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Guided Preservation of Ascending Left Colic Artery during Left Colectomy in Left Cancer Colon

***Ahmed El Sayed Mohamed Abd El Rahman**
[1]Department of Surgical Oncology, Faculty of Medicine, Al-Azhar University, Cairo
***Corresponding author: Ahmed El Sayed Mohamed Abd El Rahman**, **Phone:** +201003684164,
Email: drahmedelsayedsurge@gmail.com

ABSTRACT

Background: Left colectomy requires adequate anastomotic blood supply to prevent leakage. The ascending branch of the left colic artery (ALCA), often ligated during high inferior mesenteric artery (IMA) ligation, is critical for enhancing perfusion. Guided ALCA preservation optimizes blood flow to the colonic stump, potentially reducing complications without compromising oncological radicality.

Aim: To assess the technical feasibility and safety of guided ALCA preservation during elective left colectomy for adenocarcinoma. It aimed to objectively assess its impact on anastomotic perfusion using indocyanine green (ICG) angiography and correlate this with short-term clinical outcomes. **Patients and Methods:** One hundred consecutive patients undergoing elective left colectomy for left-sided colon adenocarcinoma at Al-Azhar University Hospitals (January 2023 – December 2024) were included. ICG fluorescence angiography assessed proximal stump perfusion with and without ALCA preservation. A standardized algorithm guided preservation decisions. Primary endpoints were ALCA preservation rates and ICG perfusion scores; secondary endpoints included anastomotic leak, hospital stay, and oncological parameters.

Results: Guided ALCA preservation was feasible in 92% of cases. ICG scores were significantly superior in the preservation group (4.5 ± 0.3 vs. 3.1 ± 0.5, $p<0.001$). The overall anastomotic leak rate was 4%, but only 1% in the ALCA preservation group versus 37.5% in the ligation group ($p=0.002$). Hospital stay was shorter with preservation (5.8 ± 1.2 days vs. 8.1 ± 2.5 days, $p=0.01$). Lymph node yield and margin status were comparable.

Conclusion: Guided ALCA preservation is feasible and safe, significantly enhancing anastomotic perfusion and reducing leak rates without compromising oncology. ICG angiography is valuable for optimizing outcomes.

Keywords: Left Colon Cancer, Left Colectomy, Ascending Left Colic Artery, Anastomotic Leak, Indocyanine Green, Fluorescence Angiography.

INTRODUCTION

Left-sided colorectal cancer, which includes tumors of the descending colon, sigmoid colon, and rectosigmoid junction, represents nearly two-thirds of all colorectal malignancies and is characterized by distinct clinical, pathological, and surgical features compared with right-sided colorectal cancer [1].

Surgical resection, most commonly in the form of a left colectomy or anterior resection, continues to serve as the cornerstone of curative treatment for colorectal malignancies. Despite major advancements in surgical techniques, perioperative care, and patient optimization, postoperative morbidity remains a significant concern. Among these complications, the integrity of the colorectal anastomosis plays a decisive role in determining both short- and long-term patient outcomes [2].

Anastomotic leakage, which occurs in approximately 3–15% of cases according to published reports, is considered one of the most severe and life-threatening postoperative events. This complication can lead to peritonitis, sepsis, and multiple organ dysfunction, substantially increasing the risk of postoperative mortality. In addition to its immediate clinical impact, anastomotic leakage is associated with extended hospitalization, delayed recovery, increased healthcare expenditures, and the need for additional surgical or radiological interventions. From an oncological perspective, the consequences are equally serious. Leakage can compromise local healing, disrupt planned adjuvant therapy, and contribute to higher rates of local tumor recurrence and poorer long-term survival outcomes. Therefore, meticulous surgical technique, proper patient selection, and the implementation of preventive strategies—such as intraoperative leak testing, tension-free anastomosis, and enhanced perioperative protocols—are essential to reduce the incidence and mitigate the consequences of this devastating complication [2,3].

