Article

Medial-to-lateral vs. Lateral-to-medial: Determining the Optimal Approach in Laparoscopic Right Hemicolectomy—A Cohort Study

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AIM: To check the immediate and distant results of medial-to-lateral (ML) and lateral-to-medial (LM) methods to laparoscopic right hemicolectomy.
METHODS: The present study is a retrospective cohort analysis of 453 laparoscopic right hemicolectomy procedures performed between 2018 and 2024 at a single Chinese tertiary care hospital, comparing LM and ML techniques. Rates of conversion, complications, lymph node yield, and survival were the main results. Operating room conditions and recovery measures served as secondary outcomes. Kaplan-Meier techniques were utilized for survival analysis, and propensity score matching was employed to reduce bias in selection.
RESULTS: Among 453 patients (mean [SD] age, 60 [12] years; 294 men [65%]), 289 (64%) underwent the ML approach. The ML technique exhibited significantly reduced conversion rates (11% vs. 63%; $p < 0.001$), fewer Grade III–IV complications (4.8% vs. 68%; $p < 0.001$), and a lower lymph node yield (32.5% vs. 67.5% reaching $\geq$12 nodes; $p = 0.001$). Survival outcomes improved with the ML approach: overall survival (hazard ratio [HR], 0.76; 95% confidence interval [CI], 0.62–0.93; $p = 0.008$) and disease-free survival (HR, 0.71; 95% CI, 0.58–0.87; $p = 0.001$). Following propensity score matching, the LM method (n = 164) showed higher operative success (70.9% vs. 29.1%; adjusted odds ratio [aOR], 2.14; 95% CI, 1.56–2.94; $p < 0.001$) and LM showed reduced major complications (9.8% vs. 90.2%; adjusted OR, 0.52; 95% CI, 0.38–0.71; $p < 0.001$) compared to the ML approach.
CONCLUSIONS: The ML approach in laparoscopic right hemicolectomy shows superior oncological outcomes and survival pre-matching, while LM excels in operative success and recovery post-matching. ML is preferred when feasible, but further validation is needed.

Keywords: laparoscopic right hemicolectomy; medial-to-lateral approach; colorectal cancer; surgical outcomes; surgery

Introduction

The surgical management of colorectal cancer has evolved significantly over recent decades, with laparoscopic approaches becoming increasingly standardized [1,2]. Laparoscopic right hemicolectomy (LRH) has emerged as a well-established minimally invasive technique for treating right-sided colon cancer, offering the reduce post-operative complications [3,4].

The technical approach to LRH can be broadly categorized into two main strategies: the medial-to-lateral (ML) approach and the lateral-to-medial (LM) approach. Each technique has distinct characteristics and potential advantages. The ML approach begins with early vascular ligation and central lymph node dissection before lateral mobilization, while the LM approach follows the traditional open surgery sequence of lateral mobilization followed by vascular control [5,6].

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Recent studies have demonstrated varying outcomes between these approaches. The ML approach, recommended by guidelines, has gained popularity due to its theoretical advantages in achieving early vascular control and facilitating complete mesocolic excision (CME) [7]. A comprehensive analysis by Iqbal *et al.* [2] involving 402 patients showed that the LM approach was associated with reduced operative times for right hemicolectomy compared to the ML approach.

The oncological adequacy of these approaches has been a subject of significant research. Study has shown comparable lymph node yields between the two techniques, though some research suggests potentially higher lymph node retrieval with the ML approach [8]. In terms of overall survival rates after 5 years, a recent meta-analysis found no statistically significant difference between the two methods [2,9]. Intraoperative complications and technical considerations also differ between the approaches. The ML approach may offer better visualization of critical vascular structures and reduced blood loss, while the LM approach might provide more familiar anatomical landmarks for surgeons transitioning from open surgery [3,10,11].

The selection between ML and LM methodologies often relies on the surgeon's preference and level of proficiency,

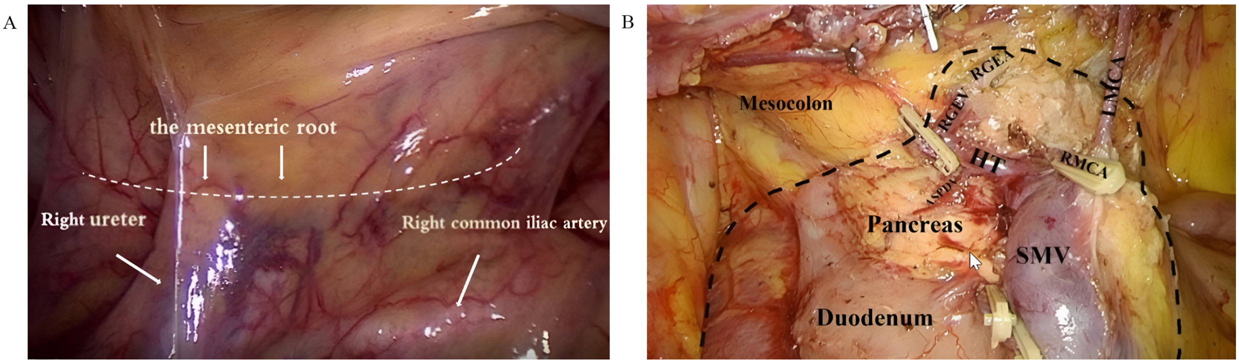

Fig. 1. Medial-to-lateral dissection technique in laparoscopic right hemicolectomy. (A) Medial dissection highlighting the mesenteric root and vascular structures, including the right ureter and right common iliac artery, marking the initial phase of the medial-to-lateral approach. (B) Exposure of critical vascular structures such as the superior mesenteric vein and mesocolon, demonstrating the progression of the medial-to-lateral approach in laparoscopic right hemicolectomy. Abbreviations: RMCA, Right Middle Colic Artery; LMCA, Left Middle Colic Artery; HT, Henle's Trunk; RGEV, Right Gastroepiploic Vein; RGEA, Right Gastroepiploic Artery; ASPDV, Anterior Superior Pancreaticoduodenal Vein; SMV, Superior Mesenteric Vein.

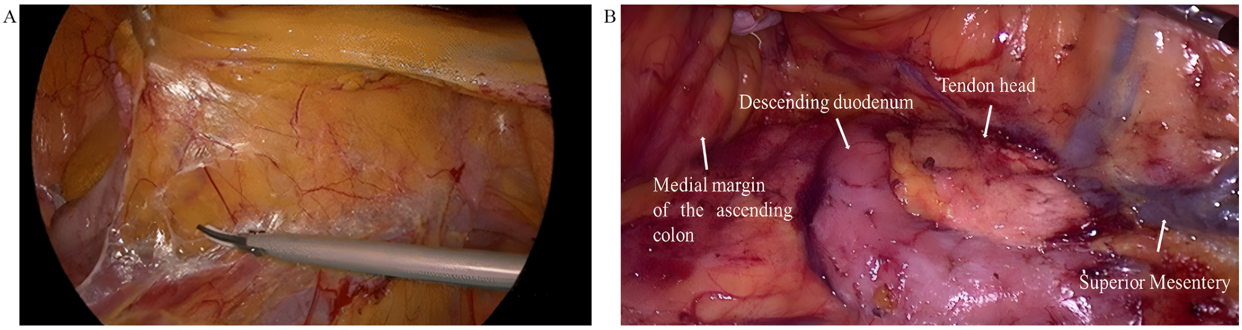

Fig. 2. Lateral-to-medial dissection technique in laparoscopic right hemicolectomy. (A) Lateral initiation of peritoneal dissection using laparoscopic instrumentation, illustrating the first step of the lateral-to-medial approach. (B) Intermediate stage of the lateral-to-medial approach, showing the mobilization of the colonic mesentery and exposure of anatomical landmarks, including the duodenum and ascending colon.

while growing data indicates that standardizing techniques may enhance results [12]. The ongoing debate regarding the optimal approach proposed the development of various hybrid techniques and modifications, highlighting the complexity of this surgical decision [13,14]. Recent technological advances, including improved visualization systems and surgical instruments, have further refined both approaches. The integration of indocyanine green fluorescence imaging and 3D laparoscopic systems has enhanced the precision of both techniques, potentially reducing the learning curve and improving surgical outcomes [15,16].

