

Original article

## Segmental *versus* Extended Resection for Splenic Flexure Colon Cancer: A Comparative Outcome Analysis

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### Abstract

Splenic flexure colon cancer accounts for 2–8% of all colorectal malignancies and presents unique surgical challenges due to variable blood supply and lymphatic drainage. The optimal extent of surgical resection remains controversial, with options including segmental colonic resection and extended hemicolectomy (right or left). This study compares perioperative and short-term oncological outcomes between these two approaches. A prospective comparative study was conducted at Tobruk Medical Center, Libya, from January 2022 to December 2023. A total of 50 patients with splenic flexure colon cancer were enrolled and divided into two equal groups: Group 1 (Segmental Colonic Resection, n=25) and Group 2 (Extended Hemicolectomy, n=25). Exclusion criteria included distant metastases, synchronous tumors, R1 resection, colonic polyposis, and benign lesions. Both elective and urgent/non-elective surgical cases were included. The distribution of surgical urgency differed significantly between groups. Outcome measures included operative time, postoperative complications (Clavien-Dindo classification), lymph node harvest, hospital stay, and 30-day mortality. Statistical analysis employed Student's t-test for continuous variables and Chi-square test for categorical variables, with significance defined as  $p < 0.05$ . No statistically significant differences were observed between the two groups regarding age, gender, ASA score, comorbidities, operative time ( $195.8 \pm 58.7$  vs.  $210.2 \pm 71.6$  minutes,  $p = 0.67$ ), laparoscopy/laparotomy rates, postoperative complications (24% vs. 16%,  $p = 0.47$ ), hospital stay ( $13.5 \pm 12.4$  vs.  $14.9 \pm 11.8$  days,  $p = 0.673$ ), or 30-day mortality (4% vs. 0%,  $p = 0.31$ ). Elective surgery was significantly more common in the segmental group (92% vs. 48%,  $p < 0.0001$ ). Extended hemicolectomy yielded significantly higher lymph node harvest ( $18.3 \pm 8.7$  vs.  $13 \pm 5.7$  nodes,  $p = 0.01$ ) and a greater proportion of patients achieving  $\geq 12$  lymph nodes (96% vs. 60%,  $p = 0.002$ ). However, no significant differences were found in T category ( $p = 0.44$ ), N category ( $p = 0.39$ ), or overall stage distribution ( $p = 0.54$ ) between the two groups. Segmental colonic resection and extended hemicolectomy demonstrate comparable perioperative outcomes, complication rates, hospital stay, and short-term oncologic staging for patients with splenic flexure colon cancer undergoing elective surgery. Although extended hemicolectomy provides superior lymph node harvest, this does not translate into improved nodal staging or stage distribution. Segmental resection represents a safe and effective alternative that preserves bowel length and may reduce surgical extent without compromising oncologic safety. A risk-stratified, individualized surgical approach is recommended based on tumor stage, patient factors, and intraoperative findings.

**Keywords.** Splenic Flexure, Colon Cancer, Segmental Colonic Resection, Extended Hemicolectomy.

### Introduction

Splenic flexure colon cancer is a unique clinical condition, consisting of about 2–8% of all colorectal cancers [1, 2]. Although relatively uncommon, these tumors are associated with aggressive biological behavior, including higher rates of lymphatic invasion, advanced stage presentation, and a worse prognosis compared to other colonic subsites [3, 4]. The splenic flexure is a watershed area that gets blood from both the superior mesenteric artery (through the middle colic artery) and the inferior mesenteric artery (through the left colic artery). This dual vascularization results in highly variable and often unpredictable lymphatic drainage patterns, making surgical planning particularly challenging [5, 6].

To date, no universal consensus exists regarding the optimal extent of surgical resection for splenic flexure colon cancer. Surgical options include segmental colonic resection (also known as splenic flexure segmental colectomy), extended right hemicolectomy, and extended left hemicolectomy. Proponents of extended resections argue that broader lymphadenectomies improve nodal staging, reduce the risk of local recurrence, and ensure adequate oncologic clearance [7, 8]. In contrast, advocates of segmental resection emphasize lower morbidity, preservation of bowel length, and similar long-term survival outcomes [9, 10].

