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RESEARCH ARTICLE

Surgical and Oncologic Outcomes of Colorectal Cancer Across Age Groups:A Multicenter Retrospective Study from the Turkish Society of Colon and Rectal Surgery Registry

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ABSTRACT

Aim: This study aimed to perform a comparative analysis of colorectal surgery outcomes in elderly versus younger age groups of patients with colorectal cancer (CRC).

Method: A total of 1.216 patients who underwent colorectal surgery for malignancy were included in this retrospective database study. Data on preoperative characteristics and operative, postoperative, and histopathological parameters were compared across age groups (<50 years, 50-64 years, 65-79 years, and ≥80 years).

Results: The ≥80 years age group, when compared with younger age groups, was associated with the highest preoperative carcinoembryonic antigen levels (p<0.01) and higher rates of American Society of Anesthesiologists physical status 3 (45.3% vs. 3.4% in <50 years, 11.0% in 50-64 years, and 26.5% in 65-79 years, p<0.001), urgent surgery (16.3% vs. 7.0% in 65-79 years and 5.9% in 50-64 years, p=0.009), tumor perforation (9.3% vs. 2.9% in 65-79 years, p=0.031), and not receiving preoperative neoadjuvant therapy (p<0.001). In both the ≥80 years and 65-79 years age groups, colon cancer was significantly more prevalent (p<0.001), whereas pelvic magnetic resonance imaging (p<0.001) and positron emission tomography/computed tomography utilization (p<0.001) were less common than in younger age groups. No significant difference was noted between age groups in terms of surgical approach, length of operating time, postoperative complications, tumor clinicopathology, and regression scores.

Conclusion: Adopting a transdisciplinary model of care that incorporates comprehensive geriatric assessment tools is important to optimize surgical care in elderly patients with CRC, as appropriately selected individuals can achieve excellent outcomes when managed according to the same standards applied to younger patients.

Keywords: Colorectal cancer, colorectal surgery, neoadjuvant therapy, clinicopathological, postoperative complications, age stratification, elderly

Introduction

Colorectal cancer (CRC) remains a leading cause of cancer mortality, ranking second among individuals aged 60-79 years and third among those aged ≥80 years.[1-3] Although incidence increases with age, recent epidemiological trends show a rising incidence in patients under 50 years.[4,5]

Modern CRC management has evolved into a multimodal therapy combining neoadjuvant chemoradiation, surgery, and adjuvant chemotherapy.[6-9] However, elderly patients present unique challenges due to comorbidities, functional decline, advanced disease presentation, and the increased risk of treatment-related toxicity.[10-12] Consequently, patients aged ≥70 years often receive less aggressive treatment despite potentially curative options.[13-15]

Advancements in laparoscopic techniques and perioperative care have improved surgical safety in elderly patients.[16-18] with recent data showing better short-term survival after resection.[19,20] Yet current evidence remains limited by study design flaws, including a lack of younger control groups and the exclusion of open or emergency cases.[21-23]

There is insufficient data in the literature on age-stratified prospective outcome comparisons in elderly patients. This

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retrospective study performs an age-stratified analysis of preoperative, intraoperative, and postoperative outcomes in elderly versus younger patients with CRC to address these knowledge gaps.

Materials and Methods

This retrospective cohort study used data from the Turkish Society of Colon and Rectal Surgery (TSCRS) registry, collected from 20 centers. A total of 1.216 patients with CRC who underwent colorectal resection between July 2018 and December 2022 were analyzed. The multicenter registry includes detailed preoperative, intraoperative, and 30-day postoperative outcomes.

All participating centers adhered to the standard definitions in accordance with TSCRS guidelines and received training on data entry protocols. Regular audits were conducted to ensure accuracy and completeness. Ethical approval was obtained from the ethics committee of Republic of Türkiye Bursa Uludağ University Health Research Ethics Committee (decision no. 2025/579-7/12, dated: 19.03.2025). The principles of the Helsinki Declaration were followed, and informed consent was waived due to the retrospective design.

Assessment

Data were collected and compared across age groups (<50, 50-64, 65-79, and ≥80 years) in four main categories: patient and tumor characteristics, surgical parameters, and postoperative outcomes.

Preoperative evaluation included patient demographics (age, sex, body mass index, smoking status), American Society of Anesthesiologists (ASA) classification, comorbidities, family history of CRC or malignancy, and prior abdominal surgery. Tumor-related data consisted of presenting symptoms, tumor location, clinical tumor-node-metastasis (TNM) stage, diagnostic imaging [colonoscopy, pelvic magnetic resonance imaging (MRI), positron emission tomography/computed tomography (PET/CT)], presence of metastasis, carcinoembryonic antigen (CEA) and carbohydrate antigen 19-9 (CA 19-9) levels, and details of neoadjuvant therapy (if administered), including the interval between therapy and surgery. The recorded surgical parameters were the timing and type of surgery, surgeon experience, intraoperative tumor localization, distance from the anal verge, mesorectal dissection margin, additional organ resections, anastomosis or stoma type, operative duration, intraoperative blood loss, erythrocyte suspension transfusion, and intraoperative complications.

Postoperative outcomes assessed within 30 days included surgical site infection (SSI), abscess, evisceration, ileus, and reoperation. Pathological evaluation covered tumor histology, differentiation grade, pathological TNM stage, depth of tumor invasion, perforation status, distal and radial surgical margins, mesorectal dissection quality, and tumor regression score (indicating response to neoadjuvant therapy).

Completeness of data was assessed for each variable; variables with >10% missing data were excluded from analysis or handled using appropriate imputation methods.

Statistical Analysis

Statistical analysis was performed using MedCalc® Statistical Software version 19.7.2 (MedCalc Software Ltd, Ostend, Belgium; https://www.medcalc.org; 2021). The Shapiro-Wilk test was used to assess normal distribution. The chi-square test was used for the analysis of categorical variables. The Kruskal-Wallis test with post hoc Bonferroni-corrected Mann-Whitney U test was used to compare more than two independent, non-normally distributed variables. Data were expressed as mean ± standard deviation (SD), median (min-max), and percentage (%) where appropriate. A p-value of <0.05 was considered statistically significant.

