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**Original Research Article**

# Low ligation inferior mesenteric artery versus selective sigmoidal artery ligation in sigmoid colon cancer: a comparative study

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## ABSTRACT

**Background:** Ligation at the root of the inferior mesenteric artery (IMA) or 'high-tie' is widely accepted during oncologic resection of sigmoid colon cancer surgery. However, IMA ligation may compromise the anastomotic blood supply and risk injury to autonomic nerve plexus. The preservation of IMA or 'low-tie' may lead to increase blood flow and decrease postoperative bowel complications, nevertheless require longer operative time and technical difficulties. This study aims to compare the results between laparoscopic sigmoidectomy with selective sigmoidal artery ligation (group A) and low-ligation IMA (group B).
**Methods:** A 1:2 case-matched comparative study and retrospective review of 27 patients with sigmoid cancer (19 female and 8 male) who underwent laparoscopic sigmoidectomy between January 2012 to December 2015. There were 9 patients in group A and 18 patients in group B. Perioperative results were collected and follow-up was recorded at 6 and 12 months after surgery.
**Results:** There were no difference in the mean operative time {group A 194.44 (+28.77), group B 178.89 (+55.52), p=0.349}, blood loss {group A 94.44 (+52.71), group B 79.44 (+58.15), p=0.51}, and mean numbers of harvested lymph nodes {group A 14.56 (+3.74), group B 17.56 (+7.64), p=0.183}. Three patients in group B experienced a short period of stool frequency (2-4 weeks postoperative) and one with constipation. No leakage, bleeding, or tumor recurrence occurred in both groups during the 1 year follow up.
**Conclusions:** Laparoscopic sigmoidectomy with selective sigmoidal artery ligation and lymph node dissection allows equivalent short-term oncologic results to low-ligation IMA technique.

**Keywords:** Inferior mesenteric artery, Low ligation, Low-tie, Sigmoid cancer, Sigmoidectomy

## INTRODUCTION

Surgical resection of the tumor including the feeding vessels and lymph node clearance is the standard of practice in oncologic surgery. The ligation at the root of the inferior mesenteric artery (IMA) or known as 'high-tie' is preferred for lymph node clearance at this area. Previous studies have demonstrated the importance lymph node clearance at the root of IMA in terms of better survival and precise staging.[1-5] However, high ligation of the IMA may compromise the blood flow of the anastomosis and contribute to anastomosis ischemia and leakage.[6] Concerns of high ligation of IMA may injury the autonomic nerve fibers of the inferior mesenteric pre-aortic plexus resulting in sympathetic denervation of the rectal stump and contributing to anterior resection syndrome which comprises of fecal incontinence, urgency, frequency, and fragmentation.[7-9]

Previous studies have compared the high-tie versus low-tie of IMA and most of them found no significant difference in the overall 30-day post-operative morbidity and mortality, anastomosis leakage, 5-year survival rate and the overall survival rate.[3,10-13] The benefits of low-tie

have been found to have higher anastomotic perfusion, longer colonic length to make anastomosis feasible.[14-15] However, concerns on the low-tie may lead to inadequate lymph node dissection at the root of IMA, leading to inadequate staging. The distribution of lymph node metastases has found to be an independent predictor for survival in sigmoid and rectal cancer. Many studies have accessed this issue by comparing results of high-tie versus low-tie with lymph node dissection of IMA and found similar oncologic outcomes.[2-4,12,16,17]

The authors have further questioned on the clinical importance of location of vascular ligation. Only high-tie and low-tie have been compared. No studies have reported on the role of selective ligation of only sigmoidal arteries and preserving left colic artery (LCA) and superior rectal artery (SRA) on colorectal cancer patients. This study aims to evaluate the short-term outcomes, the 30-day morbidity and mortality, peri-operative results, and the oncologic outcomes in 1 year.

## METHODS

A case-matched comparative study was retrospectively reviewed from a single large center tertiary hospital. A total of 27 patients diagnosed with sigmoid tumor who underwent elective sigmoidectomy between January 2012 to December 2015. All cases were staged preoperatively by colonoscopy and enhanced computed tomography.

### *Inclusion criteria*

Patients with middle sigmoid tumour without enlarged lymph nodes.

### *Exclusion criteria*

- Emergency or palliative surgery
- Disseminated disease
- Adjacent organ invasion
- Previous pelvic and/or anorectal surgery
- Previous pelvic radiotherapy
- Fecal incontinence
- Diseases and medications affecting bowel function.

The patients who underwent selective sigmoidal artery ligation were identified as group A. The patients who underwent low-ligation of the IMA were identified as group B.

All operations were performed by experienced laparoscopic colorectal surgeons.

### *Patient preparation*

On the day prior to the operation, the patient was orally given 4 L of a polyethylene glycol for bowel preparation. A third-generation cephalosporin with metronidazole were given for prophylaxis of and infection. The patient was placed in the lithotomy position on the operating table.