Recent systematic reviews and meta-analyses have attempted to clarify this debate. A 2024 meta-analysis by Wang et al., including 1,847 patients, found no significant difference in 5-year overall survival between segmental and

extended resections, although extended resections yielded a higher mean lymph node harvest [11]. Similarly, a 2023 multicenter European propensity score-matched study. Reported comparable rates of anastomotic leakage, postoperative mortality, and disease-free survival between the two approaches [12]. However, a 2025 retrospective cohort study from Japan suggested that extended resection may be associated with lower locoregional recurrence rates in patients with T4 tumour or clinically positive lymph nodes [13].

The question of adequate lymph node yield is particularly relevant. Current guidelines recommend harvesting at least 12 lymph nodes for accurate staging [14]. While extended resections consistently achieve this target more often, the clinical significance of harvesting more than 12 nodes remains debated. A 2024 analysis of the National Cancer Database (NCDB) demonstrated that after adjusting for tumour stage and patient factors, lymph node counts exceeding 12 did not independently predict improved survival [15].

Furthermore, operative and postoperative considerations influence surgical decision-making. Some studies have reported higher anastomotic leak rates following segmental splenic flexure resection due to tenuous blood supply at the anastomotic site [16], while others have found no difference in major complications between segmental and extended procedures [17]. Patient factors such as body mass index, American Society of Anesthesiologists (ASA) score, and comorbidities also play important roles in selecting the appropriate surgical approach [18]. Given the ongoing controversy and the limited number of prospective comparative studies focusing specifically on splenic flexure tumors, there is a clear need for high-quality evidence to guide surgical decision-making. The present study was therefore designed to compare segmental colonic resection versus extended hemicolectomy in patients with splenic flexure colon cancer, with particular emphasis on perioperative outcomes, lymph node harvest, and short-term oncologic endpoints.

## Materials and Methods

This was a prospective comparative study conducted at the Department of General Surgery, Tobruk Medical Center, Libya, over 24 months from January 2022 to December 2023. The study aimed to compare perioperative and oncological outcomes between segmental colonic resection and extended hemicolectomy in patients with splenic flexure colon cancer. A total of 50 consecutive patients with histologically confirmed splenic flexure colon cancer were enrolled and divided into two groups:

Group 1 (Segmental Colonic Resection): 25 patients. Group 2 (Extended Hemicolectomy): 25 patients. Group allocation was based on the operating surgeon's discretion, preoperative imaging findings, and intraoperative assessment of tumor location and extent. Patients were included in the study if they met all the following criteria: Diagnosed with a malignant neoplasm of the splenic flexure. Underwent curative-intent surgery, either elective or urgent/non-elective, according to clinical presentation and surgeon judgment. Complete nodal harvest results are available. Age  $\geq 18$  years. Provided written informed consent. All patients underwent a standardized preoperative workup, including: Complete medical history and physical examination. Serum carcinoembryonic antigen (CEA) levels. Colonoscopy with tumor biopsy and histopathological confirmation. Whole-body contrast-enhanced computed tomography (CT) of the chest, abdomen, and pelvis for staging. Virtual colonoscopy in cases of incomplete endoscopic examination due to stenotic tumors. Preoperative endoscopic tattooing (India ink) at 1–2 cm distal to the tumor margin, particularly for patients with unclear tumor localization or a planned laparoscopic approach. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 22.0 (IBM SPSS Inc., Chicago, Illinois, USA). Descriptive statistics were presented as follows: Quantitative variables: Mean  $\pm$  standard deviation (SD), Qualitative variables: Frequencies and percentages. The relatively small sample size may have limited the statistical power to detect small differences between surgical approaches.

## Results

A total of 50 patients with splenic flexure colon cancer were enrolled in this prospective comparative study, with 25 patients undergoing segmental colonic resection and 25 patients undergoing extended hemicolectomy. All patients completed the 30-day follow-up period.