Adequate blood supply to the anastomotic ends is paramount for successful healing. Traditionally, left colectomy often involves high ligation of the inferior mesenteric artery (IMA) at its origin from the aorta to achieve a radical lymphadenectomy along the main vascular trunk. This approach, while oncologically sound for central lymph node clearance, necessitates reliance on the marginal artery of Drummond or the middle colic artery for blood supply to the proximal colonic stump, which can sometimes be tenuous or compromised [4].

ALCA, a direct branch of the IMA, contributes significantly to the vascularization of the distal transverse and descending colon. Its routine ligation has been a subject of debate, with some advocating for its preservation to enhance perfusion to the proximal colon, particularly when the marginal artery is underdeveloped or interrupted [5].

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The concept of selective or guided preservation of the ALCA has emerged as a potential strategy to optimize anastomotic perfusion. This approach aims to balance the oncological imperative of lymphadenectomy with the physiological need for robust blood flow. However, the decision to preserve the ALCA cannot be arbitrary; it requires careful intraoperative assessment to confirm both its anatomical suitability and its functional contribution to perfusion [6].

Indocyanine green (ICG) fluorescence angiography has revolutionized intraoperative perfusion assessment in colorectal surgery. By providing real-time, objective visualization of vascularity, ICG allows surgeons to precisely delineate tissue perfusion, identify ischemic segments, and make informed decisions regarding anastomotic viability and the extent of vascular ligation [7].

Despite the theoretical advantages and the increasing adoption of ICG, comprehensive data on the technical feasibility, safety, and specific impact of a guided ALCA preservation strategy on anastomotic perfusion and clinical outcomes in left colectomy remains limited, particularly within specific regional cohorts. Understanding the benefits and challenges of this tailored approach is crucial for enhancing surgical techniques and improving patient safety.

This investogation therefore aimed to prospectively assess the technical feasibility and safety of guided preservation of the ALCA during elective left colectomy for left-sided colon cancer. Furthermore, it sought to objectively assess the impact of ALCA preservation on anastomotic perfusion using intraoperative ICG fluorescence angiography and to correlate these findings with short-term clinical outcomes, thereby contributing valuable evidence to optimize surgical practice.

PATIENTS AND METHODS

This prospective interventional study was executed at **Al-Azhar University Hospitals**, Cairo, Egypt, over a two-year period from **January 2023 to December 2024**.

Inclusion Criteria:

Patients were considered eligible for inclusion if they met the following criterion:

- **Age 18 years or older**, ensuring inclusion of adult participants capable of providing informed consent and tolerating the planned surgical and perioperative procedures.
- Diagnosed with histopathologically confirmed adenocarcinoma of the left colon (descending colon, sigmoid colon, or rectosigmoid junction).
- Undergoing elective left colectomy or anterior resection with primary anastomosis.
- Showing no evidence of distant metastasis on preoperative staging (CT scan of chest, abdomen, and pelvis).
- Classified as American Society of Anesthesiologists (ASA) physical status I, II, or III.
- Able to provide informed consent.

Exclusion Criteria:

Patients were excluded from the study if they met any of the following criteria:

- **Presence of distant metastases** detected during preoperative evaluation, as confirmed by imaging studies or other diagnostic assessments, which would alter the surgical management strategy and affect outcome comparability.
- Undergoing emergency surgery for colonic obstruction, perforation, or severe bleeding.
- A history of previous major abdominal or pelvic surgery that could significantly alter anatomy.
- Diagnosed with inflammatory bowel disease or familial adenomatous polyposis.
- Synchronous colorectal cancer.
- Documented contraindications to indocyanine green (ICG) administration (e.g., iodine allergy, severe liver dysfunction).
- Refused to participate or provide informed consent.

Preoperative Assessment:

All patients went through a **complete preoperative evaluation**, which involved medical history taking, thorough physical examination, and standard laboratory investigations. **Colonoscopy with biopsy** was performed to confirm the histopathological diagnosis, while **contrast-enhanced computed tomography (CT) of the chest, abdomen, and pelvis** was conducted for accurate disease staging and assessment of resectability. In addition, each patient's **nutritional status** was carefully evaluated, and appropriate **preoperative optimization measures** —such as dietary support or correction of metabolic abnormalities— were implemented when necessary to enhance surgical readiness and postoperative recovery.

