundamental principles of the surgical procedure and the extent of lymph node dissection were based on the Japanese Gastric Cancer Treatment Guidelines (2). Roux-en-Y reconstruction was performed in all cases.

In the IOUS group, suspected metastatic lymph nodes, the pancreas, and major vascular structures were evaluated during D2 dissection using IOUS. Decisions regarding surgical strategy were made based on intraoperative findings and the surgeon's judgment.

Statistical Analysis

Statistical analyses were conducted using Jamovi (version 2.7.13). The distribution of continuous variables was examined with the Shapiro-Wilk normality test. Because most continuous variables were not normally distributed, they were summarized as medians with interquartile ranges (IQRs). Differences between groups in continuous variables were assessed using the Mann-Whitney U test. Categorical variables were summarized as counts and percentages and compared using the chi-square test or Fisher's exact test when appropriate. Statistical significance was defined as a two-sided p-value of less than 0.05.

A post-hoc power analysis was conducted based on the observed group differences in perioperative outcomes. With a total sample size of 59 patients and an alpha level of 0.05, the study had approximately 78% power to detect moderate effect sizes in continuous outcomes such as total hospital stay. However, for categorical endpoints such as intraoperative complications and postoperative morbidity, the observed effect sizes were small, resulting in reduced statistical power (<70%). These findings indicate that the study was adequately powered to detect moderate differences but may be underpowered to detect small differences in complication rates.

Results

A total of 59 patients with gastric cancer were included in the analysis, comprising 28 patients in the non-IOUS group and 31 patients in the IOUS group. There was no significant difference in sex distribution between the groups (p=0.985). The median age was 66 years (IQR: 17.8) in the non-IOUS group and 65 years (IQR: 13.5) in the IOUS group, with no statistically significant difference between the groups (p=0.665). The distribution of the CCI was similar between the two groups (p=0.308).

Tumors were predominantly located in the non-cardia region in both groups, there was no significant difference in tumor localization between patients with and without IOUS (p=0.225). The pathological stage distribution was comparable between the groups, and stage I disease was the most common in both cohorts (p=0.825). No significant differences were detected between the groups in preoperative laboratory parameters, including serum albumin level (p=0.903), lymphocyte count (p=0.559), and neutrophil count (p=0.202). Neoadjuvant therapy was administered to 25.0% of patients in the non-IOUS group and to 38.7% in the IOUS group; however, this difference did not reach statistical significance (p=0.260). The demographic, clinical, and preoperative laboratory characteristics of the groups are summarized in Table 1.

Intraoperative complication rates were comparable between the non-IOUS and IOUS groups (14.3% vs. 9.7%, p=0.585). According to the Clavien-Dindo classification, the distribution of postoperative complications did not differ significantly between groups (p=0.291). The majority of patients had no complications (grade 0). The requirement for erythrocyte suspension transfusion was similar between the non-IOUS and IOUS groups (32.1% vs. 48.4%; p=0.205). The median operative time was identical in both groups (200 minutes; p=0.493). Likewise, no significant difference was observed in ICU stay (median 1 day in both groups; p=0.659) or in total hospital stay. However, a trend toward longer total hospital stay was observed in the IOUS group (median 11 vs. 8 days; p=0.085). The median total number of dissected lymph nodes was 27 (IQR: 18.8) in the non-IOUS group and 31 (IQR: 16.5) in the IOUS group (p=0.773). The median number of metastatic lymph nodes was low in both groups; no statistically significant difference was observed between groups [0.5 (IQR: 5) vs. 0 (IQR: 3), p=0.605]. Overall, the use of IOUS did not have a significant impact on intraoperative, postoperative, or short-term oncological outcomes (Table 2).

The distribution of metastatic lymph node counts by IOUS use and pathological stage was visually evaluated using raincloud plots (Figure 1). In both non-IOUS and IOUS groups, counts of metastatic lymph nodes were predominantly clustered at or near zero. Color-coding by pathological stage demonstrated that metastatic lymph node counts had a wider distribution in more advanced stages. However, no obvious visual in the distribution of metastatic lymph nodes was observed between patients with and without IOUS.