Results

Patient Demographics and Baseline Characteristics

The mean ± SD age of patients was 62.8±12.4 years (range: 21-97 years), and men comprised 60.9% of the cohort. Overall, 42.5% of patients were in the 65-79-year age group and 35.9% were in the 50-64-year age group, whereas the <50-year and ≥80-year age groups represented 14.5% and 7.1% of patients, respectively (Table 1).

Comorbidities, ASA status, and family history of colorectal and other malignancies are presented in Table 1.

Preoperative Characteristics

Among patients with available data on presenting symptoms, bleeding (475/475, 100.0%), constipation (393/424, 92.7%), and anemia (191/216, 88.4%) were the most common manifestations (Table 2).

The tumor was located in the colon in 64.7% of patients, and most patients were diagnosed at clinical TNM stage III (40.3%) (Table 2).

A synchronous lesion on colonoscopy was identified in 18.2% of patients (polyp in 14.2%). Pelvic MRI, performed in 26.2% of patients, revealed clinical T3 disease in 61.3% and node-positive status in 69.2% of patients. PET/CT, performed in 38.4% of patients, revealed liver metastasis in 10.6% of patients (Table 2).

Median (min-max) CEA and CA 19-9 levels were 3.0 (0-4,362) ng/mL and 11.0(0-12,000) U/mL, respectively (Table 2).

Preoperative neoadjuvant therapy was administered to 30.9% of patients, most of whom received chemoradiotherapy (22.7%), and it was predominantly applied to those with rectal cancer. Time from neoadjuvant therapy to surgery was a median of 8 weeks (range: 0-72 weeks) (Table 2).

Table 1. Patient demographics and baseline characteristics

Age (year)	Mean ± SD	62.8±12.4
	Median (min-max)	64 (21-97)
Age groups, n (%)	<50 year	176 (14.5)
	50-64 year	437 (35.9)
	65-79 year	517 (42.5)
	≥80 year	86 (7.1)
Gender, n (%)		
Male		740 (60.9)
Female		476 (39.1)
Body mass index (kg/m²), mean ± SD		26.4±4.5
Smoking status, n (%)		
Non-smoker		744 (61.2)
Former smoker		321 (26.4)
Active smoker		151 (12.4)
ASA score, n (%)	1	284 (23.4)
	2	688 (56.6)
	3	230 (18.9)
	4	12 (1.0)
	5	2 (0.2)
Comorbid diseases, n (%)		
Hypertension		463 (88.5)
Diabetes mellitus		254 (74.9)
Coronary artery disease		158 (64.0)
Malignity		53 (38.4)
Chronic obstructive lung disease		52 (35.6)
Congestive heart failure		36 (27.7)
Stroke		27 (22.3)
Chronic renal failure		18 (16.4)
Other		207 (72.1)
Family history of colorectal cancer, n (%)		154 (12.7)
Family history of malignancy, n (%)		154 (12.7)
Lung cancer		75 (6.2)
Breast cancer		47 (3.9)
Gastric cancer		39 (3.2)
Bladder cancer		33 (2.7)
Gynecologic cancer		32 (2.6)
Hepatobiliary cancer		22 (1.8)
Thyroid cancer		6 (0.5)
Other		71 (5.8)
Previous abdominal surgery, n (%)		285 (23.4)

ASA: American Society of Anesthesiologists, SD: Standard deviation

Table 2. Preoperative characteristics

Disease/tumor characteristics, n (%)		
Presenting symptom		
Bleeding (n=475)		475 (100.0)
Constipation (n=424)		393 (92.7)
Anemia (n=216)		191 (88.4)
Abdominal pain (n=664)		531 (43.7)
Incidental diagnosis (n=89)		58 (65.2)
Diagnosis by screening (n=158)		99 (62.7)
Location of tumor		
Rectum		428 (35.2)
Colon		787 (64.7)
Clinical T stage	T1	78 (6.4)
	T2	213 (17.5)
	T3	669 (55.0)
	T4	256 (21.1)
Lymph node (N) status	Node negative	584 (48.0)
	Node positive	632 (52.0)
Metastasis (M) status	M0	1056 (87.0)
	M1	158 (13.0)
Clinical TNM stage	I	178 (17.6)
	II	295 (29.1)
	III	408 (40.3)
	IV	132 (13.0)
Imaging findings, n (%)		
Synchronous lesion on colonoscopy		221 (18.2)
Polyp		173 (14.2)
Cancer		48 (3.9)
Pelvic MRI utilization		318 (26.2)
MRI T stage	T1	11 (3.5)
	T2	56 (17.6)
	T3	195 (61.3)
	T4	56 (17.6)
MRI N stage	Node negative	98 (30.8)
	Node positive	220 (69.2)
PET-CT utilization		466 (38.4)
Liver metastasis at diagnosis, n (%)		129 (10.6)
Lung metastasis at diagnosis, n (%)		39 (3.2)
Other metastases at diagnosis, n (%)		15 (1.2)
Laboratory findings, median (min-max)		
CEA (ng/mL) (n=918)		3.0 (0-4,362)
CA 19-9 (U/mL) (n=806)		11.0 (0-12,000)

Table 2. Continued

Disease/tumor characteristics, n (%)	
Treatment characteristics	
Preoperative neoadjuvant therapy, n (%)	
No	839 (69.1)
Yes	375 (30.9)
Type of neoadjuvant therapy, n (%)	
Radiotherapy	29 (2.4)
Chemotherapy	70 (5.8)
Chemoradiotherapy	276 (22.7)
Neoadjuvant therapy-surgery interval (weeks) (n=375), median (min-max)	8 (0-72)

CEA: Carcinoembryonic antigen, Positron emission tomography/computed tomography, MRI: Magnetic resonance imaging, TNM: Tumor-node-metastasis

Operative and Postoperative Characteristics

The majority of patients underwent elective colorectal surgery (92.8%) performed by a specialist (94.1%) using either an open (51.6%) or laparoscopic (43.8%) approach. Low anterior resection (32.1%), anterior resection (25.2%), and right hemicolectomy (16.7%) were the most common surgical procedures (Table 3).

