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Total mesorectal excision quality as a predictor of overall survival in rectal cancer: A retrospective cohort study

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ABSTRACT

Objective: Achieving complete total mesorectal excision (TME) is considered an important indicator of surgical quality in rectal cancer surgery. However, the impact of TME quality on overall survival (OS) remains controversial. This study aimed to evaluate the association between TME quality and OS in patients undergoing rectal cancer surgery.

Material and Methods: A retrospective analysis was conducted on 171 patients who underwent elective low anterior resection or abdominoperineal resection for rectal cancer between 2021 and 2022. OS was compared between patients with incomplete TME and those with near-complete or complete TME. In addition, clinical and pathological factors associated with TME quality were assessed.

Results: Incomplete TME was independently associated with worse OS [hazard ratio (HR)=2.53, 95% confidence interval (CI) 1.15-5.59, p=0.021], while undergoing a Hartmann procedure showed the strongest negative impact on OS (HR=4.60, 95% CI 2.04-10.38, p<0.001). At 36 months, OS was 86.3% in the near-complete/complete TME group versus 68.3% in the incomplete group (log-rank p=0.008). Factors associated with incomplete TME included lower preoperative albumin levels, larger tumor size, previous abdominal surgery, tumors located closer to the anal verge, lymphovascular invasion, and positive circumferential resection margins.

Conclusion: Incomplete TME was associated with significantly worse OS in patients undergoing rectal cancer surgery. These findings highlight the importance of achieving optimal TME quality. Larger prospective studies are warranted to validate these results.

Keywords: Rectal cancer, total mesorectal excision quality, mesorectal grade, overall survival

INTRODUCTION

Approximately 46,000 new cases of rectal cancer are reported each year in the United States (1). There have been significant developments in the treatment of rectal cancer in recent years. The introduction of neoadjuvant radiotherapy and then total neoadjuvant treatment has contributed greatly to long-term oncologic outcomes (2). Despite these developments, total mesorectal excision (TME), first described by Bill Heald, remains the cornerstone of curative treatment for rectal cancer (3-7).

The completeness of the mesorectal excision specimen is widely regarded as a key indicator of surgical quality. Nagtegaal et al. (8) highlighted that TME quality can be assessed through macroscopic evaluation of the specimen and may influence oncologic outcomes. Consequently, achieving complete TME has become an essential goal for colorectal surgeons. However, existing literature reports conflicting results regarding the prognostic value of TME quality. While several studies have shown that better-quality TME specimens are associated with improved oncologic outcomes (9,10), others have failed to demonstrate a significant relationship between TME quality and prognosis (11,12).

Although TME is considered the standard of care in rectal cancer surgery, the clinical significance of TME quality remains uncertain. The rationale behind our study was to contribute to this ongoing debate by presenting data from our own cohort.

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Specifically, we aimed to evaluate the impact of incomplete TME on survival and to identify factors associated with both prognosis and TME quality.

MATERIAL and METHODS

Study Design and Patient Selection

This study is designed as a retrospective, single-center study. Ethical approval was obtained from the Clinical Research Ethics Committee of the Marmara University Faculty of Medicine (approval number: 09.2025.25-0364, date: 18.04.2025). Patients who underwent rectal surgery at the Department of General Surgery, Marmara University between January 2021 and December 2022 were identified using the hospital information system. In our institution, the standard approach for patients with locally advanced mid-to-low rectal tumors is surgery following neoadjuvant therapy. However, this strategy could not always be applied due to factors such as surgeon preference, patient comorbidities, and individual patient choice. All patients who underwent low anterior resection (LAR) or abdominoperineal resection (APR) were screened. Inclusion criteria consisted of being over 18 years of age and having undergone elective rectal cancer surgery involving TME. Exclusion criteria included the presence of synchronous tumors, distant metastasis at the time of diagnosis, and a history of inflammatory bowel disease.

