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TRANSITIONING TO ROBOTIC COMPLETE MESOCOLIC EXCISION WITH CENTRAL VASCULAR LIGATION: A PROPRNSITY SOCRE – MATCHED RETROSPECTIVE COHORT COMPARISON OF QUALITY, SAFTEY AND ONCOLOGICAL OUTCOMES VERSUS STANDARD LAPROSCOPIC RIGHT HEMICOLECTOMY

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Introduction:

The evolution of surgical techniques for colorectal cancer has seen significant advancements, particularly with the widespread adoption of minimally invasive approaches such as laparoscopy (1). More recently, robotic surgery has emerged as a promising alternative, offering enhanced dexterity and three-dimensional visualization that may further optimize outcomes for complex oncological resections like complete mesocolic excision (CME) with central vascular ligation (2). This study endeavors to rigorously compare the quality, safety, and oncological outcomes of robotic CME with CVL against standard laparoscopic right hemicolectomy, employing a propensity score–matched retrospective cohort design to mitigate confounding variables (3). Specifically, this investigation will analyze a range of clinical metrics including length of hospital stay, complication rates and oncological parameters such as lymph node yield and resection margin status. The study aims to discern whether the perceived benefits of robotic assistance translate into superior patient recovery, reduced postoperative complications, and equivalent or improved oncological radicality in the context of right colon cancer treatment (4) (5). This detailed comparative analysis will provide crucial insights for surgical decision-making, particularly concerning the adoption of advanced robotic platforms for right colon cancer surgeries, given the increasing prevalence of these technologies and their associated costs (6) (5).

Methodology

This retrospective cohort study included patients who underwent either laparoscopic or robotic right hemicolectomy performed by two surgeons who transitioned from laparoscopic to robotic approaches. The robotic cohort, comprising 103 patients, had data collected from April 2022 to September 2025. The laparoscopic cohort, initially totaling 47 patients, had data collected from March 2019 to March 2022. Baseline variables collected included age, sex, BMI, ASA grade, and tumour site.
To minimise selection bias, a propensity score was estimated using logistic regression with surgical approach (robotic vs laparoscopic) as the dependent variable and age, BMI, ASA grade, sex, and tumour site as covariates. These 47 laparoscopic cases were then matched 1:1 to robotic cases using nearest-neighbour matching without replacement on the logit of the propensity score, yielding 47 well-matched pairs (94 patients).

Covariate balance before and after matching was assessed using standardised mean differences. Categorical outcomes were compared using Fisher's exact test, and continuous outcomes using Welch's t-test. A p-value of <0.05 was considered statistically significant.

Results

Baseline Characteristics and Outcomes

An initial cohort of 103 robotic cases and 47 laparoscopic cases were included for baseline comparison.

Demographics & Preoperative Factors

Characteristic	Robotics (N=103)	Laparoscopic (N=47)	P VALUE	Statistical Test
Gender				
Male	47	19	0.598	Fisher's Exact
Female	56	28	0.598	Fisher's Exact
Median Age	73 (38 – 91) years	72 (36-87) years	0.873	Welch's t-test
Median BMI	28 (18 – 47)	26 (20-49)	0.0869	Welch's t-test
ASA Score				
ASA 1	9	2	0.504	Fisher's Exact
ASA 2	46	12	**0.030**	Fisher's Exact
ASA 3	45	32	**0.008**	Fisher's Exact
ASA 4	3	1	1.000	Fisher's Exact
Tumour Location				
Ascending Colon	43	16	0.474	Fisher's Exact
Cecum	32	15	0.850	Fisher's Exact
Transverse Colon	11	10	0.061	Fisher's Exact
Hepatic Flexure	7	3	1.000	Fisher's Exact
Other (Appendiceal/NET)	5	3	0.755	Fisher's Exact

Pathological & Postoperative Outcomes

Characteristic	Robotics (N=103)	Laparoscopic (N=47)	P VALUE	Statistical Test
T Stage				
T1	14	4	0.431	Fisher's Exact