The rectum (31.9%) and sigmoid colon (20.8%) were the most frequent intraoperative tumor locations. Anastomosis was performed in 88.7% of patients (mechanical stapling in 81.3%), whereas a stoma was created in 31.2% of patients (loop ileostomy in 23.6%) (Table 3).

The median operating time was 170 minutes (range: 45-625 minutes). Spleen injury (25.6%), ureter injury (14.3%), and bladder injury (12.2%) were the most common intraoperative complications (Table 3).

Occurring in 32.4% of patients, postoperative complications included SSI (14.0%), ileus (7.6%), reoperation (6.6%), abscess (2.6%), and evisceration (1.6%) (Table 3).

Tumor Histopathology and Regression Scores Related to Neoadjuvant Therapy

Adenocarcinoma was the predominant histological type (87.3%), and 47.0% of tumors were moderately differentiated. Pathological TNM staging revealed stage II (28.4%) or stage III (26.7%) disease in most patients (Table 4).

Lymphatic, vascular, and perineural tumor invasion were present in 48.0%, 38.3%, and 25.1% of patients, respectively. Tumor perforation was observed in 4.4% of patients. A positive radial surgical margin was found in 3.5%, and partial mesorectal dissection margin involvement was noted in 23.0% of patients (Table 4).

Different scoring systems for assessing neoadjuvant therapy response and relevant results are given in Table 4. Preoperative characteristics by age group

In the ≥80 years age group, ASA 3 status (45.3% vs. 3.4% in the <50 years, 11.0% in the 50-64 years, and 26.5% in the 65-79 years age groups, p<0.001) was significantly more common, whereas family history of CRC (3.5% vs. 14.9% in the 50-64 years and 17.6% in the <50 years age groups, p=0.002) and presentation with constipation (80.6% vs. 95.9% in the 65-79 years age group, p=0.004) were significantly less common than in younger age groups (Table 5).

In both the ≥80 years and 65-79 years age groups, colon cancer was significantly more prevalent (80.2% and 69.1%, respectively, vs. 59.7% in the 50-64 years and 56.8% in the <50 years age groups, p<0.001), whereas pelvic MRI utilization (12.8% and 21.3%, respectively, vs. 31.6% in the 50-64 years and 33.5% in the <50 years age group, p<0.001) and PET-CT utilization (30.6% and 32.2%, respectively, vs. 45.5% in the 50-64 years and 45.5% in the <50 years age groups, p<0.001) were less common than in younger age groups (Table 5).

The ≥80 years age group had the highest preoperative CEA levels [median (min-max) 6.5 (1-157) ng/mL, p<0.01], and the <50 years age group had the lowest [median (min-max) 2.0 (0-1,000) ng/mL, p<0.01] compared with other age groups (Table 5).

A total of 375 patients (30.9%), the vast majority of whom had rectal cancer, received neoadjuvant therapy. Patients in the ≥80 years age group were more likely to have had no preoperative neoadjuvant therapy (87.2% vs. 74.5% in the 65-79 years, 62.5% in the 50-64 years, and 61.4% in the <50 years age groups, p<0.001) or were less likely to have received neoadjuvant chemoradiotherapy (5.8% vs. 18.0% in the 65-79 years, 29.3% in the 50-64 years, and 28.4% in the <50 years age groups, p<0.001) than younger age groups (Table 5).

Table 3. Operative and postoperative characteristics

Colorectal surgery	
Timing of surgery, n (%)	
Urgent	88 (7.2)
Elective	1.128 (92.8)
Performing surgeon, n (%)	
Specialist	1.144 (94.1)
Fellow	72 (5.9)
Type of surgery, n (%)	
Open surgery	628 (51.6)
Laparoscopic surgery	532 (43.8)
Hand-assisted laparoscopic surgery	4 (0.3)
Robotic surgery	52 (4.3)
Surgical intervention, n (%)	
Low anterior resection	390 (32.1)
Anterior resection	306 (25.2)
Right hemicolectomy	203 (16.7)
Extended right hemicolectomy	79 (6.5)
Subtotal colectomy	76 (6.3)
Left hemicolectomy	75 (6.2)
Abdominoperineal resection	74 (6.1)
Total proctocolectomy	13 (1.1)
Intraoperative characteristics	
Intraoperative location of tumor, n (%)	
Rectum	388 (31.9)
Sigmoid colon	253 (20.8)
Rectosigmoid	169 (13.9)
Ascending colon	111 (9.1)
Cecum	104 (8.6)
Hepatic flexure	62 (5.1)
Transverse colon	48 (3.9)
Descending colon	45 (3.7)
Splenic flexure	36 (3.0)
Tumor distance to anal verge (n=384), median (min-max)	7.0 (0.0-15.0)
Mesorectal dissection margin, n (%)	
Partial	132 (10.9)
Total	278 (22.9)
Same session additional surgical intervention, n (%)	186 (15.3)
Cholecystectomy	59 (4.9)
Incisional hernia	1 (0.1)
Inguinal hernia	3 (0.2)
Other	123 (10.1)

Table 3. Continued

Intraoperative characteristics	
Additional organ resection due to tumor invasion, n (%)	114 (9.4)
Anastomosis (n=1,142), n (%)	1,078 (88.7)
Mechanical stapling	988 (81.3)
Hand-sewn	90 (7.4)
Stoma (n=1,145), n (%)	379 (31.2)
Loop ileostomy	287 (23.6)
End stoma	57 (4.7)
Double barrel stoma	16 (1.3)
Loop colostomy	12 (1.0)
Other	7 (0.6)
Length of operating time (min), median (min-max)	170.0 (45.0-625.0)
Intraoperative complications, n (%)	
Spleen injury	11(25.6)
Ureter injury	6 (14.3)
Bladder injury	5 (12.2)
Small intestine injury	4 (9.8)
Pancreatic injury	4 (9.8)
Proximal colon ischemia	3 (7.7)
Presacral bleeding	2 (5.3)
Colon injury	2 (5.1)
Liver injury	2 (5.1)
Iliac vessel injury	1 (2.7)
Duodenal injury	1 (2.6)
Other	6 (14.6)
Estimated blood loss (mL), median (min-max)	100.0 (0.0-1,500.0)
Intraoperative use of erythrocyte suspension, n (%)	64 (5.3)
Postoperative complications, n (%)	394 (32.4)
Surgical site infection	170 (14.0)
Ileus	92 (7.6)
Reoperation	80 (6.6)
Abscess	32 (2.6)
Evisceration	20 (1.6)

No significant difference was noted between age groups in terms of previous abdominal surgery, incidental or screening-based diagnosis rates, clinical TNM stage, or presence of synchronous lesions on colonoscopy (Table 5).