### *Surgical technique*

The initial access port was through the umbilicus via open technique. A 10 mm, 30-degree camera was inserted through the port, followed by 5 mm working ports at four standard quadrants under direct vision. Generalized exploration of the abdominal cavity was done, then medial to lateral approach sigmoidectomy was done. The pelvic peritoneum was incised at the sacral promontory and dissection continued cephalad toward the root of IMA. In the selective sigmoidal artery ligation group, dissection of the surrounding lymph nodes at the root of IMA was done along with meticulous dissection to identify the LCA, SRA, and all sigmoidal branches. The sigmoidal branches must be clearly skeletonized at the root for individual ligation, while preserving the LCA and SRA. For the low-ligation of the IMA group, same lymph node dissection at the root of IMA and ligation of the IMA distal to the LCA take off to preserve the LCA (Figure 1).

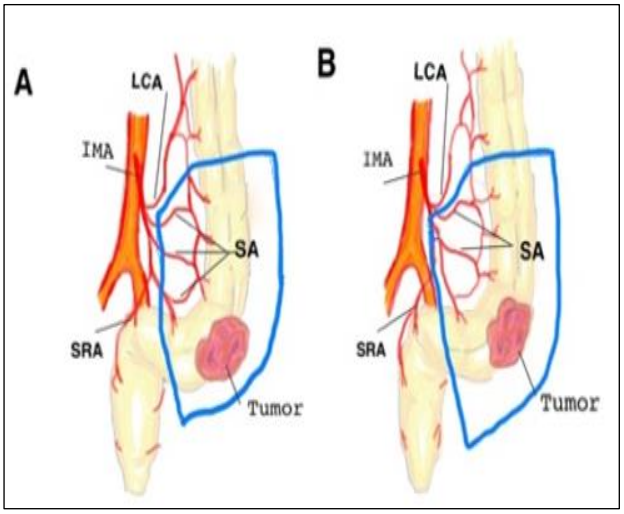


**Figure 1a and 1b: Sigmoidectomy with selective sigmoidal artery ligation (a) and low-ligation IMA (b)**

Dissection was continued laterally along the line of Toldt and high ligation of the IMV was performed in most cases. Then dissection was continued caudally to mobilize the upper rectum. The hypogastric nerves, genitofemoral nerve, left ureter, gonadal vessels, common iliac vessels were identified and preserved. Transaction of the upper rectum was done using endostapler. Then a small pfannelsteil incision was extended and Alexis wound protector was used, then the specimen was brought out of the abdomen. Careful selection to ensure at least 10 cm proximal and distal margin from the tumor and transection of the sigmoid colon was done. Then colorectal anastomosis was done using circular stapler, end-to-end anastomosis was done. Air-leak test was routinely performed.

***Follow up***

Adjuvant chemotherapy was provided to all patients with pathological stage III sigmoid cancer. Fluorouracil and folinic acid were given every 4 weeks for a period of 6 months. Oncological follow-up was performed every 6 months with assessment of carcinoembryonic antigen serum level and chest X-ray, and every 12 months with colonoscopy and computed tomography/ultrasound examination of the abdomen. The level of the anastomosis above the anal verge was determined during follow-up endoscopic examination. Bowel function was follow up at outpatient clinic at 1, 6 and 12 months after surgery.

***Statistical analysis***

Statistical analysis was performed using SPSS statistical software, version 18.0; SPSS, Inc., Chicago, IL, USA. For categorical variables, the Fisher's exact test was applied. Mann-Whitney U test was calculated for each association between continuous variable.

## RESULTS

A total of 27 patients, 9 in group A, and 18 in group B. There was no significant difference in the baseline characteristics between the two groups (Table 1).

**Table 1: Base line characteristic of the patient.**

| Characteristics | IMA-preservation | IMA-ligation | P-value |
|---|---|---|---|
| | Group A (n = 9) | Group B (n = 18) | |
| Age Mean±SD[a] (years) | 60.11±8.61 | 64.44±9.74 | 0.269 |
| Sex (Male:female) | 4:5 | 4:14 | 0.375 |
| Female (%) | (55.6%) | (77.8%) | |
| BMI[b] (kg/m$^2$) | 22.0±5.61 | 22.4±9.09 | 0.324 |
| **Pre-stage (%)** | | | |
| I | 0 (0%) | 1 (5.6%) | 0.723 |
| II | 8 (88.9%) | 11 (61.1%) | |
| III | 1 (11.1%) | 5 (27.8%) | |
| **ASA[c]** | | | |
| I | 1 (11.1%) | 1 (5.6%) | 0.262 |
| II | 8 (88.9%) | 12 (66.6%) | |
| III | 0 (0%) | 5 (27.8%) | |
| IV | 0 | 0 | |

[a]SD = Standard Deviation; [b]BMI = Body Mass Index; [c]ASA = American Society of Anesthesiologists physical status