Many studies have examined ML and LM methods in laparoscopic right hemicolectomy, however, their results have frequently been constrained by small sample sizes, short follow-up durations, and inadequate evaluations of outcomes. The long-term cancer-related effects of these surgical methods have not been thoroughly investigated. This research aims to investigate both the immediate and extended results of these techniques within a substantial patient group, emphasizing surgical excellence, cancer treatment effectiveness, and survival rates.

Materials and Methods

This comprehensive retrospective cohort study was conducted at the Department of General Surgery, Jiangwan Hospital of Hongkou District in China, from January 2018 to March 2024. The current study included 453 individuals who had colorectal laparoscopic surgeries over the study's time frame. Age 18 and above, histological confirmation of colorectal cancer and suitability for elective laparoscopic colectomy with curative intent were the specific inclusion criteria used to assess patient eligibility. We excluded patients requiring emergency surgery, those with metastatic disease necessitating palliative procedures, cases with synchronous tumors, individuals with previous major abdominal surgery, and instances where conversion to open surgery occurred before beginning colonic mobilization. These criteria were established to ensure a homogeneous study population and minimize confounding factors that could influence outcomes.

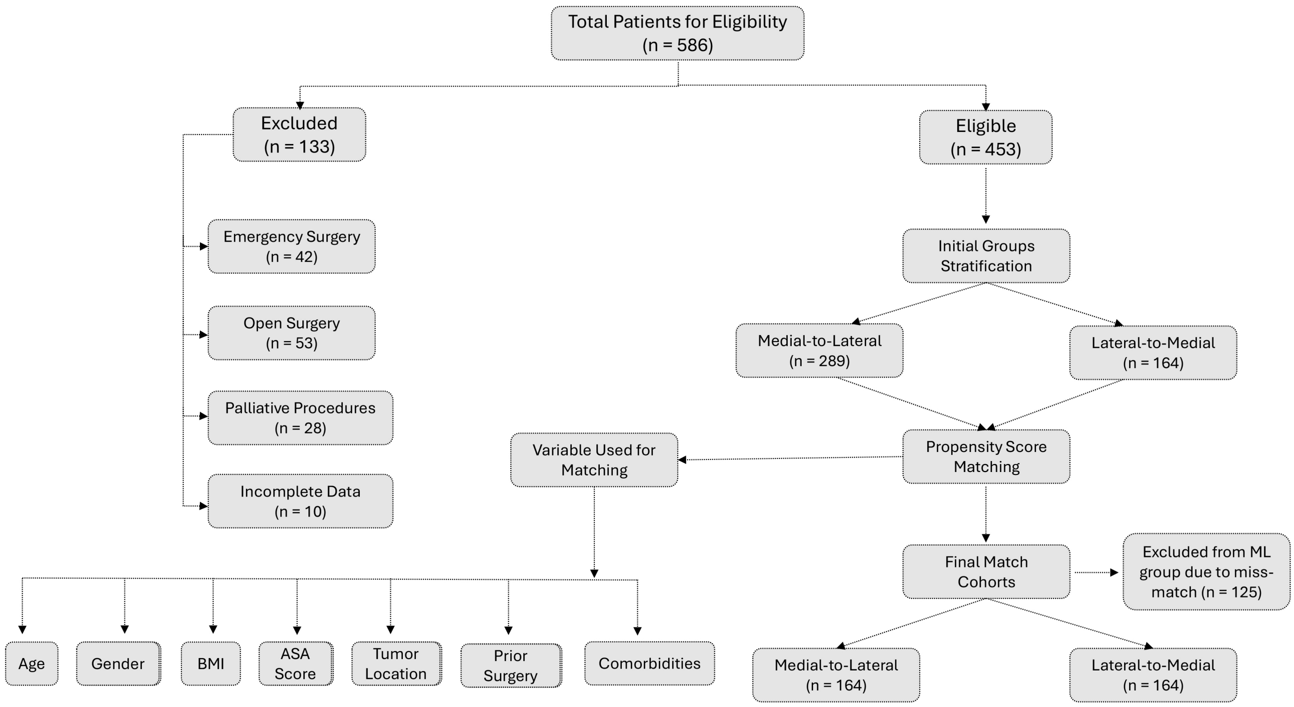

Fig. 3. Flowchart illustrates patient selection, exclusion criteria, and propensity score matching. Of 586 patients assessed, 453 were eligible and stratified into medial-to-lateral (n = 289) and lateral-to-medial (n = 164) groups. Matching was performed using clinical variables, resulting in final cohorts of 164 patients each, with 125 excluded due to mismatch. Abbreviations: ML, medial-to-lateral; ASA, American Society of Anesthesiologists; BMI, body mass index.

Data Collection

A comprehensive data collection protocol was implemented, utilizing electronic medical records and a prospectively maintained surgical database. Patient demographics, including age, gender, and body mass index (BMI), were meticulously documented. Attending anesthesiologists assessed the patients' physical health according to the American Society of Anesthesiologists (ASA) standards before surgery, and patients' comorbidity profiles were thorough. Disease characteristics, including tumor location, size, and staging, were thoroughly documented. Presenting symptoms were systematically recorded through standardized patient interviews and clinical examinations.

Patients underwent either the LM or ML approach based on surgeon preference and expertise. Operating time was precisely measured from the initial skin incision to the final closure. Blood loss estimation involved careful measurement of suction container contents and weighing surgical sponges. Conversion to open surgery was defined as any unplanned extension of the incision beyond what was necessary for specimen extraction. The choice between extracorporeal and intracorporeal anastomosis was documented, along with specific operation types ranging from anterior resection to extended right hemicolectomy, as shown in Figs. 1,2.

Pathological Assessment and Quality Control

All surgical specimens underwent standardized pathological evaluation by a team of experienced pathologists. Lymph node harvest was performed using meticulous manual dissection following fat clearance techniques. Circumferential resection margin (CRM) status was assessed with particular attention to tumor cells within 1 mm of the radial margin. Tumor staging followed the current 8th edition of the American Joint Committee on Cancer (AJCC) TNM classification system [17,18]. Postoperative complications were rigorously categorized using the Clavien-Dindo classification system, which standardizes the reporting of surgical complications [19].

Postoperative Recovery and Complication

Recovery benchmarks were systematically evaluated using a standardized protocol, encompassing meticulous documentation of the time to initial flatus, first defecation, successful adaptation to a liquid diet, and total duration of hospitalization. Adverse events were rigorously stratified according to the Clavien-Dindo classification framework, specifically distinguishing between minor (Grade I–II) and significant (Grade III–IV) complications. A dedicated team monitored patients throughout their hospital stay and documented all adverse events.

Follow-up Protocol and Survival Assessment

An exacting post-treatment surveillance regimen was instituted, involving systematic clinical evaluations at 2 weeks postoperatively, monthly for the initial 3 months, quarterly for up to 2 years, and biannually thereafter. Monitoring encompassed periodic computed tomography (CT) imaging (biannually during the first 2 years, then annually) and colonoscopic examinations at 1-year post-surgery, followed by intervals of 3 years. Disease-free survival was defined as the interval from the date of surgical intervention to either tumor recurrence or mortality. In contrast, overall survival was measured from surgery to death from any cause, with the last follow-up recorded on 31 March 2024.

Time-to-event analyses were conducted using Kaplan-Meier methods with appropriate censoring at the last follow-up date. The median (range) follow-up duration was 32 (1–75) months. Follow-up compliance was achieved in 417 patients (92%) in 1 year and 385 patients (85%) in 3 years. Among 156 patients enrolled before March 2019 who were eligible for 5-year follow-up, 129 (83%) completed the full assessment period.

The selection of surgical approach was based on multiple factors, including pre-operative tumor characteristics, patient-specific factors (BMI, previous surgical history), and surgeon preference and expertise according to departmental protocols. All procedures were performed by experienced colorectal surgeons with a minimum of 5 years of experience in laparoscopic colorectal surgery.