Patient Demographics and Clinical Data

Demographic and clinical data, including age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) score, Charlson comorbidity index, albumin level, smoking status, history of previous abdominal surgery, neoadjuvant therapy status, hospital length of stay, and follow-up duration, were collected from patient records. Operative details such as surgical procedure (LAR, APR, or Hartmann) and tumor distance from the anal verge were also recorded. Pathology reports were reviewed to obtain T and N stages, tumor size, number of harvested and positive lymph nodes, TME quality, presence of lymphovascular invasion (LVI) and perineural invasion, circumferential resection margin (CRM) status, and distal resection margin status. Mortality status during follow-up was also documented. TME quality was classified in pathology reports as incomplete, near complete, or complete. In this study, near complete and complete cases were grouped together, while incomplete cases formed a separate group.

Definitions

Tumor staging was determined according to the 8th edition of the American Joint Committee on Cancer TNM classification system. Overall survival (OS) was defined as the time from the date of surgery to the date of death from any cause. CRM positivity was defined as a tumor distance of <1 mm from the mesorectal fascia.

No intraoperative assessment of TME quality by the surgical team was documented in the operative reports or pathology request forms. In addition, no photographic documentation of the surgical specimen or the pelvic operative field after resection was available. Therefore, the classification of TME quality was based exclusively on the macroscopic evaluation of the resected specimen performed by an experienced gastrointestinal pathologist. The quality of TME was assessed according to the macroscopic grading system described by Nagtegaal et al. (8) commonly referred to as the "Quirke classification".

TME quality was categorized into three groups:

-Complete: Well-preserved mesorectum with a smooth surface, only minor superficial irregularities, no surface defects greater than 5 mm in depth; no distal coning observed.

-Near-complete: Moderate mesorectal bulk, irregular mesorectal surface with defects larger than 5 mm but none reaching the muscularis propria, no exposure of the muscularis propria except at the insertion of the levator ani.

-Incomplete: Limited mesorectal tissue with deeper defects exposing the muscularis propria and/or a markedly irregular CRM.

Outcomes of the Study

The primary outcome of this study was to evaluate whether near complete/complete TME is associated with better OS in patients with rectal cancer. Secondary outcomes included identifying other independent predictors of OS, as well as determining clinical and pathological factors associated with TME quality.

Statistical Analysis

Statistical analyses were performed using SPSS software version 21.0 (SPSS Inc., Chicago, IL, USA) and Jamovi version 2.3.28. Continuous variables were summarized as mean ± standard deviation or median with interquartile range (IQR), while categorical variables were expressed as frequencies and percentages. Comparisons between groups were made using the Student's t-test or Mann-Whitney U test for continuous variables, and the chi-square or Fisher's exact test for categorical variables, as appropriate.

OS was estimated using the Kaplan-Meier method and compared between groups using the log-rank test. Cox proportional hazards regression analyses were performed to identify independent predictors of OS. Candidate variables for inclusion in the Cox model were determined based on exploratory univariate and multivariate logistic regression analyses evaluating 36-month mortality, which are presented in Supplementary Tables S1 and S2. Results of the Cox regression analysis are reported as hazard ratios (HR) with 95% confidence intervals (CI) and corresponding p-values. A p-value <0.05 was considered statistically significant.

RESULTS

Between January 2021 and December 2022, the medical records of 246 patients who underwent LAR or APR in our department were reviewed. A total of 171 patients who met the inclusion criteria were included in the analysis (Figure 1). Approximately 60% of the cohort were male, and the mean age was 62.4±11.4 years. The mean BMI was 26.3±4.2 kg/m^2, indicating that the majority of patients were overweight. Most patients had low ASA scores (I-II) (88%, n=149) and did not receive neoadjuvant therapy (56.2%, n=95). The median follow-up duration was 42 months (IQR 13), during which the overall mortality rate was 22% (n=38) (Table 1). The median tumor distance from the anal verge was 8 cm (IQR 9). The most common surgical procedure was LAR in 63.7% of patients, followed by Hartmann's procedure (20.5%) and APR (15.8%).

