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RETROCOLIC TUNNEL VERSUS CONVENTIONAL MEDIAL-TO-LATERAL APPROACH IN LAPAROSCOPIC RIGHT HEMICOLECTOMY WITH COMPLETE MESOCOLIC EXCISION: COMPARATIVE COHORT STUDY AND CUSUM LEARNING-CURVE ANALYSIS

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ABSTRACT

Background: Laparoscopic right hemicolectomy with complete mesocolic excision (CME) entails careful embryological-plane dissection and central vascular control. Retrocolic tunnel dissection may provide early orientation and safer access to the superior mesenteric vascular axis, but comparative data and technique-specific learning-curve assessment remain limited. Objective: To compare perioperative safety, pathological adequacy and early recovery after retrocolic tunnel versus conventional medial-to-lateral laparoscopic right hemicolectomy, and to evaluate procedural proficiency using cumulative sum (CUSUM) methods.

Methods: A comparative cohort design was conducted in the Surgery department at General Hospital Lahore from January 2025 to January 2026.Consecutive adults undergoing elective laparoscopic right hemicolectomy with CME. A minimum of 84 participants (42 per arm), with a recruitment target of 96–100, is proposed. The primary outcomes are operative duration, blood loss, conversion to open surgery, lymph-node retrieval and mesocolic specimen quality. Secondary outcomes include vascular injury, recovery milestones, hospital stay, 30-day morbidity and learning-curve change points. Regression, propensity-based sensitivity analysis, chronological CUSUM and risk-adjusted CUSUM was performed.

Results: To demonstrate statistical reporting, Tables 1–3 contain explicitly hypothetical group summaries for 50 patients per arm, with p values computed using Welch independent-samples t-tests or Fisher exact tests. Tables 4–5 use a separately generated synthetic patient-level dataset for demonstration only; model and change-point values

Conclusion: The protocol provides an operational framework for evaluating whether retrocolic tunnel dissection improves technical efficiency while maintaining CME quality. Any superiority or equivalence claim must await completed analyses. Keywords: complete mesocolic excision; laparoscopic right hemicolectomy; retrocolic tunnel; medial-to-lateral; CUSUM; learning curve.

KEYWORDS: Complete mesocolic excision; Laparoscopic right hemicolectomy; Retrocolic tunnel; Medial-to-lateral approach; Cumulative sum (CUSUM); Learning curve.

INTRODUCTION

Right-sided colon cancer is commonly treated by right hemicolectomy incorporating regional lymphadenectomy, secure vascular pedicle division and negative resection margins. The introduction of minimally invasive techniques has improved perioperative recovery in selected patients while maintaining oncological principles. Nevertheless, the right mesocolon is anatomically complex. The superior mesenteric vein (SMV), ileocolic pedicle, variable right colic vessels and branches supplying the transverse colon occupy a narrow operative field in which inadvertent injury can rapidly transform a controlled laparoscopic dissection into an emergency haemostatic procedure. The choice of dissection sequence therefore matters for surgical safety and teaching.

Complete mesocolic excision (CME) emphasises intact mesocolic-envelope resection along embryological planes, with central vascular ligation where appropriate. Its proposed advantages include improved pathological quality, greater lymph-node harvest and potentially better disease control. However, CME is not a single universally standardised operation, and the extent of central dissection remains contested. An updated systematic review found associations with improved node yield and selected oncological outcomes, whereas later reviews stressed uncertainty about which stages of disease benefit enough to justify extensive central dissection [3–6]. A randomised multicentre trial has further

informed the debate about extended lymphadenectomy [7]. Consequently, demonstrating technical feasibility is not equivalent to proving oncological superiority.

The conventional medial-to-lateral approach begins near the ileocolic vascular pedicle, enters the mesocolic plane and mobilises the right colon toward the lateral attachments. Familiarity, early vascular control and adherence to a limited-handling principle favour its use. Its main difficulty is that the correct plane may be obscured by thick mesentery, adhesions or unusual vascular branching. The consequence may be prolonged operation, blood loss, pancreatic or duodenal injury and conversion. Surgeons must recognise that no single route eliminates risks posed by anatomical variants.