Discussion

In this study, we evaluated the impact of IOUS on early postoperative surgical and short-term oncological outcomes in patients undergoing laparoscopic total gastrectomy for gastric cancer. The principal findings demonstrated that the use of IOUS

Table 1. Demographic and clinicopathological characteristics of gastric cancer patients with and without intraoperative ultrasonography

Variable	No USG (n=28)	USG (n=31)	p-value
Gender, n (%)			0.985[1]
Male	18 (64.3)	20 (64.5)	
Female	10 (35.7)	11 (35.5)	
Age, years, median (IQR)	66 (17.8)	65 (13.5)	0.665[2]
CCI, n (%)			0.308[1]
2	16 (57.1)	24 (77.4)	
3	9 (32.1)	5 (16.1)	
4	2 (7.1)	2 (6.5)	
5	1 (3.6)	0 (0.0)	
Tumor location, n (%)			0.225[1]
Cardia	3 (10.7)	7 (22.6)	
Non-cardia	25 (89.3)	24 (77.4)	
Pathological stage, n (%)			0.825[1]
Stage I	17 (60.7)	19 (61.3)	
Stage II	5 (17.9)	7 (22.6)	
Stage III	6 (21.4)	5 (16.1)	
Albumin (g/L), median (IQR)	41.5 (3.2)	41.8 (5.95)	0.903[2]
Lymphocyte count (×10⁹/L), median (IQR)	2.00 (1.11)	1.78 (1.20)	0.559[2]
Neutrophil count (×10⁹/L), median (IQR)	4.48 (2.24)	4.05 (1.70)	0.202[2]
Neoadjuvant therapy, n (%)			0.260[1]
No	21 (75.0)	19 (61.3)	
Yes	7 (25.0)	12 (38.7)	

Data are presented as median (IQR) for continuous variables and number (percentage) for categorical variables. Comparisons between groups were performed using the Mann-Whitney U test for continuous variables and the chi-square test for categorical variables. A two-sided p-value <0.05 was considered statistically significant

[1]: Chi-square test, [2]: Mann-Whitney U test, USG: Ultrasonography, IQR: Interquartile range, CCI: Charlson comorbidity index

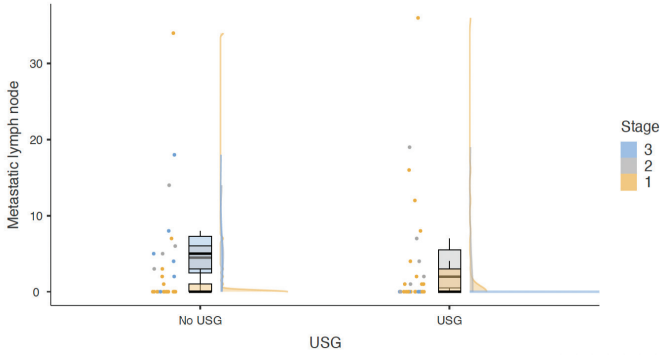

Figure 1. Raincloud plot analysis
USG: Ultrasonography

did not result in a statistically significant difference in operative time, perioperative complications, total and metastatic lymph node counts, or early postoperative outcomes. Notably, the low number of metastatic lymph nodes observed in both groups and the similarity in their distribution patterns suggest that IOUS did not meaningfully enhance the detection of pathological lymph nodes in this patient cohort. Nevertheless, the demonstration that IOUS can be integrated into laparoscopic gastric cancer surgery without disrupting surgical workflow, prolonging operative time, or increasing morbidity may be considered an important finding regarding clinical feasibility.

The primary objective established during project planning was to improve the detection of metastatic lymph nodes and to minimize the risk of leaving positive nodes behind through the use of IOUS. However, the present results indicate that this objective was not achieved to the expected extent. One possible explanation is the relatively high proportion of early-stage disease and the overall low metastatic nodal burden in the study population. As demonstrated in the raincloud plot analysis, metastatic lymph node counts in both groups were largely clustered near zero. This finding suggests that the potential benefit of IOUS may become more apparent in patient populations with more advanced disease and a higher expected nodal burden.