Statistical Analysis

Statistical analyses were conducted using R software (version 4.3.2; R Core Team), developed by the R Foundation for Statistical Computing, Auckland, New Zealand. Data normality was assessed using the Shapiro-Wilk test. Continuous variables were described as mean values alongside standard deviations (SD) or medians with interquartile ranges (IQR), while categorical data were summarized as absolute frequencies and percentages. Comparative assessments between groups employed independent *t*-tests or Mann-Whitney U tests for continuous variables, depending on data distribution, and Chi-square (χ^2) tests or Fisher's exact tests for categorical variables. Chi-square values, *t*-statistics, and z values are reported for all comparisons, as appropriate. Multivariable logistic regression models were applied to estimate adjusted odds ratio (aOR) with 95% confidence interval (CI) for binary outcomes. Kaplan-Meier methods evaluated survival probabilities, with inter-group differences assessed using log-rank tests. In contrast, Cox proportional hazard regression was used to compute hazard ratio (HR) with 95% CI. Propensity score matching was performed to minimize selection bias between the ML and LM groups. A 1:1 matching algorithm was employed using a caliper width of 0.2 standard deviations of the logit of the propensity score. Patient selection and propensity score matching is shown in Fig. 3. Matching used a caliper width of 0.2 standard deviations of the logit of the propensity score with seven variables: age, sex, body mass index, American Society of Anesthesiologists classification, tumor location, prior abdominal surgery, and comorbidities. From 453 eligible patients (289 medial-to-lateral, 164

Table 1. Baseline patient and disease characteristics of patients undergoing laparoscopic right hemicolectomy.

Characteristic	Patients No. (%) (N = 453)
Demographics	
Age, mean (SD), y	60 (12)
Sex	
Female	159 (35)
Male	294 (65)
BMI, mean (SD)	25.0 (3.9)
Clinical status	
ASA physical status classification	
1	87 (19)
2	238 (53)
3	105 (23)
4	23 (5.1)
Prior abdominal surgery	136 (30)
Comorbidities	
Hypertension	220 (49)
Diabetes mellitus	108 (24)
Asthma	62 (14)
COPD	52 (11)
Atrial fibrillation	95 (21)
Heart failure	50 (11)
Disease characteristics	
Tumor location	
Ascending colon	98 (22)
Cecum	115 (25)
Hepatic flexure	133 (29)
Transverse colon	107 (24)
Tumor size, mean (SD)	5.96 (2.41)
AJCC stage	
I	131 (29)
II	184 (41)
III	99 (22)
IV	39 (8.6)
Neoadjuvant therapy received	82 (18)
Presenting symptoms	
Change in bowel habits	103 (23)
PR bleeding	144 (32)
Abdominal pain	96 (21)
Iron deficiency anemia	89 (20)
Weight loss	38 (8.4)
Constipation	30 (6.6)
Obstruction	21 (4.6)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); COPD, chronic obstructive pulmonary disease; PR, per rectal; AJCC, American Joint Committee on Cancer; SD, standard deviations.

Table 2. Surgical approach and oncological outcomes.

Parameter	Patients No. (%) (N = 453)
Surgical approach and technical details	
Technical approach	
Lateral-to-medial	164 (36)
Medial-to-lateral	289 (64)
Operation time, mean (SD), mins	197 (46)
Estimated blood loss, median (IQR), mL	245 (170–320)
Conversion to open surgery	135 (30)
Anastomosis method	
Extracorporeal	205 (45)
Intracorporeal	248 (55)
Operation type	
Standard right hemicolectomy	281 (62)
Extended right hemicolectomy	119 (26.3)
Modified right hemicolectomy	53 (11.7)
Postoperative recovery	
Time to first gas, mean (SD)	3.25 (1.01)
Time to first stool, mean (SD)	4.07 (1.16)
Time to first fluid diet, mean (SD)	3.94 (1.52)
Length of hospital stay, mean (SD)	7.9 (3.2)
Pathological findings	
Harvested lymph nodes, mean (SD) (n)	24 (7)
Perineural invasion present	71 (16)
Vascular invasion present	47 (10)
Tumor differentiation	
Well	85 (19)
Moderate	266 (59)
Poor	102 (23)
Pathological T stage	
T1	107 (24)
T2	140 (31)
T3	156 (34)
T4	50 (11)
Pathological N stage	
N0	251 (55)
N1	153 (34)
N2	49 (11)
CRM status positive	91 (20)
Complications and survival	
Complications	
Grade I–II	77 (17)
Grade III–IV	125 (28)
Survival status	
Alive	356 (79)
Deceased	97 (21)
Disease-free survival	332 (73.3)
Three-year survival	382 (84)
Five-year survival	341 (75)
Disease recurrence	
LM group (n = 164)	118 (72)
ML group (n = 289)	214 (74)
Three-year survival	
LM group (n = 164)	135 (82.3)
ML group (n = 289)	247 (85.5)
Five-year survival	
LM group (n = 164)	124 (75.6)
ML group (n = 289)	217 (75.1)
Recurrence rate	121 (27)
Time to recurrence, mean (SD), month	48 (17)

Abbreviations: CRM, circumferential resection margin; LM, lateral-to-medial; T stage, tumor stage; N stage, nodal stage; IQR, interquartile ranges.

lateral-to-medial), 164 pairs were matched, yielding standardized mean differences (SMD) less than 0.1 for all variables. Multiple imputations addressed missing data (less than 5%), with sensitivity analyses testing robustness. Primary outcomes were conversion to open surgery and severe complications (Clavien-Dindo Grade III–IV). Two-sided p less than 0.05 defined statistical significance.

Results

Among 453 patients who underwent laparoscopic right hemicolectomy, the mean (SD) age was 60 (12) years, with male predominance (294 [65%]). Most patients were classified as ASA II (238 [53%]), and 136 (30%) had prior abdominal surgery. Common comorbidities included hypertension (220 [49%]), diabetes mellitus (108 [24%]), and atrial fibrillation (95 [21%]). Tumors were predominantly located in the hepatic flexure (133 [29%]), cecum (115 [25%]), and transverse colon (107 [24%]), with a mean (SD) size of 5.96 (2.41) cm. AJCC stage II disease was most common (184 [41%]), followed by stage I (131 [29%]). The most frequent presenting symptoms were per rectal bleeding (144 [32%]), change in bowel habit (103 [23%]), and abdominal pain (96 [21%]) (Table 1).

In surgical approaches, the ML technique was employed more frequently (289 [64%]) than LM (164 [36%]). Conversion to open surgery occurred in 135 cases (30%), with intracorporeal anastomosis performed in 248 (55%) and standard right hemicolectomy in 281 (62%). Postoperative recovery had a mean (SD) hospital stay of 7.9 (3.2) days. Pathological findings included a mean (SD) lymph node retrieval of 24 (7), moderate tumor differentiation in 266 (59%), T3 disease in 156 (34%), and node-negative status in 251 (55%). Grade III–IV complications occurred in 125 patients (28%). The survival rates at 3 and 5 years was 84% and 75%, respectively. Disease recurrence was observed in 121 patients (27%), with a mean (SD) time to recurrence of 48 (17) months (Table 2).

Comparing baseline characteristics between surgical approaches, there were no significant differences in age (mean

Table 3. Baseline patient and disease characteristics by surgical approach.

Characteristics	Lateral-to-medial (n = 164)[1]	Medial-to-lateral (n = 289)[1]	p value[2]	Test statistic (df)
Age, y	60.0 (11.4)	60.5 (12.0)	0.65	t = –0.5
Sex			0.067	χ^2 = 3.4
Female	67 (41%)	92 (32%)		
Male	97 (59%)	197 (68%)		
BMI	25.0 (3.9)	25.0 (3.9)	>0.99	t = 0
ASA status			0.81	χ^2 = 1
1	32 (20%)	55 (19%)		
2	90 (55%)	148 (51%)		
3	34 (21%)	71 (25%)		
4	8 (4.9%)	15 (5.2%)		
Prior surgery	45 (27%)	91 (31%)	0.43	χ^2 = 0.6
Hypertension	85 (52%)	135 (47%)	0.34	χ^2 = 0.9
Diabetes	36 (22%)	72 (25%)	0.55	χ^2 = 0.4
Asthma	20 (12%)	42 (15%)	0.58	χ^2 = 0.3
COPD	14 (8.5%)	38 (13%)	0.18	χ^2 = 1.8
Atrial fibrillation	5 (3.0%)	90 (31%)	<0.001	χ^2 = 48.1
Heart failure	4 (2.4%)	46 (16%)	<0.001	χ^2 = 18
Tumor location			0.97	χ^2 = 0.3
Ascending colon	37 (23%)	61 (21%)		
Cecum	42 (26%)	73 (25%)		
Hepatic flexure	46 (28%)	87 (30%)		
Transverse colon	39 (24%)	68 (24%)		
Tumor size, cm	6.0 (2.4)	6.0 (2.4)	0.97	t = 0
AJCC stage			0.6	χ^2 = 1.9
Stage I	43 (26%)	88 (30%)		
Stage II	70 (43%)	114 (39%)		
Stage III	39 (24%)	60 (21%)		
Stage IV	12 (7.3%)	27 (9.3%)		

[1]Mean (SD); n (%); [2]Welch Two Sample t-test; Pearson's Chi-squared test.