Regarding pathological staging, 81.2% of patients had early-stage tumors (Tis-T3) and Node-negative disease (N0) was present in 63.5% of patients. Specifically, the distribution of T stages was as follows: T0 in 7.6%, Tis in 1.2%, T1 in 4.1%, T2 in 12.4%, T3 in 55.9%, and T4 in 18.8% of patients (data not shown in table). The median number of harvested lymph nodes was 15 (IQR 9.75). Based on pathological assessment, complete TME was achieved in 51.3% of patients, near-complete TME in 32.5%, and incomplete TME in 16.2%. A positive CRM was observed in 11.8% of cases (Table 2).

In the univariable Cox regression analysis, surgical procedure (Hartmann vs. others), TME quality, Charlson comorbidity index, and serum albumin were significantly associated with OS, while nodal status showed a borderline association (p=0.051). In the multivariable Cox model, only surgical procedure (Hartmann vs. others: HR=4.60, 95% CI 2.04-10.38, p<0.001) and TME quality (incomplete vs. near complete/complete: HR=2.53, 95% CI 1.15-5.59, p=0.021) remained independent predictors of OS, with both Hartmann procedures and incomplete TME being associated with significantly worse survival (Table 3). Kaplan-Meier survival analysis demonstrated significantly worse OS in patients with incomplete TME compared with those with near complete/complete TME. For the entire cohort, the 36-month OS rate was 83.6%. At 36 months, survival was 86.3% in the near complete/complete TME group versus 68.3% in the incomplete group, with 22 observed deaths among 129 patients and 10 deaths among 25 patients, respectively. The log-rank test showed a statistically significant difference between the groups (p=0.008) (Figure 2).

Among the evaluated clinicopathological factors, several variables were significantly associated with TME quality. Patients with incomplete TME had lower preoperative albumin levels

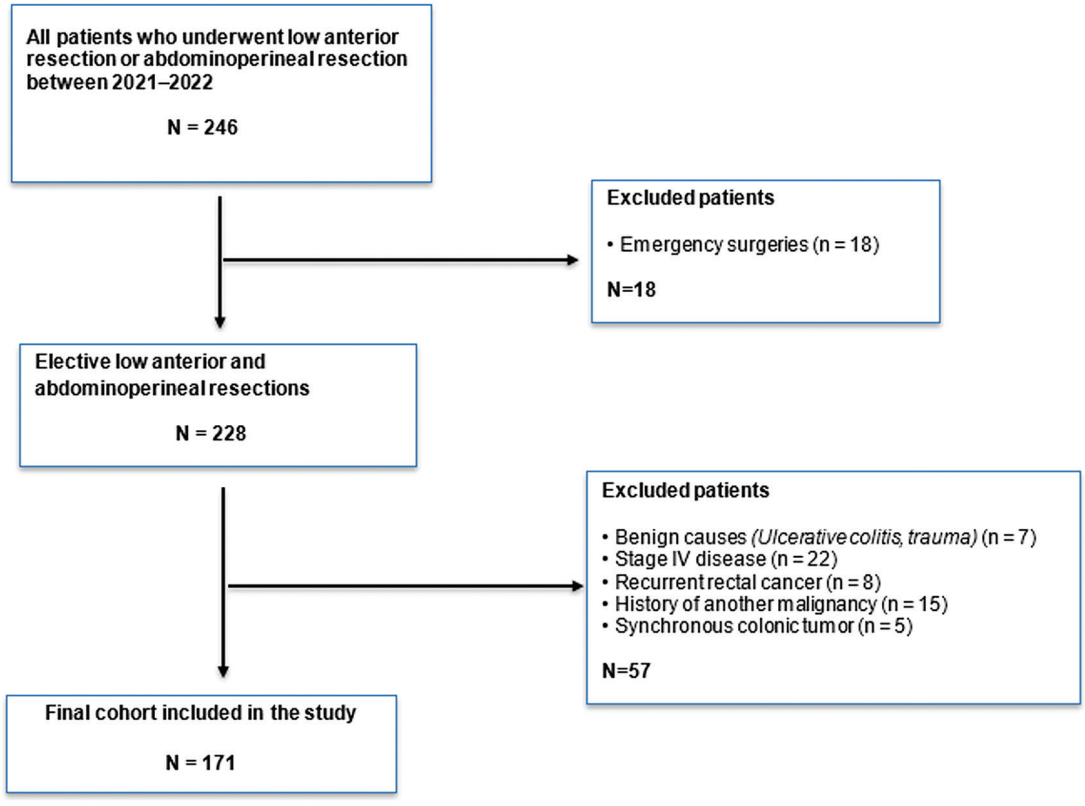

Figure 1. Flow diagram of the study.