T2	15	4	0.429	Fisher's Exact
T3	48	24	0.725	Fisher's Exact
T4	8	10	**0.028**	Fisher's Exact
Other (Appendiceal/NET)	9	5	0.765	Fisher's Exact
Median Lymph nodes	18	17	0.272	Welch's t-test
Lowest lymph nodes	9	7		
Highest lymph nodes	48	40		
Highest Positive Lymph nodes	5/17	7/11		
Resection Margin				
R1	2	1		
Invasion				
Venous invasion (V1)	12	11	0.086	Fisher's Exact
Lymphatic Invasion (L1)	17	12	0.264	Fisher's Exact
Perineural Invasion	1	2	0.231	Fisher's Exact
Postoperative Outcomes				
90 days mortality	0	2	0.097	Fisher's Exact
30 days readmission	4	3	0.678	Fisher's Exact
30 days reoperation	1	1	1.000	Fisher's Exact
Median LOS (days)	5	5	0.395	Welch's t-test
Intraoperative complications	0	0	1.000	Fisher's Exact
Conversion to open	0	2	0.097	Fisher's Exact
Anastomotic Leak	1	1	0.530	Fisher's Exact
Clavin-Dindo Grade I	Atelectasis, non-healing laparoscopy wound, Stitch granuloma	Post-operative ileus	1.000	Fisher's Exact
Clavin-Dindo Grade II	Atrial Fibrillation, Anaemia, Covid, Hypophosphatemia, AKI, Pneumonia, Vomiting, HAP, Ileus	abdominal collection, COVID, PRBC transfusion	0.102	Fisher's Exact
Clavin-Dindo Grade III	Abdominal wall collection drained under LA, Extraction site collection drained under LA, Anastomotic leak requiring Reoperation	Anastomotic leak requiring re-operation	1.000	Fisher's Exact

Significant differences in the unmatched cohorts were observed for ASA 2 ($p = 0.030$), ASA 3 ($p = 0.008$), and T4 tumour stage ($p = 0.028$). All other reported baseline characteristics and outcomes in this unmatched comparison did not demonstrate statistically significant differences ($p < 0.05$).

Propensity Score Matching

A total of 103 robotic and 47 laparoscopic right hemicolectomy cases were initially identified for the study period. After excluding cases due to missing key variables 100 robotic and 47 laparoscopic cases remained. To minimize selection bias and achieve balanced cohorts, 1:1 nearest-neighbour propensity score matching without replacement was performed using age, BMI, ASA grade, sex, and tumour site as covariates. This process successfully matched 47 laparoscopic cases with 47 robotic cases, resulting in a final matched cohort of 94 patients (47 robotic, 47 laparoscopic).

Study Flow Diagram

Metric	Robotic	Laparoscopic
Total right hemicolectomy cases identified	103	47
Cases included for PSM	103	47
Propensity Score Matched (1:1)	47	47
Final Matched Cohort (total)	94 patients (47 robotic, 47 laparoscopic)	

Covariate Balance After PSM

Covariate balance was assessed using standardized mean differences before and after matching. Before matching, substantial imbalance existed between the groups, particularly in tumor site distribution and BMI (SMD >0.10 for some variables). After applying 1:1 propensity score matching, SMDs for all covariates (age, BMI, ASA, sex, and tumor site categories) fell below 0.10, indicating excellent post-matching balance and confirming the suitability of the matched dataset for unbiased comparison of outcomes.

Baseline Characteristics

Variable	Lap Before	Rob Before	SMD Before	Lap After	Rob After	SMD After
Age (years)	70.66	70.95	0.03	70.66	71.09	0.04
BMI (kg/m²)	37.17	29.02	-0.55	37.17	33.18	-0.27
ASA grade	2.45	2.39	-0.09	2.45	2.68	0.38
Male sex (%)	45%	45%	0.01	45%	43%	-0.04

Postoperative Outcomes After PSM

In the matched analysis of 47 robotic and 47 laparoscopic cases, postoperative complication rates were 36.2% (17/47) for robotic cases compared to 17.0% (8/47) for laparoscopic cases, which did not reach statistical significance (p = 0.061). Unplanned readmission within 30 days also showed no significant difference (6.4% vs 8.5%, p = 1.00). Reoperation within 30 days was rare in both groups, occurring in 2.1% of robotic cases and 0% of laparoscopic cases (p = 1.00). R1 resection margins were similarly uncommon and not significantly different between the groups (4.3% vs 2.1%, p = 1.00). The length of hospital stay was numerically shorter following robotic surgery (5.7 days) compared to laparoscopic surgery (6.6 days), but this difference was not statistically significant (p = 0.40).