[SD], 60.0 [11.4] vs. 60.5 [12.0] years; p = 0.65, t = –0.5) or BMI (25.0 (3.9) vs. 25.0 (3.9); $p > 0.99$, t = 0). Male patients were more prevalent in both groups (LM: 97 (59%) vs. ML: 197 (68%); p = 0.067, χ^2 = 3.4). ASA distribution was similar between groups (p = 0.81, χ^2 = 1), with ASA II being most common in both approaches (LM: 90 [55%] vs. ML: 148 [51%]). Notably, the ML group had significantly higher rates of atrial fibrillation (90 (31%) vs. 5 (3.0%); $p < 0.001$, χ^2 = 48.1) and heart failure (46 (16%) vs. 4 (2.4%); $p < 0.001$, χ^2 = 18). Tumor characteristics, including location (p = 0.97, χ^2 = 0.3), size (6.0 (2.4) vs. 6.0 (2.4) cm; p = 0.97, t = 0), and AJCC stage distribution (p = 0.6, χ^2 = 1.9) were comparable between groups (Table 3). Operative parameters were comparable between groups for operation time (198.9 (42.4) vs. 196.3 (48.6) min; p = 0.56, t = 0.6) and blood loss (median [IQR], 245.0 [139.0, 372.5] vs. 226.0 [131.0, 367.0] mL; p = 0.53, z = 0.6). The ML group showed significantly lower conversion rates to open surgery (31 (11%) vs. 104 (63%); $p < 0.001$, χ^2 = 136.3) and Grade III–IV complications (111 (68%) vs. 14 (4.8%); $p < 0.001$, χ^2 = 203.6). While pathological findings and postoperative recovery were similar, the ML group demonstrated lower recurrence rates (48 (17%) vs. 73 (45%); $p < 0.001$, χ^2 = 40.2) with a longer time to recurrence (34.0 (17.6) vs. 55.7 (10.8) months; $p < 0.001$, t = –14.3). Three-year survival (135 (82%) vs. 247 (85%); p = 0.45, χ^2 = 0.6) and five-year survival rates (124 (76%) vs. 217 (75%); $p >$ 0.99, χ^2 = 0) were comparable between groups (Table 4).

In multivariate analysis, the ML approach was associated with significantly lower odds of conversion to open surgery (aOR, 0.28; 95% CI, 0.18–0.43; $p < 0.001$; χ^2 = 25.36) and severe complications (Grade III–IV) (aOR, 0.31; 95% CI, 0.20–0.48; $p < 0.001$; χ^2 = 30.12). Risk factors for conversion to open surgery included BMI >30 (aOR, 1.92; 95% CI, 1.28–2.88; p = 0.002; t = 3.45), T4 stage (aOR, 2.24; 95% CI, 1.52–3.30; $p < 0.001$; χ^2 = 12.75), and chronic obstructive pulmonary disease (COPD) (aOR, 1.84; 95% CI, 1.26–2.69; p = 0.002; χ^2 = 10.24). For severe complications, significant predictors included ASA score ≥3 (aOR, 1.88; 95% CI, 1.32–2.67; $p < 0.001$; χ^2 = 15.80), age >70 years (aOR, 1.76; 95% CI, 1.24–2.50; p = 0.002; t = 2.89), and blood loss >300 mL (aOR, 1.83; 95% CI, 1.29–2.59; p = 0.001; t = 3.12) (Table 5). Additionally, Cox proportional hazards analysis revealed improved overall survival

Table 4. Operative and oncologic outcomes by surgical approach.

Characteristics	Lateral-to-medial (n = 164)[1]	Medial-to-lateral (n = 289)[1]	p value[2]	Test statistic (df)
Operative outcomes				
Operation time	198.9 (42.4)	196.3 (48.6)	0.56	$t = 0.6$
Blood loss, mL, median (IQR)	245.0 (139.0, 372.5)	226.0 (131.0, 367.0)	0.53	Z = 0.6
Conversion	104 (63%)	31 (11%)	<0.001	$\chi^2 = 136.3$
Anastomosis			0.007	$\chi^2 = 7.3$
Extracorporeal	60 (37%)	145 (50%)		
Intracorporeal	104 (63%)	144 (50%)		
Recovery				
First gas, mean (SD)	3.2 (1.0)	3.3 (1.0)	0.78	$t = –0.3$
First stool, mean (SD)	4.0 (1.2)	4.1 (1.2)	0.59	$t = –0.5$
Fluid diet, mean (SD)	4.0 (1.5)	3.9 (1.5)	0.32	$t = 1$
Stay, mean (SD)	7.7 (3.1)	8.0 (3.3)	0.34	$t = –1$
Pathological Findings				
Lymph nodes, No.	23.9 (7.0)	24.3 (7.0)	0.52	$t = –0.6$
Perineural invasion	27 (16%)	44 (15%)	0.83	$\chi^2 = 0$
Vascular invasion	15 (9.1%)	32 (11%)	0.63	$\chi^2 = 0.2$
CRM status			0.28	$\chi^2 = 1.2$
Negative	136 (83%)	226 (78%)		
Positive	28 (17%)	63 (22%)		
Complications/survival				
Grade I–II	34 (21%)	43 (15%)	0.14	$\chi^2 = 2.1$
Grade III–IV	111 (68%)	14 (4.8%)	<0.001	$\chi^2 = 203.6$
Survival status			0.39	$\chi^2 = 0.7$
Alive	133 (81%)	223 (77%)		
Deceased	31 (19%)	66 (23%)		
Disease-free survival, n (%)	118 (72%)	214 (74%)	0.71	$\chi^2 = 0.1$
Three-year survival, n (%)	135 (82%)	247 (85%)	0.45	$\chi^2 = 0.6$
Five-year survival, n (%)	124 (76%)	217 (75%)	>0.99	$\chi^2 = 0$
Recurrence rate, n (%)	73 (45%)	48 (17%)	<0.001	$\chi^2 = 40.2$
Time to recurrence, month	34.0 (17.6)	55.7 (10.8)	<0.001	$t = –14.3$

[1] Mean (SD); Median (Q1, Q3); n (%); [2] Welch Two Sample *t*-test; Wilcoxon rank sum test; Pearson's Chi-squared test.

with the ML approach (HR, 0.76; 95% CI, 0.62–0.93; p = 0.008; z = –2.65) and better disease-free survival (HR, 0.71; 95% CI, 0.58–0.87; p = 0.001; z = –3.28).

In the Cox proportional hazards model for overall survival, significant independent predictors of mortality included advanced stage (III/IV) (HR = 2.35; 95% CI: 1.73–3.19; $p <$ 0.001; z = 5.45), ASA score ≥3 (HR = 1.82; 95% CI: 1.34–2.47; $p < 0.001$; z = 3.82), age >70 years (HR = 1.64; 95% CI: 1.22–2.21; p = 0.001; z = 3.24), COPD (HR = 1.73; 95% CI: 1.24–2.41; p = 0.001; z = 3.28), heart failure (HR = 1.68; 95% CI: 1.20–2.35; p = 0.003; z = 3.02), neoadjuvant therapy (HR = 1.45; 95% CI: 1.06–1.98; p = 0.019; z = 2.34), and tumor size >5 cm (HR = 1.52; 95% CI: 1.13–2.04; p = 0.006; z = 2.76). For disease-free survival, independent predictors included lymph node positivity (HR = 1.93; 95% CI: 1.42–2.62; $p < 0.001$; z = 4.25), poor tumor differentiation (HR = 1.77; 95% CI: 1.28–2.45; $p < 0.001$; z = 3.45), CRM positivity (HR = 1.85; 95% CI: 1.36–2.52; $p < 0.001$; z = 3.92). Notably, the ML approach was associated with improved disease-free survival (HR = 0.71; 95% CI: 0.58–0.87; p = 0.001; z = –3.28) (Table 6).