[median 41 (IQR 4) vs. 43 (IQR 5.25), p=0.04] and larger tumor size [median 5.0 cm (IQR 3.0) vs. 3.8 cm (IQR 2.5), p=0.05] compared to those with near complete/complete TME. Previous abdominal surgery was more frequent in the incomplete TME group (37.5% vs. 13.9%, p=0.02). Tumors located closer to the anal verge were strongly associated with incomplete TME [median distance 5.0 cm (IQR 6.0) vs. 9.0 cm (IQR 9.0), p<0.001]. Presence of LVI was higher in patients with incomplete TME (22.4% vs. 10.0%, p=0.04). CRM positivity showed the strongest association, being markedly higher in the incomplete group (50.0% vs. 11.8%, p<0.001). Other variables, including age, BMI, ASA score, neoadjuvant therapy, T stage, and surgical procedure, showed no statistically significant differences between groups (Table 4).

DISCUSSION

The quality of TME is widely regarded as a key indicator of the adequacy of rectal cancer surgery. However, whether this attributed importance truly translates into clinically meaningful outcomes has remained a subject of debate. In the present study, we retrospectively analyzed data from 171 patients and found that complete or near-complete TME quality was achieved in approximately 84% of cases, while the rate of positive CRM was 11.8%. In our multivariable Cox regression analysis, incomplete TME was found to be independently associated with worse OS, with a 2.53-fold increased risk of mortality compared to patients with near complete/complete TME. Notably, previous studies investigating the prognostic impact of TME quality have reported inconsistent results, likely due to substantial heterogeneity in study designs, patient populations, and outcome definitions.

In the study by Garoufalia et al. (12), retrospective single-center data were analyzed, and incomplete TME was not found to be associated with any disadvantage in terms of DFS. In this cohort, where complete/near-complete TME was achieved in the majority of patients (87%), the reported rate of pathological CRM positivity was 4.8%. Notably, only 15% of the patients had not received neoadjuvant therapy, and no statistically significant difference in CRM positivity was observed between the complete/near-complete and incomplete TME groups. When comparing these findings with our study, several key distinctions should be highlighted. Our sample size was larger (171 vs. 124),

Table 1. Demographic and baseline characteristics of the study cohort (n=171)

Parameter	Value
Age (years), mean ± SD	62.4±11.4
Sex, n (%) - Female - Male	 69 (40.4%) 102 (59.6%)
BMI (kg/m^2), mean ± SD	26.3±4.2
ASA score, n (%) - Low (I-II) - High (III-IV)	 149 (87.6%) 21 (12.4%)
Charlson comorbidity index, median (IQR)	4 (2)
Albumin (g/L), median (IQR)	41.5 (5)
Smoking status, n (%) - Yes - No	 75 (45.0%) 92 (55.0%)
Previous abdominal surgery, n (%) - Yes - No	 20 (11.8%) 150 (88.2%)
Neoadjuvant therapy, n (%) - Yes - No	 74 (43.8%) 95 (56.2%)
Length of stay (day), median (IQR)	6 (2)
Mortality, n (%) - Yes - No	 38 (22.2%) 133 (77.8%)
Follow-up (months), median (IQR)	42 (13)

SD: Standard deviation, BMI: Body mass index, IQR: Interquartile range, ASA: American Society of Anesthesiologists.