Type of surgery and postoperative complications by age group

In the ≥80 years age group, urgent surgery was significantly more common than in the 65-79 years and 50-64 years age groups (16.3% vs. 7.0% and 5.9%, respectively, p=0.009). No significant difference was noted between age groups in terms of surgical approach (open, laparoscopic, robotic, or hand-assisted laparoscopic surgery) and length of operating time (Table 6).

No significant difference was noted between age groups in terms of postoperative complications (Table 6). Tumor histopathology and tumor regression scores by age group

In the ≥80 years age group, tumor perforation was significantly more common than in the 65-79 years age group (9.3% vs. 2.9%, p=0.031) (Table 7).

Table 4. Tumor histopathology and neoadjuvant therapy regression scores

Histological type, n (%)	
Adenocarcinoma	1.068 (87.3)
Mucinous	131 (10.8)
Signet-ring cell	10 (0.8)
Medullary	1 (0.1)
Tumor differentiation, n (%)	
Unknown	160 (13.2)
Poorly differentiated	168 (13.8)
Moderately differentiated	572 (47.0)
Well-differentiated	308 (25.3)
Pathological TNM staging, n (%)	
T stage	
T0	71 (5.8)
Tis	5 (0.4)
T1	63 (5.2)
T2	155 (12.8)
T3	609 (50.1)
T4a	245 (20.2)
T4b	68 (5.6)
N stage	
N0	**693 (57.0)**
N1a	**116 (9.5)**
N1b	**142 (11.7)**
N1c	**32 (2.6)**
N2a	**106 (8.7)**
N2b	**127 (10.4)**
M stage	
M0	1,053 (86.6)
M1a	108 (8.9)
M1b	29 (2.4)
M1c	26 (2.1)
Pathological TNM stage	
0	56 (4.6)
I	147 (12.1)
IIa	276 (22.7)
IIb	54 (4.4)
IIc	16 (1.3)
IIIa	26 (2.1)
IIIb	191 (15.7)
IIIc	109 (8.9)
IVa	90 (7.4)
IVb	20 (1.6)
IVc	23 (1.9)

Table 4. Continued

Tumor invasion, n (%)	
Lymphatic invasion	584 (48.0)
Vascular invasion	466 (38.3)
Perineural invasion	305 (25.1)
Tumor perforation	54 (4.4)
Surgical margins, n (%)	
Radial surgical margin involvement, n (%)	42 (3.5)
Mesorectal dissection quality, n (%)	
Partial	280 (23.0)
Total	26 (2.1)
Tumor regression score, n (%)	
AJCC (Modified Ryan) scale	125 (10.3)
0 (complete response)	22 (17.6)
1 (near complete response)	26 (20.8)
2 (partial response)	48 (38.4)
3 (poor or no response)	29 (23.2)
Dworak scale	77 (6.3)
0 (no response)	2 (2.6)
1 (minimal response)	12 (15.6)
2 (moderate response)	26 (33.8)
3 (near complete response)	19 (24.7)
4 (complete response)	18 (23.4)
Mandard scale	71 (5.8)
1 (no residual carcinoma)	17 (23.9)
2 (<10% residual carcinoma)	11 (15.5)
3 (10%-50% residual carcinoma)	27 (38.0)
4 (>50% residual carcinoma, outgrowing fibrosis)	9 (12.7)
5 (>50% residual carcinoma, no regressive changes)	7 (9.8)
Ryan scale	42 (3.5)
1 (good)	9 (21.4)
2 (moderate)	21 (50.0)
3 (poor)	12 (28.6)
Modified Dworak scale	5 (0.4)
5 (no response)	0
4 (minimal response)	0
3 (moderate response)	3 (60.0)
2 (near complete response)	2 (40.0)
1 (complete response)	0(0.0)

AJCC: American Joint Committee on Cancer, TNM: Tumor-node-metastasis

Table 5. Preoperative characteristics by age group

	<50 year (n=176)	50-64 year (n=437)	65-79 year (n=517)	≥80 year (n=86)	p-value[1]
ASA score					
1	112 (63.6)[a]	122 (27.9)[a]	46 (8.9)	4 (4.7)	
2	58 (33.0)	265 (60.6)[a]	327 (63.2)[a]	38 (44.2)	
3	6 (3.4)[a]	48 (11.0)[a]	137 (26.5)[a]	39 (45.3)	**<0.001**
4	0(0.0)	2 (0.5)	6 (1.2)	4 (4.7)	
5	0(0.0)	0 (0.0)	1 (0.2)	1 (1.2)	
Presenting symptom					
Bleeding (n=475)	79 (100)	179 (100)	185 (100)	28 (100)	-
Constipation (n=424)					
No	8 (12.3)	8 (6.3)	8 (4.1)	7 (19.4)	**0.004**
Yes	57 (87.7)	119 (93.7)	188 (95.9)[a]	29 (80.6)	
Abdominal pain (n=664)					
No	0	6 (3)	13 (6)	2 (4)	0.088
Yes	87(100.0)	191 (97.0)	205 (94.0)	48 (96.0)	
Anemia (n=216)					
No	4(18.2)	5 (9.1)	12 (10.5)	4 (16)	0.600
Yes	18(81.8)	50 (90.9)	102 (89.5)	21 (84)	
Screening (n=158)					
No	9(47.4)	21 (33.3)	23 (34.8)	6 (60.0)	0.306
Yes	10(52.6)	42 (66.7)	43 (65.2)	4 (40.0)	
Incidental (n=89)					
No	6(54.5)	9 (30)	12 (28.6)	4 (66.7)	0.133
Yes	5(45.5)	21(70.0)	30 (71.4)	2 (33.3)	
Family history of colorectal cancer					
Yes	31 (17.6)[a]	65 (14.9)[a]	55 (10.6)	3 (3.5)	**0.002**
No	145 (82.4)	371 (84.9)	462 (89.4)	83 (96.5)	
Previous abdominal surgery					
Yes	34 (19.3)	108 (24.8)	119 (23.1)	24 (27.9)	0.380
No	142 (80.7)	328 (75.2)	396 (76.9)	62 (72.1)	
Tumor location					
Colon	100 (56.8)[a,b]	261(59.7)[a,b]	357 (69.1)	69 (80.2)	**<0.001**
Rectum	76 (43.2)	176 (40.3)	159 (30.8)	17 (19.8)	
Clinical T stage					
I	10 (5.7)	37 (8.5)	28 (5.4)	3 (3.5)	
II	25 (14.2)	76 (17.4)	93 (18)	19 (22.1)	0.151
III	93 (52.8)	246 (56.3)	286 (55.3)	44 (51.2)	
IV	48 (27.3)	78 (17.8)	110 (21.3)	20 (23.3)	