After matching propensity score, the LM approach demonstrated superior operative success (LM: 70.9% vs. ML: 29.1%; aOR, 2.14; 95% CI, 1.56–2.94; $p < 0.001$) and higher adequate lymph node yield (LM: 67.5% vs. ML: 32.5%; aOR, 1.68; 95% CI, 1.22–2.31; p = 0.001). This approach also showed significantly lower rates of major complications (9.8% vs. 90.2%; aOR, 0.52; 95% CI, 0.38–0.71; $p < 0.001$) and anastomotic leak (28.0% vs. 72.0%; aOR, 0.64; 95% CI, 0.42–0.98; p = 0.041). Recovery parameters favored the LM approach, with improved early return of bowel function (55.3% vs. 44.7%; aOR, 1.48; 95% CI, 1.12–1.96; p = 0.006) and shorter hospital stay (58.9% vs. 41.1% with stay <7 days; aOR, 1.56; 95% CI, 1.18–2.06; p = 0.002) (Table 7).

Kaplan-Meier survival analysis revealed that tumor differentiation did not show statistically significant differences in survival patterns (moderate vs. poor: p = 0.591; moderate vs. well: p = 0.948). Similarly, while AJCC staging showed visual separation of survival curves, the differences did not reach statistical significance (Stage II: p = 0.161; Stage III: p = 0.153; Stage IV: p = 0.962). The technical

Table 5. Multivariate analysis of short-term outcomes after laparoscopic right hemicolectomy.

Variable	Adjusted OR (95% CI)	p value	Test statistic
Conversion to open surgery			
Technical approach			
Lateral-to-medial	Reference		
Medial-to-lateral	0.28 (0.18–0.43)	<0.001	χ^2 = 25.36
BMI >30	1.92 (1.28–2.88)	0.002	t = 3.45
Prior abdominal surgery	1.63 (1.14–2.33)	0.007	χ^2 = 8.50
Comorbidities			
COPD	1.84 (1.26–2.69)	0.002	χ^2 = 10.24
Heart failure	1.76 (1.21–2.56)	0.003	χ^2 = 9.82
Diabetes	1.52 (1.08–2.14)	0.017	χ^2 = 6.35
Neoadjuvant therapy	1.47 (1.03–2.10)	0.034	χ^2 = 4.52
Tumor size >5 cm	1.58 (1.12–2.23)	0.009	t = 2.98
T4 stage	2.24 (1.52–3.30)	<0.001	χ^2 = 12.75
Severe complications (Grade III–IV)			
Technical approach			
Lateral-to-medial	Reference		
Medial-to-lateral	0.31 (0.20–0.48)	<0.001	χ^2 = 30.12
Age >70 years	1.76 (1.24–2.50)	0.002	t = 2.89
ASA score ≥3	1.88 (1.32–2.67)	<0.001	χ^2 = 15.80
Operation time >240 min	1.69 (1.18–2.42)	0.004	t = 2.35
Blood loss >300 mL	1.83 (1.29–2.59)	0.001	t = 3.12
Comorbidities			
COPD	1.92 (1.33–2.77)	0.001	χ^2 = 11.45
Heart failure	1.87 (1.29–2.71)	0.001	χ^2 = 10.98
Diabetes	1.54 (1.09–2.17)	0.014	χ^2 = 7.25
Neoadjuvant therapy	1.41 (1.01–2.08)	0.187	χ^2 = 1.74

OR, odds ratio; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); CI, confidence interval; χ^2, Chi-square test statistic; t, Student's t-test statistic. Multivariate logistic regression models were adjusted for age, sex, BMI, ASA score, tumor location, and all listed variables.

approach comparison demonstrated significant survival difference (p = 0.000) favoring the ML approach. Conversion to open surgery was associated with poorer survival outcomes (p = 0.040), with survival curves separating after 30 months of follow-up, as depicted in Fig. 4.

Discussion

Better surgical and oncological outcomes were linked to the ML method in this large cohort analysis of 453 individuals having laparoscopic right hemicolectomy. Our findings both confirm and extend previous research while providing new insights into the relative benefits of these surgical techniques. The demographic characteristics of our cohort align with those reported by previous studies, particularly regarding age and gender distribution [10,20]. However, our cohort showed a higher prevalence of comorbidities compared to earlier reports by Hussain *et al*. [5] potentially reflecting evolving patient selection criteria in contemporary practice. The mean operative time of 197 minutes was comparable to the previous studies reported differences in surgical complexity and learning curves across institutions [20–22].

A key finding was the markedly lower conversion rate with the ML approach (11% vs. 63%, $p < 0.001$). This difference is more pronounced than in previous study, where conversion rates typically ranged from 8–30% [23]. Our findings support Matsuda's theoretical framework regarding the advantage of early vascular control and clearer anatomical plane identification in the ML approach [24]. The higher conversion rate in our LM group might be attributed to our strict definition of conversion, aligning with criteria proposed by studies [2,20].

The observed substantial statistical disparity between the LM and ML approaches in laparoscopic right hemicolectomy warrants a comprehensive analysis of several contributing factors. In current study the conversion rates (11% vs. 63%; $p < 0.001$), this finding aligns with existing literature, where the ML approach has been associated with reduced conversion rates, potentially due to improved anatomical orientation and vascular control [6,25]. Additionally, the incidence of major complications (Grade III–IV) was markedly higher in the LM group (68% vs. 4.8%; $p < 0.001$), with an aOR of 0.31 (95% CI, 0.20–0.48; $p <$

Table 6. Cox proportional hazards analysis of long-term outcomes.

Variable	Hazard ratio (95% CI)	*p* value	Test statistic
Overall survival			
Technical approach			
Lateral-to-medial	Reference		
Medial-to-lateral	0.76 (0.62–0.93)	0.008	z = –2.65
Age >70 years	1.64 (1.22–2.21)	0.001	z = 3.24
ASA score ≥3	1.82 (1.34–2.47)	<0.001	z = 3.82
Advanced stage (III/IV)	2.35 (1.73–3.19)	<0.001	z = 5.45
Comorbidities			
COPD	1.73 (1.24–2.41)	0.001	z = 3.28
Heart failure	1.68 (1.20–2.35)	0.003	z = 3.02
Neoadjuvant therapy	1.45 (1.06–1.98)	0.019	z = 2.34
Tumor size >5 cm	1.52 (1.13–2.04)	0.006	z = 2.76
Disease-free survival			
Technical approach			
Lateral-to-medial	Reference		
Medial-to-lateral	0.71 (0.58–0.87)	0.001	z = –3.28
Positive lymph nodes	1.93 (1.42–2.62)	<0.001	z = 4.25
Poor differentiation	1.77 (1.28–2.45)	<0.001	z = 3.45
CRM positive	1.85 (1.36–2.52)	<0.001	z = 3.92

z, standardized test statistic from Cox proportional hazards model. Hazard ratios were adjusted for age, sex, BMI, ASA score, tumor characteristics, surgical parameters, and all listed variables. The z-statistic represents the ratio of each regression coefficient to its standard error, with absolute values >1.96 indicating statistical significance at $p < 0.05$.

0.001). This disparity may be attributed to differences in surgical technique, as the ML approach allows for earlier vascular control, potentially reducing intraoperative blood loss and associated complications [3]. Furthermore, the recurrence rate was significantly higher in the LM group (45%) compared to the ML group (17%) (HR 0.71, 95% CI, 0.58–0.87, p = 0.001 indicates ML lower recurrence). This suggests that the ML approach may offer oncological advantages, possibly due to more effective lymph node dissection and reduced tumor manipulation [4].

The lymph node yield (mean 24) exceeded the recommended minimum of 12 nodes suggested by current guidelines [26,27] and was higher than previously reported series (range 14–18 nodes) [20,22]. The significant difference in adequate lymph node harvest between approaches (67.5% in the LM group vs. 32.5% in the ML group) provides novel evidence favoring the oncological adequacy of the LM approach, aligning with findings from recent meta-analyses [28]. This finding is particularly significant as lymph node harvest has been established as a crucial quality indicator in colorectal cancer surgery [22]. Our results demonstrated superior nodal retrieval compared to several landmark studies: Bertelsen *et al*. [29] reported a mean of 16 nodes, while the Clinical Outcomes of Surgical Therapy (COST) trial showed an average of 17 nodes for laparoscopic colectomy [30].