The retrocolic tunnel approach reverses part of the usual sequence by developing a posterior plane between the mesocolon and retroperitoneum and connecting dissection windows before definitive central pedicle management. The initial retrocolic endoscopic tunnel approach was described in detail by Subbiah and colleagues [1]. Zhang and colleagues subsequently compared tunnel and medial approaches in a retrospective cohort of 106 patients, identifying an important direct comparator for the present study [2]. Other alternative sequences, including cranial-to-caudal and top-down procedures, demonstrate that surgical teams seek reliable spatial orientation rather than a universally preferred direction [8,9].

Claims that a technique is easier to learn should be tested rather than assumed. Conventional early-versus-late case comparisons impose arbitrary stage boundaries and may conceal changes in complexity or supervision. Cumulative sum (CUSUM) analysis sequentially accumulates deviations in performance and can reveal changes in operative efficiency. In experienced centres, reported CME proficiency thresholds vary substantially; a 2025 systematic review identified a range of approximately 21–32 procedures across the studies it included [10]. Other individual studies have reported values around 13, 24–33 or 32 cases under differing conditions [11–13]. Thus, institutional context, outcome definition and risk adjustment are essential when interpreting learning.

The study is designed to compare the two laparoscopic routes under the same CME objective and to quantify the tunnel approach learning trajectory. The clinical question is whether earlier posterior-plane definition can shorten operating time or reduce blood loss without adversely affecting lymph-node yield, mesocolic integrity or postoperative events. Its educational question is how many consecutively performed cases are required before operative-time performance becomes stable, and whether safety changes alongside speed. The investigation is especially relevant to centres introducing complex colorectal laparoscopy with limited opportunities for formal proctorship.

MATERIALS AND METHODS

A comparative cohort design was conducted in the Surgery department at General Hospital Lahore from January 2025 to January 2026 Consecutive eligible patients was identified over approximately 12–18 months at a tertiary general or colorectal surgery department. Both retrospective and prospective enrolment could be used if records were complete; the exact sampling frame, hospital and dates must be entered before journal submission. Technique choice follows the participating surgeon's usual practice, rather than random allocation. Study reporting should follow the STROBE statement, with a transparent flow chart of assessed, excluded and analysed patients.

Eligible participants were adults aged 18 years or older scheduled for elective laparoscopic right hemicolectomy with CME for right-sided colonic pathology requiring oncological-standard resection. A complete clinical, operative and histopathology record is necessary for the relevant analysis. Exclusion criteria was emergency procedures for perforation or urgent obstruction, an intended open operation or planned conversion for locally advanced disease, extensive previous surgery preventing standard laparoscopic access, and metastases at presentation. Benign and malignant indications was distinguished because they differ in expected lymph-node yield and pathological stage.

An explicit case-level exposure definition wasl distinguish initial retrocolic tunnel access from conventional medial-to-lateral dissection. The approach initially attempted, rather than the final completed route, was assign study group for the primary analysis. Switching to a different laparoscopic plane is recorded as a crossover; conversion to open surgery was recorded separately. This preserves clinically meaningful estimates of the consequences of the initial operative strategy.

Surgical technique and perioperative standardisation

Under general anaesthesia, port positioning, patient tilt and exposure was follow local laparoscopic colorectal protocols. In the tunnel group, careful posterior separation of the mesocolon from retroperitoneal structures creates a working tunnel, with deliberate preservation of the duodenum, pancreatic head and fascial envelope. The tunnel was connected to the intended central dissection plane before ligating mesenteric vessels according to pathology and anatomy. In the conventional group, the dissection proceeds medially from the ileocolic region, defines the vascular axis and advances laterally through the embryological plane. Both groups aim for an intact mesocolic specimen and appropriate margins.

The operative record should document whether an intracorporeal or extracorporeal anastomosis was performed, use of energy devices, fluorescence assessment, surgeon grade, assistant experience and whether the operation was supervised. These variables are not mere technical details: they can influence operative duration, costs, ileus and complication rates. Enhanced-recovery elements, antimicrobial prophylaxis, thromboprophylaxis and postoperative mobilisation should be applied consistently whenever feasible.

Total operative duration was measured from skin incision to skin closure in minutes. Estimated intraoperative blood loss is measured in millilitres using anaesthetic and surgical documentation. Conversion was an unplanned switch to laparotomy to complete dissection or anastomosis. Vascular injury was defined as unintended injury to a named mesenteric vessel requiring repair, clipping, transfusion or a change in dissection plan; minor routine bleeding should be captured separately. Major morbidity is defined as Clavien–Dindo grade III or higher within 30 days, while any-grade morbidity was a distinct secondary outcome.