Operative Details: Left Colectomy with Guided ALCA Preservation:

All surgical procedures were performed by experienced colorectal surgeons with expertise in laparoscopic and open colorectal surgery and ICG fluorescence angiography. The surgical approach (laparoscopic or open) was determined by the surgeon's preference and patient factors, but the principles of guided ALCA preservation and ICG assessment were applied consistently.

1. **Patient Positioning and Access:** Patients were placed in the modified lithotomy position. A standard laparoscopic setup (if applicable) or midline laparotomy incision was used.
2. **Mobilization and IMA Dissection:** The left colon was mobilized from the splenic flexure to the rectosigmoid junction. The inferior mesenteric artery (IMA) was identified and dissected at its origin from the aorta. The left colic artery (LCA)

and its ascending and descending branches, as well as the superior rectal artery, were carefully identified.

3. **Initial Perfusion Assessment (Pre-ligation):** Before any vascular ligation related to the IMA, a preliminary assessment of the proximal colonic stump (distal transverse/descending colon) was performed.
4. **Guided ALCA Preservation Strategy:**

- **ALCA** was carefully identified and meticulously dissected to delineate its anatomical course and ensure preservation or controlled ligation as per the study protocol.
- **Intraoperative Indocyanine Green (ICG) Fluorescence Angiography:** After complete mobilization of the left colon and clear identification of the ALCA, **5 mg of Indocyanine Green (ICG)** was administered intravenously. Real-time **near-infrared (NIR) fluorescence imaging** was then performed to assess the vascular perfusion of the colon, confirming the patency and perfusion territory of the ALCA and adjacent colonic segments before proceeding with resection or anastomosis.
- Using a near-infrared fluorescence imaging system (e.g., [Specify System, e.g., SPY Elite, PINPOINT, etc.], the perfusion of the proximal colonic stump was assessed.

Decision Algorithm:

- If the ALCA provided robust perfusion to the proximal colonic stump (visualized as rapid, intense, and homogeneous fluorescence in the planned transection line) and there was no suspicion of metastatic lymph nodes along the ALCA requiring its high ligation for oncological clearance, the ALCA was *preserved*.
- If the ALCA's contribution to proximal stump perfusion was deemed suboptimal by ICG, or if there was clear evidence or strong suspicion of metastatic lymph nodes directly adjacent to or involving the ALCA requiring its ligation for oncological radicality, the ALCA was *ligated* at its origin from the LCA or IMA.
    - The inferior mesenteric artery was ligated at its origin, distal to the ALCA if preserved, or including the ALCA if ligated. The inferior mesenteric vein was also ligated.
    5. **Resection and Anastomosis:** The left colon was resected according to oncological principles, ensuring adequate proximal and distal margins. A tension-free, well-perfused colorectal or coloanal anastomosis was created, typically using a stapled technique.
6. **Final Perfusion Assessment (Post-anastomosis):** A second dose of ICG (5 mg) was administered after the anastomosis was completed to confirm adequate perfusion of the anastomotic site. Any areas of poor perfusion would prompt consideration of anastomotic revision or diversion.
7. **Data Collection:** Critical intraoperative details, including total operative time, estimated blood loss, ICG perfusion scores (qualitative assessment based on fluorescence intensity and homogeneity, scored on a 1-5 scale, where 5 is excellent and 1 is poor), and the occurrence of any intraoperative complications, were meticulously recorded. The decision regarding ALCA preservation (preserved vs. ligated) was also documented.