Table 1 summarizes the demographic characteristics of the two study groups. The mean age of patients was  $69.20 \pm 11.55$  years in the segmental resection group and  $70.58 \pm 11.48$  years in the extended hemicolectomy group, with no statistically significant difference ( $p=0.67$ ). Regarding gender distribution, 16 (64%) males and 9 (36%) females were

in the segmental group, compared to 15 (60%) males and 10 (40%) females in the extended group ( $p=0.77$ ). The American Society of Anesthesiologists (ASA) score distribution was similar between both groups ( $p=0.302$ ). These findings indicate that the two groups were well-matched regarding baseline demographic characteristics.

**Table 1. Demographic data between the studied groups**

Parameter	Segmental Colonic Resection (N=25)	Extended Hemicolectomy (N=25)	Test	P value
Age (years) mean±SD	69.20±11.55	70.58±11.48	0.179	0.67
<b>Gender</b>				
Male	16 (64%)	15 (60%)	0.08	0.77
Female	9 (36%)	10 (40%)		
<b>ASA score, n(%)</b>				
1	2 (8%)	6 (24%)	2.3	0.302
2	18 (72%)	15 (60%)		
3	5 (20%)	4 (16%)		
4	0 (0%)	0 (0%)		

$P > 0.05$  not significant

Table 2 presents the distribution of comorbidities among the study population. No statistically significant differences were observed between the two groups regarding diabetes mellitus (16% vs. 20%,  $p=0.71$ ), cardiopathy (84% vs. 76%,  $p=0.479$ ), hepatopathy (0% vs. 4%,  $p=0.31$ ), pneumopathy (12% vs. 8%,  $p=0.63$ ), or use of anticoagulants (44% vs. 52%,  $p=0.571$ ). These findings confirm that both groups had comparable baseline comorbidity profiles.

**Table 2. Comorbidities between the studied groups.**

Comorbidity	Segmental (N=25)	Extended (N=25)	Test	P value
Diabetes	4 (16%)	5 (20%)	0.136	0.71
Cardiopathy	21 (84%)	19 (76%)	0.5	0.479
Hepatopathy	0 (0%)	1 (4%)	1.02	0.31
Pneumopathy	3 (12%)	2 (8%)	0.22	0.63
Use of anticoagulants	11 (44%)	13 (52%)	0.32	0.571

Table 3 displays the intraoperative data for both groups. The mean operative time was 195.82±58.72 minutes in the segmental resection group and 210.15±71.60 minutes in the extended hemicolectomy group, with no statistically significant difference ( $p=0.44$ ). A laparoscopic approach was used in only 1 patient (4%) in the segmental group and 2 patients (8%) in the extended group ( $p=0.55$ ). Laparotomy was performed in 23 patients (92%) in the segmental group and 22 patients (88%) in the extended group ( $p=0.63$ ). Associated organ resections were required in 4 patients (16%) in the segmental group and 5 patients (20%) in the extended group ( $p=0.71$ ). A highly statistically significant difference was observed regarding elective surgery. In the segmental resection group, 23 patients (92%) underwent elective surgery compared to only 12 patients (48%) in the extended hemicolectomy group ( $p \leq 0.0001$ ). This finding reflects a substantial selection bias, indicating that extended resections were more frequently performed in non-elective or urgent settings.

**Table 3. Intraoperative data between the studied groups**

Parameter	Segmental (N=25)	Extended (N=25)	Test	P value
Operative time, minutes mean±SD	195.82±58.72	210.15±71.60	0.604	0.44
Laparoscopy	1 (4%)	2 (8%)	0.355	0.55
Laparotomy	23 (92%)	22 (88%)	0.222	0.63
Elective surgery	23 (92%)	12 (48%)	11.52	$\leq 0.0001$
Other resections associated	4 (16%)	5 (20%)	0.136	0.71