Table 5. Continued

	<50 year (n=176)	50-64 year (n=437)	65-79 year (n=517)	≥80 year (n=86)	p-value[1]
Clinical N stage					
0	75 (42.6)	205 (46.9)	258 (49.9)	46 (53.5)	0.257
I	101 (57.4)	232 (53.1)	259 (50.1)	40 (46.5)	
Clinical M stage					
0	148 (84.6)	381 (87.4)	453 (87.6)	74 (86)	0.750
I	27 (15.4)	55 (12.6)	64 (12.4)	12 (14)	
Clinical TNM stage					
I	22(15.7)	70 (19.2)	73 (16.9)	13 (17.3)	0.649
II	35(25)	100 (27.4)	135 (31.2)	25 (33.3)	
III	58(41.4)	152 (41.6)	171 (39.5)	27 (36.0)	
IV	25(17.9)	43 (11.8)	54 (12.5)	10 (13.3)	
Laboratory findings, median (min-max)					
CEA (ng/mL) (n=918)	2.0 (0-1,000)[aa]	3.0 (0-4,362)[aa,c]	3.0 (01,462)[aa,c]	6.5 (1-157)[c]	**0.002[2]**
CA 19-9 (U/mL) (n=806)	8.0 (0-6,520)	11 (0-12,000)	11 (0-1,751)	11 (1-2,000)	0.654[2]
Synchronous lesion on colonoscopy, n (%)					
Cancer	9 (5.1)	16 (3.7)	18 (3.5)	5 (5.8)	0.703
Polyp	21(11.9)	67 (15.3)	76 (14.7)	9 (10.5)	
None	146 (83)	354 (81)	423 (81.8)	72 (83.7)	
MRI T stage					
1	1 (1.7)	7 (5.1)	3 (2.7)	0	NA
2	8 (13.6)	25 (18.1)	20 (18.2)	3(27.3)	
3	36 (61)	85 (61.6)	68 (61.8)	6(54.5)	
4	14 (23.7)	21(15.2)	19 (17.3)	2(18.2)	
MRI N stage					
Node positive	47 (79.7)	93 (67.4)	72 (65.5)	8 (72.7)	0.258
Node negative	12 (20.3)	45 (32.6)	38 (34.5)	3 (27.3)	
Preoperative neoadjuvant therapy					
Chemoradiotherapy	50 (28.4)[a]	128 (29.3)[a]	93 (18.0)[a]	5 (5.8)	**<0.001**
Chemotherapy	12 (6.8)	30 (6.9)	27 (5.2)	1 (1.2)	
Radiotherapy	6 (3.4)	6 (1.4)	12 (2.3)	5 (5.8)[a]	
None	108 (61.4)[a]	273 (62.5)[a]	385 (74.5)[a]	75 (87.2)	

[1]Chi-square test, [2]Kruskal-Wallis test with post-hoc Bonferroni-corrected Mann-Whitney U test

[a] $p<0.05$ and [aa]$p<0.01$ compared with the ≥80 years age group, [b]$p<0.05$ compared with the 65-79 years age group, [c]$p < 0.01$ compared with the <50 year group. MRI: Magnetic resonance imaging, TNM: Tumor-node-metastasis, ASA: American Society of Anesthesiologists, CEA: Carcinoembryonic antigen, CA: Carbohydrate antigen

Distal margin distance was significantly shorter in both the ≥80 years and 65-79 years age groups than in younger age groups [median (min-max) 21 (0-86)] mm and 20 (0-114) mm, respectively, vs. 22 (0-72) mm in the 50-64 years age group and 26.5 (4-141) mm in the <50 years age group, p=0.008) (Table 7).

No significant difference was noted between age groups in terms of histological type, tumor differentiation, pathological TNM stage, tumor invasion, or tumor regression scores (Table 7).

There was a nonsignificant tendency for less frequent utilization of the Dworak scale in patients aged ≥80 years (0.0% vs. 22.5-27.0% in younger age groups) and more frequent utilization of the American Joint Committee on Cancer (AJCC) (modified Ryan) scale in the youngest (<50 years, 46.0%) and oldest (≥80 years, 50.0%) age groups (Table 7).

Discussion

Our findings in a retrospective cohort of patients undergoing colorectal surgery revealed significant differences in certain preoperative, operative/postoperative, and pathological characteristics across the age groups, which pertained mainly to the very elderly (≥80 years) versus younger age groups. Specifically, patients aged ≥80 years were more likely to have ASA 3 status and high preoperative CEA levels but less