Table 2. Surgical and tumor-related characteristics of the study cohort (n=171)

Parameter	Value
Distance from anal verge (cm), median (IQR)	8 (9)
Type of surgery, n (%) - LAR - Hartmann's procedure - APR	 109 (63.7%) 35 (20.5%) 27 (15.8%)
T stage, n (%) - Early (Tis, T0, T1, T2, T3) - Advanced (T4)	 138 (81.2%) 32 (18.8%)
N stage, n (%) - N0 - N1 - N2	 108 (63.5%) 41 (24.1%) 21 (12.4%)
Number of harvested lymph nodes, median (IQR)	15 (9.75)
Number of positive lymph nodes, median (IQR)	0.0 (1.0)
Lymphovascular invasion, n (%) - Yes - No	 87 (53.4%) 76 (46.6%)
Perineural invasion, n (%) - Yes - No	 54 (33.1%) 109 (66.9%)
TME quality, n (%) - Incomplete - Near complete - Complete	 25 (16.2%) 50 (32.5%) 79 (51.3%)
Distal resection margin, n (%) - Positive - Negative	 8 (4.7%) 163 (95.3%)
Circumferential resection margin, n (%) - Positive - Negative	 20 (11.8%) 150 (88.2%)

IQR: Interquartile range, TME: Total mesorectal excision, LAR: Low anterior resection, APR: Abdominoperineal resection.

Table 3. Cox proportional hazards regression analysis for overall survival		
Variable	**HR (univariable)**	**HR (multivariable)**
Type of surgery (Hartmann's vs. others)	5.64 (2.70-11.76), p<0.001	4.60 (2.04-10.38), p<0.001
TME quality (incomplete vs. others)	2.81 (1.31-6.02), p=0.008	2.53 (1.15-5.59), p=0.021
N stage (positive vs. negative)	2.05 (1.00-4.19), p=0.051	1.97 (0.93-4.20), p=0.078
Charlson comorbidity index (per 1-point increase)	1.23 (1.04-1.45), p=0.016	1.04 (0.87-1.24), p=0.701
Albumin (per 1 g/dL increase)	0.93 (0.88-0.99), p=0.024	0.98 (0.92-1.05), p=0.594
HR: Hazard ratio, TME: Total mesorectal excision.		

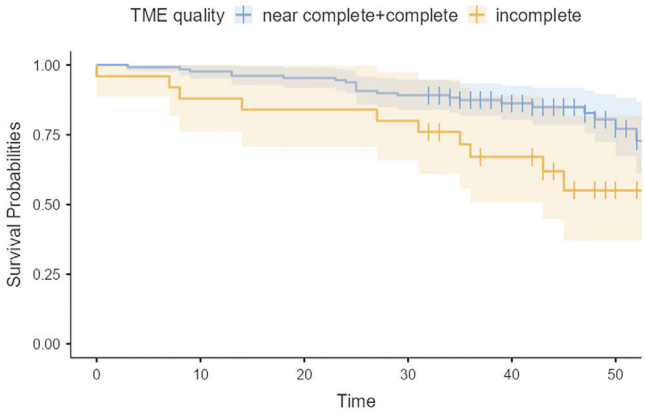

Figure 2. Kaplan-Meier overall survival curves stratified by TME quality (near complete/complete vs. incomplete). Patients with incomplete TME had significantly worse overall survival compared with those with near complete/complete TME (Log-rank χ^2=7.01, p=0.008).

TME: Total mesorectal excision

and the proportion of patients who did not receive neoadjuvant therapy was considerably higher (56.2%). While the rate of achieving complete/near-complete TME was comparable, the CRM positivity rate in our cohort was higher (11.8%). Since neoadjuvant therapy is known to facilitate tumor downstaging and reduce radiologic CRM involvement, the lower rate of neoadjuvant treatment in our population may partly explain the relatively higher incidence of CRM positivity observed. Nevertheless, our reported CRM involvement rate remains consistent with previously published literature (13). Our lower rate of neoadjuvant therapy utilization may partly be explained by the impact of the coronavirus disease-2019 pandemic during the years when our patients underwent surgery, as a surgery-first approach was often preferred to minimize prolonged hospital visits and potential treatment-related risks. Additionally, the proportion of early-stage tumors in our cohort might be higher compared to other studies. However, due to the lack of detailed data on this aspect, we acknowledge this as a limitation of our study.