Pathological adequacy was assessed using total lymph nodes examined, proximal and distal margin status, radial or retroperitoneal margin where relevant and a standardised mesocolic-plane quality score determined by a pathologist unaware of group allocation when possible. Patients with benign disease should not be pooled with malignant cases for tumour stage comparisons. A sensitivity analysis restricted to confirmed invasive adenocarcinoma is required to avoid distorting oncological endpoints. Time to first flatus, postoperative length of stay, readmission and anastomotic leak are collected up to day 30 using explicit clinical definitions.

Baseline variables include age, sex, body mass index, American Society of Anesthesiologists physical-status category, diabetes, prior abdominal surgery, indication for resection, tumour location, pathological T and N stage, and preoperative imaging-based complexity features if available. Because surgeon preference determines the approach, case-mix imbalance and learning effects are foreseeable. Consecutive case number must be captured separately for each individual primary surgeon; simply ordering all tunnel operations across several surgeons can produce a misleading pooled learning curve.

Sample size and statistical plan

The synopsis proposes an anticipated mean operative-time difference of approximately 17 minutes and a common standard deviation of 20 minutes, with two-sided alpha 0.05 and 80% power. It specified at least 42 patients in each group, targeting 48–50 per group after allowance for missing records. Because conventional two-sample formulas with those exact assumptions might yield a different minimum depending on design and continuity assumptions, the final protocol should reproduce and independently verify its calculation before recruitment. The sample is primarily sized for operative time; it was be adequate to establish equivalence for rare vascular injuries or leaks.

Continuous variables was screened with visual distribution plots and the Shapiro–Wilk test. Approximately symmetric measurements was summarised as mean ± standard deviation; skewed data as median and interquartile range. Group comparisons was use Welch independent t tests or Mann–Whitney U tests as appropriate, with mean or median differences and 95% confidence intervals. Categorical outcomes was described using counts and percentages, analysed by chi-square or Fisher exact tests, and accompanied by risk differences or ratios with confidence intervals. All analyses was used two-sided $p < 0.05$, while effect magnitude and precision was taken precedence over threshold-based interpretations.

RESULTS

Tables 1–3 was a hypothetical teaching example, with assumed n = 50 per group. P values had been calculated from these illustrative inputs, not measured from actual patients. Tables 4–5 additionally used separately generated, fully synthetic case-level records (fixed random seed 20261018) for illustrative multivariable and learning-curve computations.

Table 1. Baseline characteristics by operative approach

Characteristic	Tunnel (n = 50)	Medial (n = 50)	p value
Age, years	61.2 ± 10.8	62.7 ± 11.2	0.497
Female, n (%)	22 (44%)	24 (48%)	0.841
BMI, kg/m²	26.1 ± 3.8	26.8 ± 4.1	0.378
ASA III–IV, n (%)	10 (20%)	12 (24%)	0.810
Diabetes mellitus, n (%)	13 (26%)	15 (30%)	0.824
Prior abdominal surgery, n (%)	8 (16%)	9 (18%)	1.000
Malignant indication, n (%)	46 (92%)	45 (90%)	1.000
pT3–T4 among cancers, n (%)	24 (48%)	27 (54%)	0.689

Report denominators for cancer-only variables; format numerical data as mean ± SD or median [IQR].

Table 2. Intraoperative and specimen outcomes

Outcome	Tunnel	Medial	Effect (95% CI)	p value
Operative time (min)	128 ± 19	146 ± 22	-18.0 (-26.2 to -9.8)	<0.001
Estimated blood loss (mL)	72 ± 38	105 ± 51	-33.0 (-50.9 to -15.1)	<0.001
Conversion to open, n (%)	1 (2%)	3 (6%)	-4 percentage points	0.617
Vascular injury, n (%)	1 (2%)	2 (4%)	-2 percentage points	1.000
Lymph nodes retrieved	23.8 ± 6.1	22.9 ± 6.5	+0.9 (-1.6 to +3.4)	0.477

Complete mesocolic plane, n (%)	44 (88%)	42 (84%)	+4 percentage points	0.774
R0 margins among cancer cases, n (%)	46 (92%)	45 (90%)	+2 percentage points	1.000

Continuous outcomes are mean ± SD, with mean differences (tunnel minus medial) and 95% CIs; p values use two-sided Welch tests. Categorical comparisons show assumed n (%) with risk differences in percentage points and two-sided Fisher exact p values.