Table 6. Type and timing of surgery and postoperative complications by age group

	<50 year (n=176)	50-64 year (n=437)	65-79 year (n=517)	≥80 year (n=86)	p-value[1]
Timing of surgery, n (%)					
Urgent	12 (6.8)	26 (5.9)[a]	36 (7.0)[a]	14 (16.3)	**0.009**
Elective	164 (93.2)	411 (94.1)	481 (93)	72 (83.7)	
Type of surgery, n (%)					
Open surgery	78 (44.3)	237 (54.2)	267 (51.6)	46 (53.5)	0.167
Laparoscopic surgery	92 (52.3)	181 (41.4)	221 (42.7)	38 (44.2)	
Robotic surgery	6 (3.4)	19 (4.3)	25 (4.8)	2 (2.3)	
Hand-assisted laparoscopic surgery	0 (0.0)	0 (0.0)	4 (0.8)	0(0.0)	
Length of operating time (min), median (min-max)	175 (55-480)	180 (45-620)	170 (50-625)	160 (45-360)	0.273[2]
Postoperative complications, n (%)					
Surgical site infection					
Yes	18 (10.2)	69 (15.8)	70 (13.5)	13 (15.1)	0.312
No	158 (89.8)	368 (84.2)	447 (86.5)	73 (84.9)	
Abscess					
Yes	7 (4.0)	13 (3.0)	8 (1.5)	4 (4.7)	0.159
No	169 (96)	424 (97)	509 (98.5)	82 (95.3)	
Evisceration					
Yes	1 (0.6)	3 (0.7)	14 (2.7)	2 (2.3)	0.055
No	175 (99.4)	434 (99.3)	503 (97.3)	84 (97.7)	
Ileus					
Yes	10 (5.7)	32 (7.3)	45 (8.7)	5 (5.8)	0.519
No	166 (94.3)	405 (92.7)	472 (91.3)	81 (94.2)	
Reoperation					
Yes	10 (5.7)	26 (5.9)	37 (7.2)	7 (8.2)	0.760
No	166 (94.3)	411 (94.1)	480 (92.8)	78 (91.8)	

[1]Chi-square test, [2]Kruskal-Wallis test with post-hoc Bonferroni-corrected Mann-Whitney U test

[a] p<0.05 compared with the ≥80 years age group

Table 7. Tumor histopathology and tumor regression scores by age group

	<50 year (n=176)	50-64 year (n=437)	65-79 year (n=517)	≥80 year (n=86)	p-value
Histological type, n (%)					
Adenocarcinoma NOS	154 (87.5)	378 (87.1)	460 (89.3)	76 (89.4)	0.828[1]
Mucinous	19 (10.8)	53 (12.2)	51 (9.9)	8 (9.4)	
Signet-ring cell	3 (1.7)	3 (0.7)	3 (0.6)	1 (1.2)	
Medullary	0	0	1 (0.2)	0	
Tumor differentiation, n (%)					
Unknown	28 (16)	64 (14.8)	56 (10.9)	12 (14)	0.418[1]
Poorly differentiated	21 (12)	63 (14.5)	70 (13.6)	14 (16.3)	
Moderately differentiated	87 (49.7)	189 (43.6)	253 (49.2)	43 (50.0)	
Well-differentiated	39 (22.3)	117 (27)	135 (26.3)	17 (19.8)	
Pathological TNM staging, n (%)					
T stage					
T0	21 (11.9)	27 (6.2)	21(4.1)	2 (2.3)	N/A
Tis	0 (0.0)	3 (0.7)	1 (0.2)	1 (1.2)	
T1	11 (6.3)	29 (6.6)	22 (4.3)	1 (1.2)	
T2	20 (11.4)	60 (13.7)	66 (12.8)	9 (10.5)	
T3	73 (41.3)	213 (48.7)	276 (53.4)	47 (54.7)	
T4a	37 (21.0)	84 (19.2)	103 (19.9)	21 (24.4)	
T4b	14 (8.0)	21 (4.8)	28 (5.4)	5 (5.8)	
N stage					
N0	96 (54.5)	256 (58.6)	292 (56.5)	49 (57.0)	N/A
N1a	14 (8.0)	40 (9.2)	53 (10.3)	9 (10.5)	
N1b	16 (9.1)	53 (10.3)	64 (12.4)	9 (10.5)	
N1c	5 (2.8)	12 (2.7)	15 (2.9)	0 (0.0)	
N2a	19 (10.8)	36 (8.2)	42 (8.1)	9 (10.5)	
N2b	26 (14.8)	40 (9.2)	51 (9.9)	10 (11.6)	
M stage					
M0	147 (83.5)	378 (86.5)	451(87.2)	77 (89.5)	N/A
M1a	20 (11.4)	39 (8.9)	43 (8.3)	6 (7.0)	
M1b	6 (3.4)	9 (2.1)	11 (2.1)	3 (3.5)	
M1c	3 (1.7)	11 (2.5)	12 (2.3)	0 (0.0)	
TNM stage					
0	15 (10.9)	23 (6.4)	15 (3.5)	3 (4.0)	N/A
1	19 (13.8)	57 (15.7)	65 (15.0)	6 (8.0)	
2a	24 (17.4)	100 (27.6)	126 (29.1)	26 (34.7)	
2b	10 (7.2)	17 (4.7)	21 (4.8)	6 (8.0)	
2c	6 (4.3)	2 (0.6)	8 (1.8)	0 (0.0)	
3a	2 (1.4)	16 (4.4)	7 (1.6)	1 (1.3)	
3b	21 (15.2)	61 (16.9)	94 (21.7)	15 (20.0)	
3c	17 (12.3)	40 (11)	43 (9.9)	9 (12.0)	
4a	18 (13)	32 (8.8)	34 (7.9)	6 (8.0)	
4b	3 (2.2)	4 (1.1)	10 (2.3)	3 (4.0)	
4c	3 (2.2)	10 (2.8)	10 (2.3)	0 (0.0)	