**Table 2: Operative results.**

| Operative results | IMA-preservation (Group A) n (%) | IMA-ligation (Group B) n (%) | P-value |
|---|---|---|---|
| 30-days post-operative morbidity | Bowel ileus (1)<br>Pneumonia (1) | Bowel ileus (1)<br>Lung atelectasis (1) | 1.0 |
| Postoperative bowel dysfunction | 0 (0%) | 4 (22.2%) | 0.268 |
| Conversion to open surgery | 0 (0%) | 0 (0%) | N/A[d] |
| Diverting stoma | 0 (0%) | 0 (0%) | N/A |
| Recurrence | 0 (0%) | 0 (0%) | N/A |
| **Post-operative staging** | | | |
| I | 1 (11.1%) | 1 (5.6%) | 1.0 |
| II | 5 (55.6%) | 10 (55.6%) | |
| III | 3 (33.3%) | 6 (33.3%) | |
| IV | 1 (5.6%) | 1 (5.6%) | |
| LNe | 14.56±3.75 | 17.56±7.64 | 0.279 |
| Operation time (minutes)[e] | 194.44+28.77 | 178.89 +55.52 | 0.349 |
| Length of resected colon (cm)[e] | 22.89±3.59 | 15.00±2.91 | < 0.001 |
| Blood loss (ml)[f] | 100 (50-180) | 60 (10-200) | 0.51 |
| Length of hospital stay (days)[f] | 7 (5-21) | 8 (5-12) | 0.396 |

[d]Not available; [e]mean (SD); [f]median (range)

The operative results are demonstrated in Table 2. There was no difference in the 30-day post-operative morbidity. Four patients in group B (22.2%) had post-operative bowel dysfunction. None occurred in group A, however, it was statistically non-significant (p=0.268). Of these 4 patients with post-operative bowel dysfunction, 3 had a short period of diarrhea and 1 had constipation which all resolved within 2-4 weeks. No conversion rates and no diverting stromas were needed in both groups. No anastomosis leakage or bleeding was present in this study. There was no significant difference in the operative time, blood loss, and length of hospital stay between group A and B (194 minutes versus 178 minutes, p = 0.349), (100 ml versus 60 ml, p = 0.51), (7 days versus 8 days, p = 0.396). Group A had longer length of resected colon compared to group B (22.89 versus 15, p <0.001). There was no recurrence in the 1 year follow up period, therefore, the overall survival and disease-free survival were not reported in the study.

## DISCUSSION

Previous studies have found similar outcomes of high-tie to low-tie IMA with lymph node dissection on the complications, overall survival, disease-free survival, while the low-tie was anatomically less invasive.[3,4,12,16,17] This lead to the question of further selection ligation of the sigmoidal arteries in this study. In this study, the short-term outcomes were comparable to low-ligation IMA. However, due to the short-term follow up of 1 year with no tumor recurrence, this study failed to determine the long-term oncologic outcomes such as the 5-year disease-free survival, 5-year overall survival, and the local recurrence rate.

In this study, we observed that there was a trend toward lower post-operative bowel dysfunction in the selective arterial ligation group (0 patients versus 4 patients, p=0.268). However, it was not statistically significant. The post-operative bowel dysfunction that occurred were minor such as diarrhea and constipation, which resolved within 4 weeks, contributing to the safety of this procedure. We suggest that selective arterial ligation might contribute in lowering rate of anterior resection syndrome, however further RCT studies needed.

Both procedure achieved adequate number of lymph node harvested without significance in numbers (14.5 versus 17.5, p=0.279). Limitation of the short term follow up and no recurrence, the authors failed to identify the association of positive lymph node stations to the prognosis and survival.

A meta-analysis of randomized-controlled trials (RCTs) and non-RCTs by Cirocchi et al, did not find any advantage of IMA preservation in terms of anastomosis leakage.[11] Similar to Lehmann et al, did not find the ligation of IMA or SRA to be associated with increased anastomosis leakage.[6] However, both studies were done in sigmoid diverticulitis patients. The authors' study, there was no anastomosis leakage found and good blood supply was observed in both groups. Sekimoto et al, reported similar operative time between laparoscopic high-tie (207.6 minutes), lymph node dissection with IMA preservation (222 minutes), and ligation SRA group (198 minutes).[12] The author's study showed similar results in operative time (194 versus 178 minutes, p = 0.349), and similar blood loss, suggesting the feasibility of selective sigmoidal artery ligation.

This study found a significant difference in the resected colon length. More colonic length was resected in group A compared to B (22 versus 15 cm, p<0.001). Two hypotheses may explain this outcome. The first was only one surgeon performed operation in group A, while 3 surgeons performed operation in group B. Perhaps surgeon preference on length of bowel resection may have contributed in this difference. Another theory is that selective sigmoidal artery ligation may assist in mesenteric lengthening and facilitation a longer bowel resection. Nevertheless, the clinical importance of this difference is not noted.

## CONCLUSION

Laparoscopic sigmoidectomy with selective sigmoidal artery ligation and lymph node dissection allows equivalent short-term oncologic results to low-ligation IMA technique with similar operative time and low complications. This is a feasible and safe procedure, however, further long-term results are needed.

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