Table 3. Postoperative outcomes within 30 days

Endpoint	Tunnel	Medial	Effect (95% CI)	p value
Time to first flatus (days)	2.4 ± 0.8	2.7 ± 1	-0.3 (-0.7 to +0.1)	0.101
Length of stay (days)	5.5 ± 1.6	6.3 ± 2	-0.8 (-1.5 to -0.1)	0.030
Any complication, n (%)	8 (16%)	10 (20%)	-4 percentage points	0.795
Clavien–Dindo ≥III, n (%)	2 (4%)	3 (6%)	-2 percentage points	1.000
Anastomotic leak, n (%)	1 (2%)	2 (4%)	-2 percentage points	1.000
Readmission, n (%)	2 (4%)	3 (6%)	-2 percentage points	1.000
30-day mortality, n (%)	0 (0%)	0 (0%)	+0 percentage points	1.000

Analyse available denominators and describe missing follow-up explicitly.

Table 4. Adjusted regression reporting (synthetic demonstration, not observed data)

Dependent variable	Approach coefficient / adjusted OR	95% CI	p value	Model covariates
Operative time	-17.2 adjusted mean difference	-24.70 to -9.79	<0.001	BMI, ASA III–IV, advanced stage, surgeon
Blood loss	-33.0 adjusted mean difference	-52.04 to -13.88	<0.001	BMI, ASA III–IV, advanced stage, surgeon
Adequate mesocolic plane	1.54 adjusted OR	0.47 to 5.05	0.477	BMI, ASA III–IV, advanced stage, surgeon
30-day morbidity	0.75 adjusted OR	0.26 to 2.14	0.584	BMI, ASA III–IV, advanced stage, surgeon

NOTE: Table 4 coefficients, odds ratios, confidence intervals and p values are calculated solely from a generated synthetic dataset (50 illustrative cases per arm), using HC3-robust OLS and binomial GLM.

Table 5. CUSUM learning-curve summary (synthetic demonstration, not observed data)

Indicator	Tunnel group	Medial group	Interpretation
Cases included (n)	50 consecutive simulated cases	50 consecutive simulated cases	Chronological simulated order; not patient observations
CUSUM peak case	Case 21	Case 23	Highest operative-time CUSUM ordinate
Mean time: initial phase	142.1 ± 15.7 min (n=21)	159.2 ± 20.2 min (n=23)	Before CUSUM peak; simulated summary
Mean time: later phase	117.8 ± 14.1 min (n=29)	134.8 ± 16.8 min (n=27)	After CUSUM peak; simulated summary
Segmented regression breakpoint	Case 39	Case 13	Exploratory piecewise-linear fit; simulated
Risk-adjusted change point	Case 20	Case 34	Residual-based, case-mix-adjusted exploratory peak

Table 5 case order, CUSUM peaks, segmented breakpoints and early/late means are simulated teaching examples. Residual CUSUM adjusts for BMI, ASA grade, advanced stage and surgeon indicator.

DISCUSSION

The central premise of this study was that a predictable posterior plane might facilitated right mesocolic mobilisation while keeping the ultimate oncological target unchanged. The value of comparing the tunnel approach with standard medial dissection lies less in declaring one manoeuvre universally superior than in identifying clinical contexts in which a different entry point reduces avoidable technical burden. A valid interpretation was require demonstrating simultaneously that operative efficiency improves, central vascular hazards was not increased and mesocolic integrity remains acceptable. Faster operation alone is an incomplete quality indicator.

Prior comparative literature lends plausibility to the study question but not certainty about its outcome. The retrospective study by Zhang and colleagues directly compared tunnel and medial approaches and provides background on short-term feasibility [2]. Earlier IRETA experience established a reproducible technique and highlighted

histopathological radicality [1,14]. Nevertheless, comparisons performed by different teams or in different stages of implementation can confuse technique effects with operator experience. This study therefore needs to describe surgical seniority, proctorship and case chronology alongside ordinary baseline covariates. Ideally, independent observers should assess mesocolic specimen grades so that a technically successful-looking operation was not automatically assigned a favourable pathological score.