Postoperative Follow-up:

Patients were closely monitored in the postoperative period for potential complications, including anastomotic leak (diagnosed clinically, radiologically, or endoscopically), wound infection, ileus, and other general surgical complications. Key recovery indicators such as time to first flatus, time to first bowel movement, and overall length of hospital stay were recorded. All excised specimens underwent thorough histopathological examination to determine tumor stage (TNM classification), differentiation grade, presence of lymphovascular or perineural invasion, and the status of resection margins. The **total number of harvested lymph nodes** and the **number of metastatic (positive) lymph nodes** were carefully recorded for each specimen to ensure accurate pathological staging. Postoperatively, patients were scheduled for **regular follow-up visits at 1, 3, 6, and 12 months** after hospital discharge. During these visits, clinical evaluation, laboratory tests, and imaging studies were performed as indicated to monitor **long-term outcomes, anastomotic integrity, and disease recurrence**.

Ethical approval:

The research protocol was approved by the Institutional Review Board (IRB) of Al-Azhar University prior to initiation. All eligible participants were thoroughly informed about the study's objectives, methodology, and potential risks and benefits, after which written informed consent was obtained from each participant before enrollment. The study was designed and implemented in accordance with Good Clinical Practice (GCP) guidelines and the ethical principles outlined in the Declaration of Helsinki (2013 revision). Confidentiality of patient data was strictly maintained throughout the study, and participants were assured the right to withdraw at any stage with no impact on their medical care or treatment.

Statistical analysis

Was performed leveraging IBM SPSS Statistics version 28.0. Descriptive statistics were applied to summarize baseline demographic, intraoperative, and clinicopathological data. Continuous variables were expressed as mean ± standard deviation (SD), while categorical variables were presented as frequencies and

percentages. Comparisons of continuous variables between the ALCA-preserved and ALCA-ligated groups were performed using the independent samples t-test. Associations between categorical variables were analyzed using the Chi-square (χ^2) test. A p-value < 0.05 was considered statistically significant for all analyses.

RESULTS

100 consecutive patients undergoing elective left colectomy for left-sided colon adenocarcinoma were enrolled in this prospective study. The patient cohort comprised 58 males (58%) and 42 females (42%), with a mean age of 65.1 ± 8.7 years. The most common tumor location was the sigmoid colon (70%). Pathological examination revealed that 65% of tumors were moderately differentiated. Tumor T-stage was mainly T3 (65%). Lymphovascular invasion was present in 30% of cases, and perineural invasion was noted in 8%. The mean body mass index (BMI) was 27.8 ± 3.5 kg/m^2. Baseline patient demographics and clinicopathological characteristics are summarized in **Table 1**.

Table (1): Patient Demographics and Clinicopathological Characteristics (n=100)

Characteristic	Value (Mean ± SD or n/%)
Age (years)	65.1 ± 8.7
Gender (Male/Female)	58 / 42
BMI (kg/m^2)	27.8 ± 3.5
Tumor Location	
Descending Colon	20 (20%)
Sigmoid Colon	70 (70%)
Rectosigmoid Junction	10 (10%)
Tumor Differentiation	
Well-differentiated	25 (25%)
Moderately-differentiated	65 (65%)
Poorly-differentiated	10 (10%)
T-Stage	
T2	18 (18%)
T3	65 (65%)
T4	17 (17%)
Lymphovascular Invasion	30 (30%)
Perineural Invasion	8 (8%)

The mean operative time was 210 ± 45 minutes, and the average estimated blood loss was 180 ± 60 mL. Guided preservation of the ALCA was technically feasible and successfully achieved in 92 patients (92%). In the remaining 8 patients (8%), the ALCA was ligated. There were no intraoperative complications directly attributable to the ICG administration or the attempt at ALCA preservation **(Table 2)**.

Table 2: Surgical Outcomes and ALCA Preservation Status (n=100)

Characteristic	Value (Mean ± SD or n/%)
Operative Time (minutes)	210 ± 45
Estimated Blood Loss (mL)	180 ± 60
ALCA Preservation Achieved	92 (92%)
ALCA Ligation	8 (8%)
Reasons for ALCA Ligation:	
Suboptimal ICG Perfusion	3
Oncological Indication	4
Anatomical Variation	1

Intraoperative ICG fluorescence angiography demonstrated a significant difference in perfusion scores to the proximal colonic stump based on ALCA preservation status. In the group where the ALCA was preserved (n=92), the mean ICG perfusion score was significantly higher than in the group where the ALCA was ligated. This objective assessment confirmed that ALCA preservation led to superior vascularization of the anastomotic site. Detailed ICG perfusion scores are presented in **Table 3**.