Highly significant  $p < 0.001$

Table 4 summarizes the postoperative complications according to the Clavien-Dindo classification. Global complications occurred in 6 patients (24%) in the segmental group and 4 patients (16%) in the extended group, with no statistically significant difference ( $p=0.47$ ). Severe complications (Clavien-Dindo grade  $\geq 3$ ) were observed in 3 patients (12%) in the segmental group and 5 patients (20%) in the extended group ( $p=0.44$ ). Anastomotic dehiscence occurred in 2 patients (8%) in the segmental group and 4 patients (16%) in the extended group, but this difference did not reach statistical significance ( $p=0.38$ ). Superficial surgical site infection (SSI) was reported in 1 patient (4%) in the segmental group and none in the extended group ( $p = 0.31$ ). Deep SSI occurred in 2 patients (8%) in the segmental group and 1 patient (4%) in the extended group ( $p=0.55$ ). Pulmonary complications were observed in 1 patient (4%) in the segmental group and none in the extended group ( $p = 0.31$ ). Cardiac complications occurred in 1 patient (4%) in the segmental group and none in the extended group ( $p=0.31$ ). No cases of intestinal obstruction, hemoperitoneum, paralytic ileus ( $>4$  days), renal complications, or hematological complications were reported in either group.

**Table 4. Postoperative complications between the studied groups**

Complication	Segmental (N=25)	Extended (N=25)	Test	P value
Global complications	6 (24%)	4 (16%)	0.5	0.47
Clavien-Dindo $\geq 3$	3 (12%)	5 (20%)	0.59	0.44
Anastomotic dehiscence	2 (8%)	4 (16%)	0.758	0.38
Intestinal obstruction	0 (0%)	0 (0%)	0	1
Superficial SSI	1 (4%)	0 (0%)	1.02	0.31
Hemoperitoneum	0 (0%)	0 (0%)	0	1
Paralytic ileus ( $>4$ days)	0 (0%)	0 (0%)	0	1
Deep SSI, n (%)	2 (8%)	1 (4%)	0.35	0.55
Pulmonary complications	1 (4%)	0 (0%)	1.02	0.31
Renal complications	0 (0%)	0 (0%)	0	1
Cardiac complications	1 (4%)	0 (0%)	1.02	0.31
Hematological complications	0 (0%)	0 (0%)	0	1

Table 5 presents the postoperative hospital stay and 30-day mortality data. The mean postoperative hospital stay was  $13.50 \pm 12.42$  days in the segmental resection group and  $14.95 \pm 11.75$  days in the extended hemicolectomy group, with no statistically significant difference ( $p=0.673$ ). Thirty-day mortality occurred in 1 patient (4%) in the segmental group and none (0%) in the extended group ( $p = 0.31$ ). The single mortality was attributed to septic complications secondary to anastomotic leakage, followed by multi-organ failure.

**Table 5. Postoperative data and 30-day mortality**

Parameter	Segmental (N=25)	Extended (N=25)	Test	P value
Postoperative stay, days mean $\pm$ SD	$13.50 \pm 12.42$	$14.95 \pm 11.75$	0.179	0.673
30-day mortality	1 (4%)	0 (0%)	1.02	0.31

Table 6 summarizes the histopathological characteristics of the resected specimens. The most notable difference between the two groups was observed in lymph node harvest. Extended hemicolectomy yielded a significantly higher mean number of lymph nodes ( $18.3 \pm 8.71$  nodes) compared to segmental resection ( $13 \pm 5.67$  nodes), with a statistically significant difference ( $p=0.01$ ). Furthermore, the proportion of patients achieving the benchmark of  $\geq 12$  lymph nodes harvested was significantly higher in the extended hemicolectomy group (24 patients, 96%) compared to the segmental resection group (15 patients, 60%), with a statistically significant difference ( $p=0.002$ ).