In our study, the rate of CRM positivity was 50% in the incomplete TME group compared to 11.8% in the complete/near-complete TME group, and this difference was statistically significant. The fact that we identified TME quality as a significant factor influencing OS, while the other study did not find an association with DFS, may be partly explained by this difference in CRM involvement. We believe that the higher rate of CRM positivity in our incomplete TME group is the primary driver of poorer survival outcomes. The recent 2025 study by Alipouriani et al. (14) supports this interpretation. In this study, patients with incomplete TME were stratified based on CRM involvement, and it was demonstrated that the combination of incomplete TME and CRM involvement was associated with increased local recurrence and, similar to our findings, reduced OS. In that study, the 36-month OS rates were approximately 88% for patients without CRM involvement and 48% for those with CRM involvement, whereas in our cohort, the 36-month OS was 86.3% in the near-complete/complete TME group compared to 68.3% in the incomplete TME group. In a study evaluating the prognostic value of assessing TME quality using a two-tier versus three-tier classification system, it was found that patients with complete TME had significantly better DFS and OS compared with those classified as near-complete or incomplete TME (11).

Despite the studies that report findings consistent with ours, a broader review of the literature reveals that most studies have not demonstrated a significant association between TME quality and OS. However, there is comparatively stronger evidence suggesting that incomplete TME is associated with higher rates of local and overall recurrence (9,10,15-17). One of the pioneering studies on this topic, conducted by Nagtegaal et al. (8), presented intriguing findings regarding the impact of TME quality on patient prognosis. They argue that although CRM involvement is significantly higher in the incomplete TME group, the negative impact of incomplete TME on oncologic outcomes cannot be explained solely by its association with CRM. In their analysis excluding CRM-positive cases, overall recurrence remained significantly higher in the incomplete TME group, while no difference in OS was observed. Furthermore, the study emphasizes that the coexistence of incomplete TME and CRM positivity does not always indicate poor surgical quality, as it may also result from advanced tumor size. In our cohort, although there was no significant difference in the distribution of T4 tumors between the incomplete and complete/near-complete TME groups, the median tumor size was notably larger in the incomplete TME group, approaching statistical

Table 4. Factors associated with TME quality			
Variable	**Incomplete TME (n=25)**	**Near complete/complete TME (n=129)**	**p-value (death)**
Age (years), mean ± SD	60.6±14.9	62.2±10.6	p=0.52[3]
Sex (n, %) - Female - Male	 10 (16.4%) 15 (16.1%)	 51 (83.6%) 78 (83.9%)	p=0.96[1]
BMI (kg/m^2), mean ± SD	26.1±4.0	26.5±4.2	p=0.68[3]
ASA score, n (%) - Low (I-II) - High (III-IV)	 23 (17.2%) 2 (10.0%)	 111 (82.8%) 18 (90.0%)	p=0.53[2]
Albumin (g/L), median (IQR)	41 (4)	43 (5.25)	p=0.04[4]
Tumor size (cm), median (IQR)	5 (3)	3.8 (2.5)	p=0.05[4]
Previous abdominal surgery, n (%) - Yes - No	 6 (37.5%) 19 (13.9%)	 10 (62.5%) 118 (86.1%)	p=0.02[2]
Neoadjuvant therapy, n (%) - Yes - No	 10 (14.3%) 15 (18.3%)	 60 (85.7%) 67 (81.7%)	p=0.50[1]
Distance from anal verge (cm), median (IQR)	5 (6)	9 (9)	p<0.001[4]
Type of surgery, n (%) - Hartmann's procedure - LAR/APR	 8 (26.7%) 17 (13.7%)	 22 (73.3%) 107 (86.3%)	p=0.10[2]
T stage, n (%) - Early (Tis, T0, T1, T2, T3) - Advanced (T4)	 19 (15.%) 6 (22.2%)	 108 (85.0%) 21 (77.8%)	p=0.35[1]
Lymphovascular invasion, n (%) - Yes - No	 17 (22.4%) 7 (10.0%)	 59 (77.6%) 63 (90.0%)	p=0.04[1]
Circumferential resection margin, n (%) - Positive - Negative	 9 (50.0%) 16 (11.8%)	 9 (50.0%) 120 (88.2%)	p<0.001[2]