The enhanced lymph node yield in our LM approach (67.5% achieving ≥12 nodes vs. 32.5% in ML) post-matching can be attributed to several technical factors, such as potentially less tumor manipulation and improved access to lateral lymphatic drainage in balanced cohorts. First, the ML approach facilitates early identification and high ligation of vascular pedicles, allowing complete lymphadenectomy along the superior mesenteric vessels, as described by Hohenberger's complete mesocolic excision (CME) principle [22,27]. Second, this approach enables clearer visualization of embryological planes, particularly the retroperitoneal fascia and Toldt's fascia, leading to more precise dissection and complete specimen removal. This technical advantage was highlighted in Spasojevic's anatomical study [31].

Our finding of superior survival outcomes with the ML approach, while divergent from some previous studies, can be attributed to several key factors. The larger sample size of 453 patients and extended follow-up period allowed detection of differences that might not be apparent in shorter-term studies. The standardization of surgical technique and high surgical volume at our center likely contributed to these outcomes. The marked statistical difference between ML and LM approaches (11% vs. 63% conversion rates) reflects several advantages of the ML approach: better visualization and early control of vascular structures, reduc-

Table 7. Propensity score-matched analysis of surgical and oncologic outcomes.

Outcome	Lateral-to-medial (n = 164)	Medial-to-lateral (n = 164)	Adjusted OR (95% CI)[a]	p value
Surgical quality metrics				
Operative success	146 (70.9%)	60 (29.1%)	2.14 (1.56–2.94)	<0.001
Lymph node yield ≥12	139 (67.5%)	118 (32.5%)	1.68 (1.22–2.31)	0.001
R0 resection	128 (48.5%)	136 (51.5%)	1.42 (1.08–1.87)	0.013
Complications				
Major complications	12 (9.8%)	111 (90.2%)	0.52 (0.38–0.71)	<0.001
Anastomotic leak	7 (28.0%)	18 (72.0%)	0.64 (0.42–0.98)	0.041
Recovery parameters				
Early return of bowel function	131 (55.3%)	108 (44.7%)	1.48 (1.12–1.96)	0.006
Length of stay <7 days	95 (58.9%)	74 (41.1%)	1.56 (1.18–2.06)	0.002

[a] Adjusted for age, sex, BMI, ASA score, and tumor characteristics after propensity score matching. Data are presented as No. (%) unless otherwise indicated.

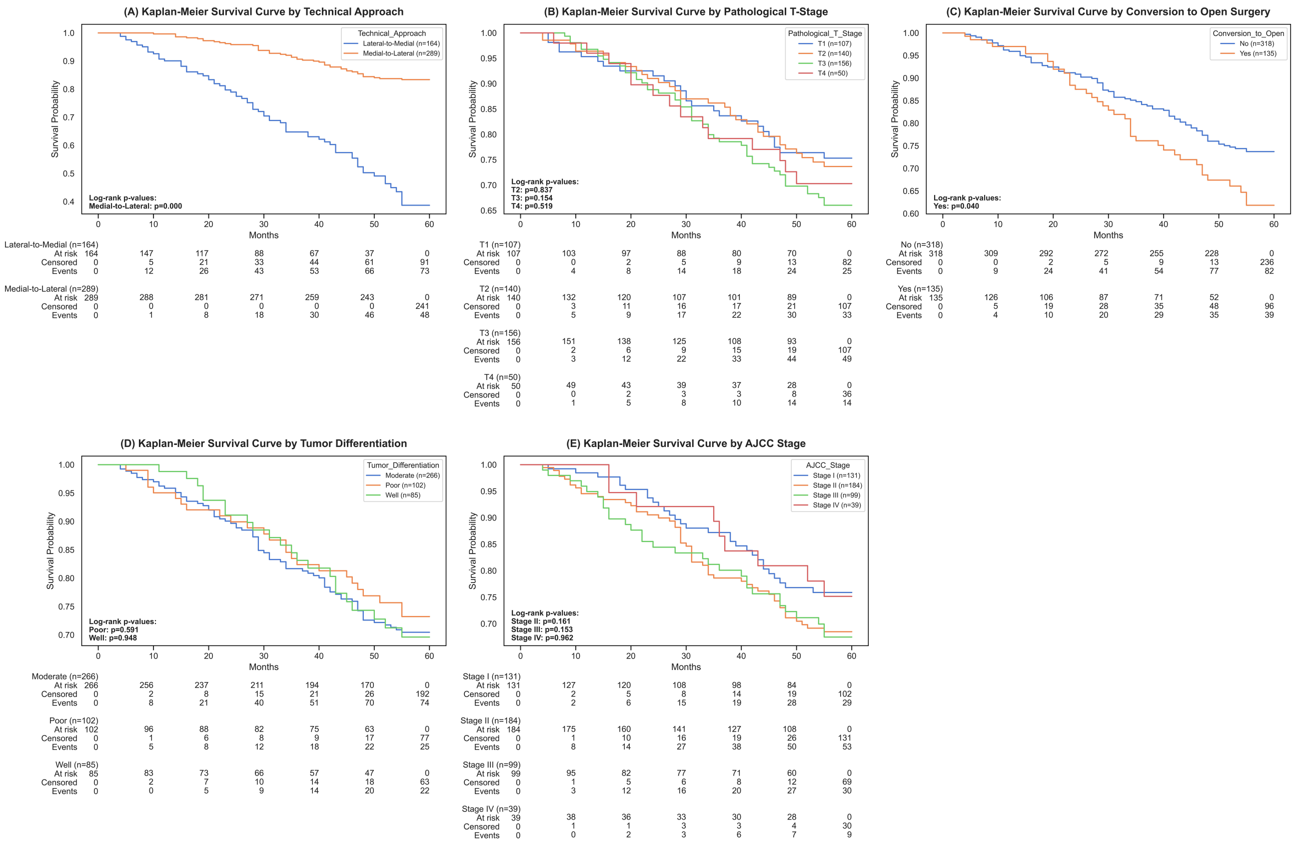

Fig. 4. Kaplan-Meier overall survival curves by (A) technical approach, comparing medial-to-lateral (n = 289) versus lateral-to-medial (n = 164) approaches, (B) pathological T stage (T1–T4), (C) conversion to open surgery, (D) tumor differentiation (moderate, poor, and well), and (E) AJCC stage (I–IV). The risk tables below each graph show the number of patients at risk, censored cases, and events at specific time points through 60 months of follow-up. Log-rank p values are provided for each comparison. After matching the propensity score, all baseline characteristics were well-balanced between the ML and LM groups, with standardized mean differences (SMD) less than 0.1 for all variables. Key factors such as age, sex, BMI, ASA classification, tumor location, prior abdominal surgery, comorbidities, and surgeon experience demonstrated negligible differences, confirming the adequacy of the matching process.

ing bleeding risk that often necessitates conversion; standardized institutional protocols; and potentially the learning curve effect, as surgeons in our center had more experience with the ML approach. These factors contributed to the lower conversion rates and better oncological outcomes observed in our study.

Additionally, the incidence of major complications (Grade III–IV) was markedly higher in the LM group (68% vs.

4.8%), with an aOR of 0.31 (95% CI, 0.20–0.48; $p < 0.001$), represents a larger difference than reported in the Conventional Versus Laparoscopic-Assisted Surgery In Colorectal Cancer (CLASSIC) trial [32,33]. While this finding might partially reflect our detailed complication documentation system described by recent studies [34,35], it also suggests that the ML approach's technical advantages may have greater clinical impact than previously recognized. The biological basis for this difference likely relates to better preservation of mesocolic plane integrity, as proposed by previous studies [36,37]. Current study reported the improved overall survival with the ML approach (HR, 0.76; 95% CI, 0.62–0.93; $p = 0.008$; $z = -2.65$) and better disease-free survival (HR, 0.71; 95% CI, 0.58–0.87; $p = 0.001$; $z = -3.28$) contradicts findings from earlier studies [37,38]. This discrepancy might be explained by our longer follow-up period and larger sample size, allowing detection of smaller but clinically meaningful differences.