Table 3: Anastomotic Perfusion Assessment by ICG Angiography

ALCA Status	Number of Patients (n)	Mean ICG Perfusion Score (1-5 scale) ± SD	p-value
Preserved	92	4.5 ± 0.3	<0.001
Ligated	8	3.1 ± 0.5	

The overall postoperative complication rate was 22% (22/100). The most critical outcome, anastomotic leak, occurred in 4 patients (4%). A statistically significant difference in anastomotic leak rates was observed between the groups: 1% (1/92 patients) in the ALCA preservation group compared to 37.5% (3/8 patients) in the ALCA ligation group. Patients with ALCA preservation also demonstrated significantly faster recovery of bowel function compared to ALCA ligation group. The mean length of hospital stay was significantly shorter in the ALCA preservation group. There was no perioperative mortality recorded in this study. Postoperative outcomes are detailed in **Table 4**.

Table 4: Postoperative Clinical Outcomes

Outcome	ALCA Preserved (n=92)	ALCA Ligated (n=8)	p-value
Overall Complication Rate	19% (17/92)	62.5% (5/8)	0.004
Anastomotic Leak	1% (1/92)	37.5% (3/8)	<0.001
Mean Time to First Flatus (days)	2.1 ± 0.5	3.5 ± 0.8	<0.001
Mean Length of Hospital Stay (days)	5.8 ± 1.2	8.1 ± 2.5	0.01
Wound Infection	7% (6/92)	25% (2/8)	0.06
Prolonged Ileus	5% (5/92)	12.5% (1/8)	0.42
Urinary Tract Infection	3% (3/92)	0% (0/8)	0.60
Perioperative Mortality	0% (0/92)	0% (0/8)	1.00

The mean number of harvested lymph nodes was 22.5 ± 5.1 in the ALCA preservation group and 20.1 ± 4.8 in the ALCA ligation group, both well above the recommended minimum for adequate staging. The rate of positive lymph nodes was 35% in the ALCA preservation group and 37.5% in the ALCA ligation group. All patients achieved clear proximal and distal resection margins. These findings suggest that ALCA preservation, when guided by oncological considerations, did not compromise the adequacy of lymphadenectomy or margin status. Oncological outcomes are summarized in **Table 5**.

Table 5: Oncological Outcomes

Outcome	ALCA Preserved (n=92)	ALCA Ligated (n=8)	p-value
Mean Harvested Lymph Nodes ± SD	22.5 ± 5.1	20.1 ± 4.8	0.21
Positive Lymph Nodes (%)	35% (32/92)	37.5% (3/8)	0.88
Clear Resection Margins (%)	100% (92/92)	100% (8/8)	1.00

DISCUSSION

The integrity of the colorectal anastomosis is a cornerstone of successful left colectomy for left-sided colon cancer, with anastomotic leak remaining a significant and feared complication [7]. Our prospective study offers compelling evidence to backup the technical feasibility, safety, and clinical benefits of a guided approach to preserving the ALCA during elective left colectomy. The findings underscore that selective ALCA preservation, informed by intraoperative indocyanine green (ICG) fluorescence angiography, significantly enhances anastomotic perfusion and is associated with a marked reduction in anastomotic leak rates without compromising oncological principles.

The demographic and clinicopathological characteristics of our cohort, with an average patient age of 65.1 years and the sigmoid colon identified as the furthermost common tumor site, are consistent with established epidemiological patterns of left-sided colorectal cancer [8]. Similarly, the observed distribution of T-stages and histological differentiation grades corresponds to the commonly reported profiles in the literature [8], supporting the representativeness of this cohort for assessing the surgical approach under investigation.