Statistical tests: [1]: Chi-square test; [2]: Fisher's exact test; [3]: Independent samples t-test, [4]: Mann-Whitney U test, SD: Standard deviation, BMI: Body mass index, IQR: Interquartile range, ASA: American Society of Anesthesiologists, TME: Total mesorectal excision, LAR: Low anterior resection, APR: Abdominoperineal resection.

significance (p=0.05). This finding suggests that larger tumors may underlie both the higher rate of incomplete TME and the increased frequency of margin involvement. In recent findings derived from population-based data (17), only 8% of patients were reported to have incomplete TME. Incomplete TME was identified as an independent risk factor for local recurrence (HR=2.73, 95% CI 1.07-7.0). However, no significant association was found between TME quality and distant metastasis or OS. The absence of an OS difference in such a large sample size represents an important finding that warrants consideration.

In our multivariable Cox regression analyses, undergoing a Hartmann procedure had the strongest negative impact on OS, indicating its potential influence on long-term oncological outcomes. In our clinical practice, the Hartmann procedure is typically reserved for older patients with significant comorbidities, impaired physiological status, or unfavorable intraoperative findings, rather than being routinely performed in elective rectal cancer surgery. Similar practice patterns are also reported in the literature, where Hartmann is generally preferred for patients with higher surgical risk or advanced disease (18). Therefore, the higher mortality and poorer OS observed in this subgroup are not unexpected (19,20).

Regarding factors associated with TME quality, we found that lower serum albumin levels, a history of previous abdominal surgery, shorter tumor distance from the anal verge, presence of LVI, and CRM involvement were all significantly correlated with poorer TME quality. Previous abdominal surgery can result in adhesions and distorted anatomical planes, making sharp dissection technically more challenging compared to a virgin abdomen (21,22).

Consequently, the quality of surgical resection may be compromised, which can naturally lead to a higher rate of incomplete TME. In low-lying rectal tumors, the risk of CRM involvement increases (23). As the tumor approaches the anal canal, invasion into adjacent structures such as the prostate or

vaginal wall becomes more likely. Moreover, advancing distally within the narrow pelvic anatomy is technically challenging, which may lead to a higher likelihood of TME plane violations. Lower albumin levels may reflect an increased tumor burden or subclinical obstruction rather than being a direct cause of poorer TME quality, suggesting that albumin may serve as a surrogate marker of more aggressive disease biology (24). Likewise, the presence of LVI is typically associated with more advanced tumor characteristics, which could inherently predispose patients to suboptimal TME planes (25).

Study Limitations

There are several important limitations should be acknowledged. First, the sample size was relatively small and therefore insufficient to reliably evaluate multiple outcomes. Second, this study was based on retrospective data from a single center, which may limit the generalizability of the results. In addition, the retrospective nature of the study precluded the availability of standardized intraoperative documentation, such as surgical assessment of TME quality or photographic recording of the specimen and pelvic operative field, and TME quality assessment relied primarily on pathological evaluation. Moreover, while the relationship between incomplete TME and local recurrence is of particular interest, our analysis was limited by the lack of data on local recurrence, distant metastasis, and DFS. Despite these limitations, our study also has several strengths. Our institution is a high-volume, referral center for colorectal cancer surgery, where resections are performed by experienced colorectal surgeons. Furthermore, all specimens were assessed by gastrointestinal pathologists with substantial expertise. Reporting long-term oncological outcomes in relation to TME quality from such a specialized, high-volume center provides valuable insights and contributes meaningfully to the ongoing discussion in the literature.

CONCLUSION

This study demonstrated that near-complete or complete TME was independently associated with better OS in patients with rectal cancer. However, these findings are based on a single-center retrospective cohort with a relatively small sample size and should be interpreted with caution. Further large-scale, prospective studies focusing on TME quality as a primary outcome are warranted to validate these results and provide more robust evidence.

Ethics

Ethics Committee Approval: Ethical approval was obtained from the Clinical Research Ethics Committee of the Marmara University Faculty of Medicine (approval number: 09.2025.25-0364, date: 18.04.2025).