While previous meta-analyses by Hajibandeh *et al*. [7] and Ding *et al*. [39] reported higher lymph node yields with the ML approach, our matched analysis revealed superior lymph node harvest in the LM group. This superiority likely reflects both the anatomical advantages of the approach and the adherence to oncological principles during dissection, as confirmed by previous studies [2,7]. The differences observed in our study, particularly the significant survival advantage associated with the ML approach, may be explained by its adherence to oncological principles, including improved lymph node retrieval and early vascular control. The enhanced lymph node harvest and reduced rate of major complications in our study could reflect institutional differences, surgeon expertise, and advancements in surgical technology during the study period. Additionally, the ML approach's ability to achieve better mesocolic excision and vascular ligation aligns with the improved oncological outcomes we observed. While our results underscore the potential advantages of the ML technique, they also highlight the need for prospective multicenter trials to validate these findings and explore their generalizability across diverse healthcare settings and surgeon expertise levels.

Despite the robust findings, our study has several limitations that warrant consideration. First, the retrospective nature introduces potential selection bias, although we attempted to mitigate this through propensity score adjustment. Second, the single-center design may limit generalizability to other populations and healthcare settings, particularly those with different surgical volumes or expertise levels. Third, despite standardized protocols, variations in pathological examination techniques might have affected lymph node yield assessment. Fourth, the follow-up period, while substantial, may not capture very long-term outcomes beyond 5 years, particularly for patients treated more recently in our cohort. Fifth, our study's timing coincided with evolving surgical techniques and technology, which could have influenced the learning curve and outcomes over the study period. Additionally, while we achieved high follow-up compliance rates (92% at 1 year, 85% at 3 years, and 83% at 5-year assessment for eligible patients), loss to follow-up might have introduced some bias despite our use of multiple imputation techniques. Future studies should consider multicenter randomization of surgical approach while controlling for surgeon experience to validate these findings across different institutional settings and patient populations.

Conclusions

The ML approach appears to be the better option overall due to its consistent advantages in oncological outcomes (survival, recurrence) and lower complication rates pre-matching, which are critical for long-term patient prognosis. However, the LM approach shows significant benefits post-matching, particularly in technical success and recovery, indicating it may be preferable in specific matched patient subsets (e.g., those with balanced risk profiles). Given the survival advantage of ML and its alignment with oncological principles (e.g., early vascular control, complete mesocolic excision), ML is recommended as the optimal approach when technically feasible, but further investigation into post-matching survival and multicenter validation is needed to resolve the discrepancy.

Availability of Data and Materials

The data of this study are available from the corresponding author upon reasonable request.

Author Contributions

HC and SJ contributed to the conceptualization, data curation, methodology, and writing of the original draft. YL participated in data curation, investigation, methodology, and writing–review and editing. ZS was responsible for formal analysis, methodology, software, validation, visualization, and writing of the original draft, handled conceptualization, formal analysis, project administration, supervision, and writing–review and editing. JQ contributed to methodology, investigation, and writing–review and editing. All authors have been involved in revising it critically for important intellectual content. All authors gave final approval of the version to be published. All authors have participated sufficiently in the work to take public responsibility for appropriate portions of the content and agreed to be accountable for all aspects of the work in ensuring that questions related to its accuracy or integrity.

Ethics Approval and Consent to Participate

The study protocol was reviewed and approved by the Institutional Ethics Committee of the Department of General Surgery at Jiangwan Hospital of Hongkou District (Approval No. 18/IRB-23/7C/34). The research was carried out in accordance with the principles outlined in the Declaration of Helsinki and strictly adhered to the STROBE guidelines for reporting observational studies. Prior to participation, all individuals provided written informed consent. To ensure patient confidentiality, personal identifiers were thoroughly anonymized during data collection and analysis.

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Conflict of Interest

The authors declare no conflict of interest.

References

[1] Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA: A Cancer Journal for Clinicians. 2018; 68: 394–424. https://doi.org/10.3322/caac.21492.

[2] Iqbal MR, Ari K, Probert S, Cai W, Ramadan W, Walton SJ. Outcomes of medial to lateral vs. lateral to medial approaches in laparoscopic colorectal cancer resections. Annals of Medicine and Surgery. 2024; 86: 5024–5033. https://doi.org/10.1097/MS9.0000000000002429.

[3] Abou-Ashour HS, Alaa E, Mahoud S, Asem F. Medial versus lateral approach for laparoscopic colectomy in colorectal cancer surgery. The Egyptian Journal of Surgery. 2022; 41: 141–146. https://doi.org/10.4103/ejs.ejs_296_21.

[4] Yang Y, Jiang X, Zhou Z, Lu B, Zhu Z, Jiang Q, *et al*. Priority Management of Henle Trunk in Cranial-to-Caudal Approach for Laparoscopic Right Hemicolon Cancer Surgery. Frontiers in Surgery. 2022; 9: 883973. https://doi.org/10.3389/fsurg.2022.883973.

[5] Hussain A, Mahmood F, Torrance AW, Tsiamis A. Impact of medial-to-lateral vs lateral-to-medial approach on short-term and cancer-related outcomes in laparoscopic colorectal surgery: A retrospective cohort study. Annals of Medicine and Surgery. 2017; 26: 19–23. https://doi.org/10.1016/j.amsu.2017.12.011.

[6] Rawat S, Aggarwal S, Parikh PM, Chaudhary A, Kumar M, Sharma M, *et al*. Complete Mesocolic Excision for Colon Cancer: The New Standard of Care? South Asian Journal of Cancer. 2025; 13: 251–258. https://doi.org/10.1055/s-0044-1801754.

[7] Hajibandeh S, Hajibandeh S, Navid A, Sarma DR, Eltair M, Mankotia R, *et al*. Meta-analysis of medial-to-lateral versus lateral-to-medial colorectal mobilisation during laparoscopic colorectal surgery. International Journal of Colorectal Disease. 2019; 34: 787–799. https://doi.org/10.1007/s00384-019-03281-7.

[8] Zhang X, Zhang J, Ma P, Cao Y, Liu C, Li S, *et al*. Tunnel versus medial approach in laparoscopic radical right hemicolectomy for right colon cancer: a retrospective cohort study. BMC Surgery. 2022; 22: 27. https://doi.org/10.1186/s12893-022-01491-5.

[9] Yao Z, Wang X, Zhang Y, Hu J, Jian M, Jiang L. Cranial-caudal-medial approach, counterclockwise complete mesocolic excision in laparoscopic right hemicolectomy. Colorectal Disease. 2022; 24: 1258–1259. https://doi.org/10.1111/codi.16186.

[10] Nagayoshi K, Nagai S, Zaguirre KP, Hisano K, Sada M, Mizuuchi Y, *et al*. Securing the surgical field for mobilization of right-sided colon cancer using the duodenum-first multidirectional approach in laparoscopic surgery. Techniques in Coloproctology. 2021; 25: 865–874. https://doi.org/10.1007/s10151-021-02444-5.

[11] Tang K, Goldman S, Avrumova F, Lebl DR. Background, techniques, applications, current trends, and future directions of minimally invasive endoscopic spine surgery: A review of literature. World Journal of Orthopedics. 2023; 14: 197–206. https://doi.org/10.5312/wjo.v14.i4.197.

[12] Maatouk M, Safta YB, Kbir GH, Mabrouk A, Dhaw AB, Haouet K, *et al*. Caudal-to-Cranial Approach for Right Colectomy with Complete Mesocolic Excision in Colon Cancer: A Systematic Review and Meta-analysis. Journal of Gastrointestinal Cancer. 2023; 54: 739–750. https://doi.org/10.1007/s12029-022-00894-0.

[13] Rabe SM, Mehdorn M, Gockel I, Stelzner S. Der Lateral-to-medial-Approach der kompletten mesokolischen Exzision. coloproctology. 2023; 45: 379–388. https://doi.org/10.1007/s00053-023-00737-x.

[14] Misra L, Sethi MK, Sahoo MR, Gond PK, Poddar KK. The tunnel versus medial versus lateral approach in laparoscopic right hemicolectomy in colon cancer: A retrospective study. Asian Journal of Medical Sciences. 2023; 14: 224–228. https://doi.org/10.71152/ajms.v14i3.3775.