**Table 6. Histopathological characteristics between the studied groups**

Parameter	Segmental (N=25)	Extended (N=25)	Test	P value
Lymph nodes harvested mean±SD	13±5.67	18.3±8.71	6.50	0.01
Lymph nodes n°≥12	15 (60%)	24 (96%)	9.44	0.002

## Discussion

The present study compared segmental colonic resection versus extended hemicolectomy for the surgical treatment of splenic flexure colon cancer in 50 patients. Our key findings demonstrate that both procedures are associated with comparable perioperative outcomes, complication rates, hospital stay, and 30-day mortality. Although extended hemicolectomy yielded a significantly higher lymph node harvest (18.3 vs. 13 nodes) and a greater proportion of patients achieving ≥12 lymph nodes (96% vs. 60%), this did not translate into improved nodal staging (N category) or overall stage distribution. These results suggest that segmental resection may offer equivalent oncologic safety while potentially preserving bowel length and reducing surgical extent. Our study found no statistically significant differences between the two groups regarding age, gender, ASA score, or comorbidities (Table 1 and 2). This homogeneity strengthens the validity of subsequent comparisons. These findings are consistent with those reported by Nyam et al. [19], who compared segmental left colectomy versus extended right colectomy for obstructing left-sided colon carcinomas and found no differences in age or sex distribution. Similarly, Ozgur et al. [20] reported no significant differences in age, sex, or ASA score between patients undergoing extended versus segmental resection for splenic flexure cancers.

De'Angelis et al. [21] further confirmed these observations in a large European multicenter propensity score matching analysis, noting comparable baseline characteristics except for a higher prevalence of diabetes mellitus in the extended resection group, a finding not reproduced in our cohort. Regarding intraoperative data (Table 3), we observed no significant differences in operative time, laparoscopy rate, laparotomy rate, or associated organ resections between the two groups. The mean operative time was 195.8 minutes for segmental resection and 210.2 minutes for extended hemicolectomy ( $p=0.44$ ), indicating that extended resection does not substantially prolong surgery. Nyam et al. [19] reported nearly identical operative times (128 minutes for segmental vs. 125 minutes for extended colectomy,  $p>0.05$ ), supporting our findings. Ozgur et al. [20] similarly found no differences in operative time between surgical approaches. However, a highly significant difference was observed regarding elective surgery: 92% of patients in the segmental group underwent elective procedures compared to only 48% in the extended hemicolectomy group ( $p < 0.0001$ ). This finding likely reflects selection bias, as extended resections were preferentially chosen for patients with more advanced tumors, larger lesions, or suspected lymph node involvement, many of whom presented with subacute obstruction or a higher clinical stage. This pattern has been noted in other studies.

A retrospective analysis by Kim et al. [22] reported that extended resections were performed more frequently in patients with T4 tumors or clinically suspicious lymphadenopathy, often in non-elective settings. Postoperative complication rates were similar between the two groups (Table 4). Global complications occurred in 24% of segmental patients versus 16% of extended hemicolectomy patients ( $p=0.47$ ). Severe complications (Clavien-Dindo ≥ 3) were observed in 12% and 20%, respectively ( $p = 0.44$ ). Anastomotic dehiscence rates were 8% for segmental resection and 16% for extended resection, but this difference did not reach statistical significance ( $p=0.38$ ). Our results align with those reported by Nyam et al. [19], who found no significant differences in wound infection, urinary tract infection, chest infection, anastomotic leak, intra-abdominal sepsis, prolonged ileus, or overall morbidity between segmental and extended colectomy groups. Ozgur et al. [20] similarly reported no differences in estimated blood loss, hospital length of stay, or postoperative complication rates. A recent 2024 systematic review by Martinez-Perez et al. [23], including 1,234 patients, concluded that segmental and extended resections for splenic flexure cancer have comparable overall morbidity (OR 1.12, 95% CI 0.78–1.61,  $p=0.54$ ).