A central finding of our study is the high technical feasibility of guided ALCA preservation, successfully achieved in 92% of cases. This demonstrates that with meticulous dissection and a clear decision-making algorithm, selective preservation is a practical option for most patients. The decision to ligate the ALCA in the remaining 8% of cases was primarily driven by either suboptimal ICG perfusion (confirming its functional inadequacy) or overriding oncological concerns (suspicion of nodal involvement along the vessel), highlighting the critical role of the "guided" aspect of our approach. This selective strategy contrasts with historical practices of routine high ligation of the inferior mesenteric artery (IMA), which often includes the ALCA, or arbitrary preservation without objective perfusion assessment [9].

The most striking result is the objective evidence from ICG fluorescence angiography, demonstrating significantly superior perfusion in the proximal colonic stump when the ALCA was preserved (mean ICG score 4.5 vs. 3.1, p<0.001). This direct, real-time visualization of enhanced vascularity provides a physiological explanation for the observed clinical benefits. ICG angiography has emerged as an invaluable tool in colorectal surgery, allowing surgeons to objectively assess tissue viability and make informed decisions at critical junctures, thereby mitigating the subjective nature of visual assessment alone [10,11]. Our data strongly support the use of ICG as an indispensable guide for tailoring vascular dissection in left colectomy.

The clinical impact of this improved perfusion is evident in the dramatically reduced anastomotic leak rate. Our overall leak rate of 4% is highly favorable compared to reported rates in the literature, which typically range from 3% to 15% for left-sided resections [2]. Crucially, the anastomotic leak rate in the ALCA preservation group was a remarkable 1%, significantly lower than the 37.5% observed in the small group where the ALCA was ligated (p=0.002). This stark difference strongly suggests that optimizing anastomotic blood supply through ALCA preservation is a powerful protective factor against leak. These findings are

consistent with recent meta-analyses and systematic reviews that have indicated a reduction in anastomotic complications with ALCA preservation strategies [12,13].

Beyond reducing leaks, ALCA preservation was also associated with improved short-term recovery metrics, including a faster return of bowel function and a shorter mean length of hospital stay (5.8 days vs. 8.1 days, p=0.01). These benefits translate directly into reduced patient morbidity, faster discharge, and potentially lower healthcare costs, further reinforcing the value of this approach.

A paramount concern with any modified surgical technique in oncology is the potential for oncological compromise. Our study rigorously addressed this by demonstrating that guided ALCA preservation did not negatively impact oncological outcomes. The mean number of harvested lymph nodes and the rates of positive lymph nodes were comparable between the preservation and ligation groups, and all patients achieved clear resection margins. This indicates that when the decision to preserve the ALCA is made judiciously, incorporating both perfusion assessment and a thorough evaluation for central nodal involvement, the radicality of the oncological resection is maintained. This finding is crucial for widespread adoption and aligns with studies suggesting that selective vascular preservation does not inherently compromise oncological clearance if central lymphadenectomy is adequately performed [14].

Despite its strengths, including its prospective design and objective ICG assessment, our study has limitations. It is a single-center study, which may limit the generalizability of the findings, although the consistent surgical team and standardized protocol enhance internal validity. The sample size for the ALCA ligation group (n=8) was small, limiting the statistical power for some comparisons, though the observed differences were highly significant. While ICG provides objective perfusion data, our scoring was qualitative; future studies could incorporate quantitative ICG metrics for even greater precision. Finally, this study focused on short-term outcomes; long-term oncological follow-up is essential to confirm no adverse impact on recurrence or survival.

CONCLUSION

In conclusion, our study provides robust evidence that guided preservation of the ALCA during left colectomy for left-sided colon cancer is a technically feasible and safe strategically. It significantly improves anastomotic perfusion, as objectively demonstrated by ICG fluorescence angiography, leading to a substantial reduction in anastomotic leak rates and improved short-term recovery without compromising oncological principles. This tailored approach, integrating real-time perfusion assessment, represents a significant advancement in optimizing patient outcomes in left-sided colorectal surgery.

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