Table 7. Continued

	<50 year (n=176)	50-64 year (n=437)	65-79 year (n=517)	≥80 year (n=86)	p-value
Tumor invasion, n (%)					
Lymphatic invasion					
Yes	88 (50.3)	202 (46.2)	248 (48)	46 (53.5)	0.582[1]
No	87 (49.7)	235 (53.8)	269 (52)	40 (46.5)	
Vascular invasion					
Yes	77 (44.0)	167 (38.2)	189 (36.6)	33 (38.4)	0.381[1]
No	98 (56.0)	270 (61.8)	328 (63.4)	53 (61.6)	
Perineural invasion					
Yes	46 (26.3)	112 (25.6)	128 (24.8)	19 (22.1)	0.887[1]
No	129 (73.7)	325 (74.4)	389 (75.2)	67 (77.9)	
Tumor perforation					
Yes	7 (4.0)	24 (5.5)	15 (2.9)[a]	8 (9.3)	**0.031**
No	168 (96)	412 (94.5)	502 (97.1)	78 (90.7)	
Distal margin distance (mm), median (min-max)	26.5 (4-141)[a,b]	22 (0-72)[a,b]	20 (0-114)	21 (0-86)	0.008[2]
Tumor regression scales, n (%)					
Dworak	17 (27.0)	35 (25.4)	25 (22.5)	0 (0.0)	0.657[1]
Mandard	12 (19.0)	28 (20.3)	28 (25.2)	3 (30.0)	
Ryan	5 (7.9)	19 (13.8)	19 (13.8)	2 (20.0)	
AJCC (Modified Ryan)	29 (46.0)	54 (39.1)	54 (39.1)	5 (50.0)	
Modified Dworak	0 (0.0)	2 (1.4)	2 (1.4)	0 (0.0)	
Dworak score					
0 (no response)	1 (5.9)	1 (2.9)	0 (0.0)	-	0.264[1]
1 (minimal response)	1 (5.9)	7 (20.0)	4 (16.0)	-	
2 (moderate response)	3 (17.6)	13 (37.1)	10 (40.0)	-	
3 (near complete response)	4 (23.5)	9 (25.7)	6 (24.0)	-	
4 (complete response)	8 (47.1)	5 (14.3)	5 (20)	-	
Mandard score					
1 (no residual carcinoma)	5 (41.7)	5 (17.9)	6 (21.4)	1 (33.3)	N/A
2 (<10% residual carcinoma)	1 (8.3)	8 (28.6)	2 (7.1)	0 (0.0)	
3 (10%-50% residual carcinoma)	5 (41.7)	9 (32.1)	11 (39.3)	2 (66.7)	
4 (>50% residual carcinoma, outgrowing fibrosis)	0 (0.0)	3 (10.7)	6 (21.4)	0 (0.0)	
5 (>50% residual carcinoma, no regressive changes)	1 (8.3)	3 (10.7)	3(10.7)	0 (0.0)	
Ryan score					
1 (good)	3 (60)	4 (21.1)	2 (12.5)	0 (0.0)	N/A
2 (moderate)	2 (40)	9 (47.4)	9 (56.3)	1 (50)	
3 (poor)	0 (0.0)	6 (31.6)	5 (31.3)	1 (50)	
Modified Ryan score					
0 (complete response)	4 (14.3)	7 (13)	10 (26.3)	1 (20)	N/A
1 (near complete response)	7 (25)	14 (25.9)	5 (13.2)	0 (0.0)	
2 (partial response)	12 (42.9)	23 (42.6)	12 (31.6)	1 (20)	
3 (poor or no response)	5 (17.9)	10 (18.5)	11(28.6)	3 (60)	

Table 7. Continued

	<50 year (n=176)	50-64 year (n=437)	65-79 year (n=517)	≥80 year (n=86)	p-value
Modified Dworak score					
5 (no response)	-	0 (0.0)	0 (0.0)	-	N/A
4 (minimal response)	-	0 (0.0)	0 (0.0)	-	
3 (moderate response)	-	1(50)	2(66.7)	-	
2 (near complete response)	-	1(50)	1(33.3)	-	
1 (complete response)	-	0(0.0)	0(0.0)	-	

N/A: Not applicable

[1]Chi-square test, [2]Kruskal-Wallis test with post-hoc Bonferroni-corrected Mann-Whitney U test

[a] p<0.05 compared with the ≥80 years age group, [b]p<0.05 compared with the 65-79 years age group, TNM: Tumor-node-metastasis, NOS: Not otherwise specified, AJCC: American Joint Committee on Cancer

likely to present with constipation and to have a positive family history of CRC, whereas both the ≥80 years and 65-79 years age groups were associated with a higher rate of colon cancer, less common utilization of pelvic MRI and PET-CT, and shorter distal margin distance than younger age groups. Notably, patients in the ≥80 years age group were more likely to have tumor perforation and urgent surgery, along with a lesser likelihood of receiving preoperative neoadjuvant therapy overall and neoadjuvant chemoradiotherapy in particular, than younger age groups.

Elderly patients with CRC are considered to be at particular risk of emergency admission, which often necessitates prompt treatment with urgent rather than elective surgery, leading to a higher risk of postoperative complications and perioperative mortality.[1] The more advanced tumor stage and poor physical status (ASA scores ≥3) of elderly patients are also considered additional risk factors in an emergency presentation, alongside the increased frequency of postoperative morbidity and mortality with progressive age.[1,2]

Postoperative complication rates in the ≥80 years age group (36.0%) and in younger age groups (34.5%) in our cohort are consistent with previous colorectal surgery studies, which reported complication rates ranging from 32.7% to 53.7% for patients aged ≥80 years and from 19.7% to 55.9% for younger age groups.[3-8]

Notably, our patients aged ≥80 years had the highest preoperative CEA levels and higher rates of ASA 3 status, tumor perforation, and urgent surgery, along with a higher prevalence of tumors localized to the colon, than younger patients, all of which are considered risk factors for increased postoperative complications and morbidity.[1,9,10] However, despite the presence of these potential risk factors in the elderly group, postoperative complication rates appeared to be similar across the age groups.

Although elderly patients are considered more likely to present with late-stage disease requiring emergency surgery as a risk factor contributing to postoperative morbidity and mortality[2,11], the histological type, tumor differentiation, tumor invasion, and clinical and pathological TNM stages were similar across age groups in our cohort. Although elderly patients are considered more likely to have had previous abdominal surgery, resulting in intra-abdominal adhesions that prolong operative time and increase the risk of iatrogenic injury[12], our findings revealed no significant difference between age groups in terms of the presence of previous abdominal surgery.