The latest evidence also cautions against presenting CME as a settled universal oncological standard. De Lange and colleagues pooled studies suggesting better lymph-node yields and selected survival metrics [3], while other analyses have emphasised controversy, selection by stage and the possibility of additional vascular morbidity [4–7,15]. A 2025 meta-analysis of 13 studies reported greater lymph-node retrieval with minimally invasive CME yet longer operations, reinforcing the need to consider efficiency and oncological adequacy together [5]. These reports address the extent of resection more than the direction of dissection, and their conclusions should not be transferred uncritically to tunnel-versus-medial comparisons in which both arms undergo CME.

The learning curve may be the most distinctive outcome of the planned study. In 2025, a systematic review identified seven studies of minimally invasive CME learning curves and reported typical proficiency thresholds within 21–32 cases [10]. A propensity-matched institutional analysis reported a CUSUM inflection at 13 cases [11], whereas a multicase analysis reached 24–33 cases with risk adjustment [12] and a two-centre series described about 32 cases [13]. Divergence between estimates is expected because surgeons differ in previous laparoscopic exposure, mentoring, anastomotic technique and case mix. Case number should therefore be understood as a locally estimated process measure rather than a universal credentialing rule.

Interpretation of the CUSUM graph needs particular care. A peak in operative-time CUSUM is mathematically derived relative to the chosen reference average, not a biological moment at which a surgeon suddenly becomes competent. An apparent learning transition can coincide with simpler patient selection, additional equipment or changes in assistant staffing. In contrast, a flat time curve may coexist with improving safety and quality. The proposed combination of time-based CUSUM, moving averages, adjusted analysis and outcome monitoring can improve credibility, particularly if the breakpoints are checked against independent segmented regression. Recent robotic right colectomy studies further show the relevance of procedure- and platform-specific trajectories [16].

Clinically important vascular injuries, anastomotic leaks and conversions are likely to be infrequent in a 100-person cohort. Even zero observed events would not prove a technique eliminates risk; confidence intervals would remain wide. These outcomes should be displayed explicitly with denominators but interpreted as signals, not definitive comparative safety estimates. A multicentre registry or larger prospective trial would be needed to test uncommon complications adequately. The possibility that surgeons selectively allocate difficult cases to one approach makes transparent preoperative risk assessment crucial.

The interpretation of lymph-node retrieval also requires restraint. Node count depends on patient biology, pathological processing, tumour inflammatory response and the extent of lymphatic dissection. It is a useful quality measure, but a higher count cannot alone establish improved survival. Mesocolic-envelope integrity, negative margins and absence of inadvertent damage must be described separately. The study may be strengthened by specimen photography and blinded pathology review, along with standardised grossing procedures. The consensus documents on right-sided colon cancer surgery emphasise the continuing importance of consistent definitions [17].

Several strengths are expected from the planned design: consecutive sampling, a shared oncological operative objective, simultaneous evaluation of surgical and pathological quality, and the preplanned learning-curve analysis. Important weaknesses are nonrandom technique assignment, single-centre recruitment, likely surgeon-level confounding, limited power for uncommon events and absence of disease-free survival assessment. Timing of a learning transition will be unreliable if there are only a handful of tunnel operations per surgeon; the data analysis plan should therefore prioritise surgeon-specific cases and report insufficient series without forcing an inflection point.

Future work should validate technical findings prospectively in multiple centres, include video-based performance assessment and determine whether retrocolic tunnelling improves outcomes among surgeons with differing baseline experience. It should also assess whether technical changes modify specimen quality in overweight patients, those with variable vascular anatomy or complex mesenteric planes. Comparative effectiveness work can examine functional recovery, anastomotic strategy, resource utilisation and long-term oncological follow-up. Ultimately the choice of entry plane should be informed by anatomy, operator competence and measurable patient outcomes rather than procedural novelty.

CONCLUSION

This article establishes a detailed analytic framework for comparing retrocolic tunnel and conventional medial-to-lateral laparoscopic right hemicolectomy with CME. The most valuable contribution will be to test whether a potentially more intuitive dissection route improves operating time and blood loss without compromising central vascular safety, specimen quality or early recovery. Formal CUSUM and risk-adjusted analyses will also permit a transparent assessment of implementation and proficiency. Because no observed cohort data were supplied, all reported numerical results are illustrative rather than study-specific, and no definitive efficacy conclusions are presented. Completion of the dataset and analyses is necessary before submission as an original clinical research report.

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