The present study demonstrated that IOUS can be incorporated into laparoscopic gastric cancer surgery without prolonging operative time. The comparable operative durations between

Table 2. Intraoperative and postoperative outcomes of gastric cancer patients with and without intraoperative ultrasonography

Variable	No USG (n=28)	USG (n=31)	p-value
Intraoperative complication, n (%)			0.585[1]
Presence	4 (14.3)	3 (9.7)	
Absence	24 (85.7)	28 (90.3)	
Clavien-Dindo classification, n (%)			0.291[1]
Grade 0	19 (67.9)	15 (48.4)	
Grade I	4 (14.3)	5 (16.1)	
Grade II	1 (3.6)	6 (19.4)	
Grade IIIa	3 (10.7)	4 (12.9)	
Grade IIIb	1 (3.6)	0 (0.0)	
Grade IVa	0 (0.0)	1 (3.2)	
Erythrocyte suspension transfusion, n (%)			0.205[1]
No	19 (67.9)	16 (51.6)	
Yes	9 (32.1)	15 (48.4)	
Operation time, min, median (IQR)	200 (45)	200 (40)	0.493[2]
ICU stay, days, median (IQR)	1 (1.5)	1 (1)	0.659[2]
Total hospital stay, days, median (IQR)	8 (8)	11 (6)	0.085[2]
Total lymph node, median (IQR)	27 (18.8)	31 (16.5)	0.773[2]
Metastatic lymph node, median (IQR)	0.5 (5)	0 (3)	0.605[2]

Data are presented as median (IQR) for continuous variables and number (percentage) for categorical variables. A two-sided p-value <0.05 was considered statistically significant
[1]: Chi-square test, [2]: Mann-Whitney U test, USG: Ultrasonography, ICU: Intensive care unit, IQR: Interquartile range

the two groups indicate that this technique does not disrupt surgical flow and has high practical feasibility. Furthermore, the single-center nature of the study ensured homogeneity of surgical techniques and perioperative care protocols, thereby strengthening the internal validity of the findings. Although difficult to quantify, the additional anatomical awareness provided by IOUS during dissections involving the pancreas and major vascular structures may represent a clinically meaningful advantage in terms of surgical safety. The current study may serve as a preliminary step for future investigations focusing on larger cohorts and selected high-risk patient populations.

Although IOUS has been widely used for various purposes in other intra-abdominal malignancies, studies directly evaluating its contribution to lymph node dissection in laparoscopic gastric cancer surgery remain limited (8,9). Shen et al. (10) reported that the use of IOUS increased the number of retrieved lymph nodes, particularly at stations 10, 11, and 12, with a more noticeable effect in patients with advanced-stage disease. However, that study did not identify a statistically significant difference between groups regarding the total number of dissected lymph nodes or the overall metastatic lymph node count. In line with these observations, our results showed no meaningful increase in total or metastatic lymph node counts associated with IOUS. Overall, these findings indicate that the potential advantage of IOUS may become more apparent in patients with advanced disease and a higher anticipated nodal burden, whereas its benefit may be limited in early-stage cases.

Study Limitations

Some limitations that may affect the results of our study. First, although the study was initially planned as a prospective randomized investigation, it was converted to a retrospective cohort design because of insufficient patient recruitment, and this conversion increased the risk of selection bias. Second, the relatively small sample size reduced the statistical power, particularly for infrequent endpoints such as the detection of metastatic lymph nodes. In addition, the focus on short-term outcomes precluded evaluation of the potential impact of IOUS on long-term outcomes such as local recurrence and survival.

Conclusion

IOUS can be safely applied in laparoscopic gastric cancer surgery and integrated into the surgical workflow without prolonging operative time. Although no statistically significant superiority was demonstrated in terms of intraoperative, postoperative, or short-term oncological outcomes in the current patient cohort, our findings provide preliminary evidence for a potential role of IOUS in laparoscopic gastric cancer surgery. Rather than for routine use, IOUS may be more appropriately considered in selected patient populations, particularly in advanced-

stage disease, in cases with a high risk of nodal burden, or in anatomically challenging dissections. Larger and more comprehensive studies are warranted to further clarify the potential oncological benefits of IOUS, especially in carefully selected patient groups.

Ethics

Ethics Committee Approval: The study was approved by the Institutional Ethics Committee of Ankara University Faculty of Medicine (approval no: İ01-07-23, date: 12.01.2023).

Informed Consent: Written informed consent was obtained from all participants.

Footnotes

Authorship Contributions

Concept/Design: S.T., A.E.Ü., Data Collection or Processing: S.Ç., K.E., M.Ş.B., Analysis or Interpretation: S.T., C.C., E.C., Literature Review: S.T., Writing, Reviewing and Editing: S.T., S.Ç.

Conflict of Interest: No conflict of interest was declared by the authors.

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