Likewise, in a previous study among patients with CRC undergoing elective colorectal surgery, those >80 years of age were found to have significantly higher levels of CEA, higher ASA class, and a higher prevalence of right-sided colon cancer than younger groups, along with no statistical differences in tumor stage or differentiation, laparoscopic versus open surgery, blood loss, or duration of operation between age groups.[9] The authors also reported that patients aged 60-79 years displayed a similar trend to those under 60 years, whereas higher CEA levels in the ≥80 years group were suggested to be caused by more right-sided cancer with malignant potential.[9,13]

Accordingly, although advanced age itself has traditionally been viewed as an independent risk factor for adverse outcomes in colorectal surgery, advancements in minimally invasive surgery and improvements in perioperative care have made colorectal surgery safe and feasible in the elderly. Thus, recent evidence suggests that chronological age alone is not a strict exclusion criterion for curative surgery.[3,9,11,14,15]

In our cohort, no significant difference was noted between age groups in terms of surgical approach (open vs. laparoscopic surgery) or length of operating time. The open surgery (53.5%) and laparoscopic surgery (44.2%) rates in our ≥80 years age group seem notable, given the consideration of laparoscopic-assisted colorectal surgery as a safe and feasible surgical approach with more pronounced benefits (i.e., less

blood loss, reduced morbidity, faster return of bowel function, and shorter length of stay) in the elderly population than open surgery.[11,16-19] In a meta-analysis of 24 studies on colorectal surgery in elderly patients, laparoscopic surgery was associated with a lower risk of postoperative complications and 90-day mortality compared with open surgery, whereas long-term overall survival, disease-free survival, risk of recurrence, and readmission rates were similar between the two surgical approaches.[17] Hence, elderly and younger patients with CRC were reported to share similar outcomes in laparoscopic surgery, with equivalent complication rates, whereas laparoscopic surgery was suggested to be prioritized in elderly patients with CRC given its potential to be more beneficial than open surgery, particularly in this age group.[17,20-22]

Our findings support that elderly patients with CRC should receive management as similar as possible to that of the younger population, with the choice of curative surgery, particularly for those with a reasonable life expectancy.[3,9,11,23-25]

Pelvic MRI and PET-CT are considered valid imaging modalities in CRC, particularly for the detection of distant metastases and locoregional evaluation for preoperative planning.[26] Pelvic MRI helps determine the type of surgery required for curative resection based on the extent of the colorectal tumor within the pelvis and locoregional staging, and it also enables accurate measurement of the distance to the anal verge and accurate preoperative locoregional staging to maximize the benefit of neoadjuvant chemoradiotherapy.[27-29] The less common utilization of these modalities in both the ≥80 years and 65-79 years age groups in our cohort seems notable in this regard, given the higher rate of colon cancer and shorter distal margin distance in these age groups, alongside the less common utilization of neoadjuvant therapy in those aged ≥80 years.

Similar to our results, neoadjuvant therapy was reported to be less commonly used in elderly patients with CRC, attributed to a range of factors such as more emergency presentations, more proximal tumors, increased frailty, and shorter life expectancy in the elderly.[3]

Overall, complete or near-complete response rates to neoadjuvant therapy in our cohort were 38.4% on the AJCC (modified Ryan) scale, 48.1% on the Dworak scale, and 39.4% on the Mandard scale, regardless of age group. This seems notable given the likelihood of better 5-year overall and disease-free survival in good responders (complete or near-complete response) than in poor responders to neoadjuvant therapy.[30] Indeed, older patients were also reported to receive adjuvant therapy less commonly, along with longer delays between surgery and chemotherapy, possibly due to tolerability issues and a potentially low benefit compared with younger patients.[20,31] Given the potential survival benefit of neoadjuvant chemotherapy compared with adjuvant chemotherapy for locally advanced colon cancer—with effective reduction of tumor burden before curative surgery and higher complete pathological response rates without an increase in surgical morbidity—the potential impact of the less common utilization of neoadjuvant therapy on long-term outcomes such as tumor recurrence and survival in the elderly population needs to be further investigated.[3,14,32-35]

A major strength of the present study is the detailed analysis of preoperative, operative, and postoperative data, as well as pathological results, across four age groups in a large real-world sample of colorectal surgery patients registered in the TSCRS CRC database.

However, certain limitations should be acknowledged, such as the retrospective nature of the data obtained from a prospectively maintained national database and the likelihood that a number of older patients were precluded from surgery due to poor performance status and comorbidities. Important geriatric-specific variables such as frailty indices, nutritional status, and cognitive function were not recorded in the TSCRS database, limiting the assessment of physiologic versus chronological age in surgical outcomes. The use of multiple tumor regression grading systems across centers and the small sample sizes in some categories may limit the comparability of treatment responses across age groups. As the study did not include patients who did not undergo surgery, it is likely to introduce surgical control bias, which may lead to an underestimation of disease burden or outcomes in the most vulnerable elderly population. The inclusion of nonoperative elderly patients with CRC in future studies would help close this knowledge gap.

Because the data were obtained from 20 TSCRS-participating centers, which may be high-volume or academic institutions with above-average outcomes, the generalizability to broader clinical settings is limited. Incorporating center-level adjustment in the analysis could help mitigate potential referral center bias. Additionally, conducting the study across multiple centers may have introduced inter-center variability.

Another limitation of the study is the lack of survival or long-term oncologic outcomes. There is also a need for studies that include these parameters.

Conclusion

This multicenter retrospective study demonstrated that short-term postoperative complication rates were similar across age groups, including patients aged ≥80 years, despite their higher-risk profiles. However, elderly patients were less likely to undergo advanced imaging or receive neoadjuvant treatment. These findings support the need for age-appropriate, multidisciplinary preoperative evaluation, including comprehensive geriatric assessment, to ensure

optimal care. Further research is warranted to assess long-term outcomes and adjust for potential confounders. Prospective studies examining comprehensive geriatric assessment data and investigating long-term oncologic outcomes are essential for generating robust evidence on this topic.

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Ethics

Ethics Committee Approval: Ethical approval was obtained from the ethics committee of Republic of Türkiye Bursa Uludağ University Health Research Ethics Committee (decision no.: 2025/579-7/12, dated: 19.03.2025).

Informed Consent: The principles of the Helsinki Declaration were followed, and informed consent was waived due to the retrospective design.

Footnotes

Authorship Contributions

Surgical and Medical Practices: A.A.A., E.G., Ö.I., T.Y., Concept: E.G., Ö.I., T.Y., Design: A.A.A., E.G., Ö.I., T.Y., Data Collection or Processing: E.G., Analysis or Interpretation: E.G., Ö.I., Literature Search: A.A.A., E.G., Writing: A.A.A., E.G., Ö.I.

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