Informed Consent: As this was a retrospective study using anonymized data, individual informed consent was waived by the Ethics Committee of Marmara University Faculty of Medicine (approval no: 09.2025.25-0364).

Footnotes

Author Contributions

Concept - A.B., M.İ.A., M.F.T., L.S.Ş., W.A.; Design - A.B., M.İ.A., M.F.T., L.S.Ş., W.A.; Data Collection or Processing - A.B., B.D., A.U.C.; Analysis or Interpretation - A.B., B.D., AU.C., M.F.T., L.S.Ş., W.A.; Literature Search - A.B., B.D., M.F.T., L.S.Ş.; Writing - A.B., M.İ.A., A.U.C., M.F.T., W.A.

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Supplementary Table S1. Univariate analyses of factors associated with 36-month mortality			
Variable	**Death no (n=86)**	**Death yes (n=34)**	**p-value (death)**
Age (years), mean ± SD	62.1±10.1	63.7±15.1	p=0.43[3]
ASA score, n (%) - Low (I-II) - High (III-IV)	 121 (81.2%) 12 (57.1%)	 28 (18.8%) 9 (42.9%)	p=0.02[2]
Charlson comorbidity index, median (IQR)	4 (2)	5 (4)	p=0.005[4]
Albumin (g/L), median (IQR)	42 (5)	40 (8)	p=0.03[4]
Neoadjuvant therapy, n (%) - Yes - No	 55 (74.3%) 77 (81.1%)	 19 (25.7%) 18 (18.9%)	p=0.29[1]
Distance from anal verge (cm), median (IQR)	9 (9.2)	7 (8)	p=0.41[4]
Type of surgery, n (%) - Hartmann's procedure - LAR/APR	 16 (45.7%) 117 (86%)	 19 (54.3%) 19 (14%)	p<0.001[1]
T stage, n (%) - Early (Tis, T0, T1, T2, T3) - Advanced (T4)	 109 (79%) 24 (75%)	 29 (21%) 8 (25%)	p=0.62[1]
N stage, n (%) - N0 - N+	 92 (85.2%) 41 (66.1%)	 16 (14.8%) 21 (33.9%)	p=0.004[1]
Number of positive lymph nodes, median (IQR)	0 (1)	0 (2)	p=0.07[4]
Perineural invasion, n (%) - Yes - No	 36 (66.7%) 90 (82.6%)	 18 (33.3%) 19 (17.4%)	p=0.02[1]
TME quality, n (%) - Incomplete - Near complete/complete	 15 (60.0%) 107 (82.9%)	 10 (40.0%) 22 (17.1%)	p=0.01[1]
Distal resection margin, n (%) - Positive - Negative	 6 (75%) 127 (77.9%)	 2 (25%) 36 (22.1%)	p=1.00[2]
Circumferential resection margin, n (%) - Positive - Negative	 10 (50%) 123 (82%)	 10 (50%) 27 (18%)	p=0.003[2]

Statistical tests: [1]: Chi-square test, [2]: Fisher's exact test, [3]: Independent samples t-test, [4]: Mann-Whitney U test, SD: Standard deviation, IQR: Interquartile range, ASA: American Society of Anesthesiologists, LAR: Low anterior resection, APR: Abdominoperineal resection, TME: Total mesorectal excision.

Supplementary Table S2. Multivariate logistic regression analysis identifying independent predictors of 36-month mortality			
Predictor	**Odds ratio**	**95% CI**	**p-value**
Charlson comorbidity index (per 1-point increase)	1.34	1.01-1.77	0.03
Albumin (per 1 g/dL increase)	0.98	0.89-1.08	0.76
Type of surgery (Hartmann's vs. others)	5.35	1.77-16.15	0.003
TME quality (incomplete vs. others)	3.15	1.00-9.90	0.04
Perineural invasion (present vs. absent)	1.98	0.73-5.33	0.06
N stage (positive vs. negative)	2.65	0.95-7.40	0.44

TME: Total mesorectal excision, CI: Confidence interval.