[15] Fu Z, Jin Z, Zhang C, He Z, Zha Z, Hu C, *et al*. The future of endoscopic navigation: a review of advanced endoscopic vision technology. IEEE Access. 2021; 9: 41144–41167. https://doi.org/10.1109/ACCESS.2021.

[16] Abdel-Raouf Hanafi O, Youssef T, Emad MM. "Caudal to Cranial" Versus "Medial to Lateral" Approaches in Laparoscopic Right Hemicolectomy, Retrospective comparative study. The Egyptian Journal of Surgery. 2025; 44: 384–389.

[17] Amin MB, Greene FL, Edge SB, Compton CC, Gershenwald JE, Brookland RK, *et al*. The Eighth Edition AJCC Cancer Staging Manual: Continuing to build a bridge from a population-based to a more "personalized" approach to cancer staging. CA: A Cancer Journal for Clinicians. 2017; 67: 93–99. https://doi.org/10.3322/caac.21388.

[18] Baxter NN, Kennedy EB, Bergsland E, Berlin J, George TJ, Gill S, *et al*. Adjuvant Therapy for Stage II Colon Cancer: ASCO Guideline Update. Journal of Clinical Oncology. 2022; 40: 892–910. https://doi.org/10.1200/JCO.21.02538.

[19] Duraes LC, Stocchi L, Steele SR, Kalady MF, Church JM, Gorgun E, *et al*. The Relationship Between Clavien-Dindo Morbidity Classification and Oncologic Outcomes After Colorectal Cancer Resection. Annals of Surgical Oncology. 2018; 25: 188–196. https://doi.org/10.1245/s10434-017-6142-6.

[20] Yi X, Liao W, Zhu B, Feng X, Li H, Chen C, *et al*. "Caudal to cranial" versus "medial to lateral" approach in laparoscopic right hemicolectomy with complete mesocolic excision for the treatment of stage II and III colon cancer: perioperative outcomes and 5-year prognosis. Updates in Surgery. 2023; 75: 1149–1160. https://doi.org/10.1007/s13304-023-01514-7.

[21] Zhou L, Diao D, Ye K, Feng Y, Yi X, Tong W, *et al*. The Medial Border of Laparoscopic D3 Lymphadenectomy for Right Colon Cancer: Results from an Exploratory Pilot Study. Diseases of the Colon and Rectum. 2021; 64: 1286–1296. https://doi.org/10.1097/DCR.0000000000002046.

[22] Yang SY, Kim MJ, Kye BH, Han YD, Cho MS, Park JW, *et al*. Surgical quality assessment for the prospective study of oncologic outcomes after laparoscopic modified complete mesocolic excision for nonmetastatic right colon cancer (PIONEER study). International Journal of Surgery. 2024; 110: 1484–1492. https://doi.org/10.1097/JS9.0000000000000956.

[23] Ichikawa N, Homma S, Yoshida T, Emoto S, Imaizumi K, Miyaoka Y, *et al*. Modified complete mesocolic excision with central vascular ligation by the squeezing approach in laparoscopic right colectomy. Langenbeck's Archives of Surgery. 2022; 407: 409–419. https://doi.org/10.1007/s00423-021-02267-w.

[24] Fujiwara S, Kaino K. Laparoscopic Sigmoidectomy for Sigmoid Cancer With Persistent Descending Mesocolon: Anatomical Char-

acteristics and Technical Tips. Cureus. 2022; 14: e27942. https://doi.org/10.7759/cureus.27942.

[25] Thürig G, Herbst E, Deichsel A, Peez C, Briese T, Glasbrenner J, *et al*. The Effect of C-Arm Position on Femoral Tunnel Placement in Medial Patellofemoral Ligament Reconstruction. Orthopaedic Journal of Sports Medicine. 2024; 12: 23259671241288153. https://doi.org/10.1177/23259671241288153.

[26] Ong MLH, Schofield JB. Assessment of lymph node involvement in colorectal cancer. World Journal of Gastrointestinal Surgery. 2016; 8: 179–192. https://doi.org/10.4240/wjgs.v8.i3.179.

[27] Anania G, Tamburini N, Sanzi M, Schimera A, Bombardini C, Resta G, *et al*. Extracorporeal versus intracorporeal anastomosis in laparoscopic right hemicolectomy for cancer. Minimally Invasive Therapy & Allied Technologies. 2022; 31: 112–118. https://doi.org/10.1080/13645706.2020.1757464.

[28] Jansen-Winkeln B, Holfert N, Köhler H, Moulla Y, Takoh JP, Rabe SM, *et al*. Determination of the transection margin during colorectal resection with hyperspectral imaging (HSI). International Journal of Colorectal Disease. 2019; 34: 731–739. https://doi.org/10.1007/s00384-019-03250-0.

[29] Bertelsen CA, Neuenschwander AU, Jansen JE, Wilhelmsen M, Kirkegaard-Klitbo A, Tenma JR, *et al*. Disease-free survival after complete mesocolic excision compared with conventional colon cancer surgery: a retrospective, population-based study. The Lancet. Oncology. 2015; 16: 161–168. https://doi.org/10.1016/S1470-2045(14)71168-4.

[30] Clinical Outcomes of Surgical Therapy Study Group, Nelson H, Sargent DJ, Wieand HS, Fleshman J, Anvari M, *et al*. A comparison of laparoscopically assisted and open colectomy for colon cancer. The New England Journal of Medicine. 2004; 350: 2050–2059. https://doi.org/10.1056/NEJMoa032651.

[31] Matsuda T, Iwasaki T, Sumi Y, Yamashita K, Hasegawa H, Yamamoto M, *et al*. Laparoscopic complete mesocolic excision for right-sided colon cancer using a cranial approach: anatomical and embryological consideration. International Journal of Colorectal Disease. 2017; 32: 139–141. https://doi.org/10.1007/s00384-016-2673-8.

[32] Guillou PJ, Quirke P, Thorpe H, Walker J, Jayne DG, Smith AMH, *et al*. Short-term endpoints of conventional versus laparoscopic-assisted surgery in patients with colorectal cancer (MRC CLASICC trial): multicentre, randomised controlled trial. Lancet. 2005; 365: 1718–1726. https://doi.org/10.1016/S0140-6736(05)66545-2.

[33] Gustafsson UO, Scott MJ, Hubner M, Nygren J, Demartines N, Francis N, *et al*. Guidelines for Perioperative Care in Elective Colorectal Surgery: Enhanced Recovery After Surgery (ERAS®) Society Recommendations: 2018. World Journal of Surgery. 2019; 43: 659–695. https://doi.org/10.1007/s00268-018-4844-y.

[34] Shinji S, Yamada T, Matsuda A, Sonoda H, Ohta R, Iwai T, *et al*. Recent Advances in the Treatment of Colorectal Cancer: A Review. Journal of Nippon Medical School. 2022; 89: 246–254. https://doi.org/10.1272/jnms.JNMS.2022_89-310.

[35] Ivey GD, Johnston FM, Azad NS, Christenson ES, Lafaro KJ, Shubert CR. Current Surgical Management Strategies for Colorectal Cancer Liver Metastases. Cancers. 2022; 14: 1063. https://doi.org/10.3390/cancers14041063.

[36] Lin HS, Watts JN, Peel NM, Hubbard RE. Frailty and post-operative outcomes in older surgical patients: a systematic review. BMC Geriatrics. 2016; 16: 157. https://doi.org/10.1186/s12877-016-0329-8.

[37] Brown KGM, Ng KS, Solomon MJ, Chapuis PH, Koh CE, Ahmadi N, *et al*. Complete mesocolic excision for colon cancer: current status and controversies. ANZ Journal of Surgery. 2024; 94: 309–319. https://doi.org/10.1111/ans.18741.

[38] Wang J, Zhou J, Cheng Y, Zhao S, Li R, Zhang C, *et al*. Comparing cranial-caudal-medial and medial-lateral approaches for laparoscopic right hemicolectomy: a propensity score-matched analysis. World Journal of Surgical Oncology. 2024; 22: 187. https://doi.org/10.1186/s12957-024-03465-8.

[39] Ding J, Liao GQ, Xia Y, Zhang ZM, Pan Y, Liu S, *et al*. Medial versus lateral approach in laparoscopic colorectal resection: a systematic review and meta-analysis. World Journal of Surgery. 2013; 37: 863–872. https://doi.org/10.1007/s00268-012-1888-2.