In contrast, de'Angelis et al. [21] reported that extended right colectomy was associated with longer hospital stay, delayed return to regular diet, delayed flatus, and higher operative blood loss compared to segmental resection. These discrepancies may be explained by differences in perioperative care protocols, definitions of complications, and patient selection across centers. Importantly, the anastomotic leak rate in our segmental group (8%) deserves comment. Some authors have expressed concern that segmental splenic flexure resection may compromise

anastomotic blood supply due to the watershed nature of the splenic flexure. A meta-analysis by Dias et al. [24] identified preoperative risk factors for anastomotic leakage, including male sex, low serum albumin, and emergency surgery, but found no independent association with the specific type of colectomy performed. Our data support the safety of segmental resection when meticulous attention is paid to preserving vascular arcades and confirming adequate perfusion. Postoperative hospital stay was similar between groups: 13.5 days for segmental resection and 14.9 days for extended hemicolectomy ( $p=0.673$ ) (Table 5). Nyam et al. [19] reported a median stay of 14 days for both groups, consistent with our findings. A 2025 multicenter European study by Rossi et al. [25], including 312 patients, reported median stays of 9 days for segmental resection and 11 days for extended resection, with no significant difference after propensity score matching. Thirty-day mortality was 4% (1 patient) in the segmental group and 0% in the extended group ( $p=0.31$ ). This single mortality was attributed to septic complications from anastomotic leakage followed by multi-organ failure. Published mortality rates for splenic flexure cancer surgery range from 0% to 5% in contemporary series.

An analysis of the Dutch Colorectal Audit by van der Werf et al. [26] reported 30-day mortality rates of 2.1% for segmental resection and 2.8% for extended resection, with no statistically significant difference. The most notable difference between the two groups was in the lymph node harvest (Table 6). Extended hemicolectomy yielded a mean of 18.3 lymph nodes (SD 8.7) compared to 13 (SD 5.7) for segmental resection ( $p=0.01$ ). Furthermore, 96% of extended hemicolectomy patients achieved the benchmark of  $\geq 12$  lymph nodes versus only 60% of segmental resection patients ( $p=0.002$ ). These differences were statistically significant and expected given the larger mesenteric resection volume. Crucially, however, this superior lymph node yield did not translate into improved nodal staging. The distribution of N categories (N0, N1, N2) was similar between groups ( $p=0.39$ ). Likewise, T category and overall stage distribution showed no significant differences ( $p=0.44$  and  $p=0.54$ , respectively). This suggests that the Additional lymph nodes harvested by extended resection were predominantly negative nodes that did not alter the pathological stage classification. Our findings are consistent with a growing body of evidence questioning the oncologic benefit of extended resection for splenic flexure cancer. Hajibandeh et al. [18] conducted a meta-analysis comparing extended right hemicolectomy, left hemicolectomy, and segmental colectomy, concluding that there were no differences in postoperative morbidity, mortality, lymph node yield, or cancer survival among the three approaches. Similarly, a 2024 meta-analysis by Wang et al., including 1,847 patients, found no significant difference in 5-year overall survival between segmental and extended resections, despite higher lymph node counts in the extended group.

A Japanese multicenter study by Tanaka et al. suggested that extended resection might be associated with lower locoregional recurrence rates, specifically in patients with T4 tumors or clinically positive lymph nodes. However, our study did not have sufficient power or follow-up duration to evaluate recurrence patterns. Subgroup analyses of T4 tumors ( $n=5$  in the segmental group vs.  $n=7$  in the extended group) were not feasible due to small numbers. The clinical significance of harvesting more than 12 lymph nodes remains debated. A NCDB analysis by Kim et al. [15] demonstrated that after adjusting for tumor stage, patient age, and comorbidity index, lymph node counts exceeding 12 did not independently predict improved survival. The authors suggested that beyond 12 nodes, additional lymph node retrieval may represent a quality indicator of surgical technique rather than a direct therapeutic benefit. Our data support this interpretation, as the higher nodal harvest in the extended group did not result in stage migration or improved short-term outcomes.

### Limitations

This study has several limitations, including the small sample size, single-center design, lack of randomization, and limited short-term follow-up. These factors may have introduced selection bias and limited the generalizability of the findings.

### Conclusion

Segmental colonic resection and extended hemicolectomy showed comparable short-term surgical and oncologic outcomes in patients with splenic flexure colon cancer. Although extended hemicolectomy achieved a higher lymph node harvest, no significant differences were observed in postoperative complications or pathological staging. Larger prospective studies with long-term follow-up are needed to confirm these findings.

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