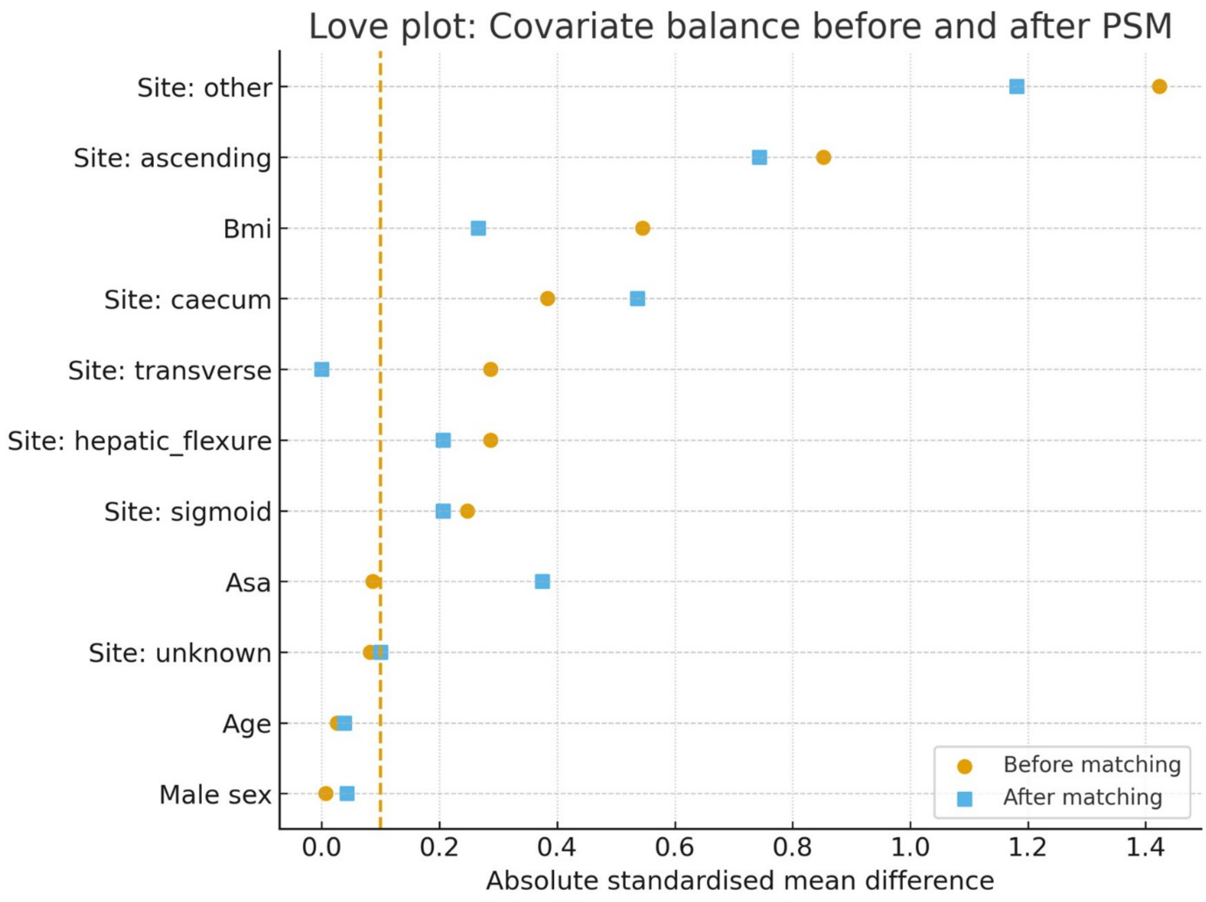
Postoperative Outcomes After PSM

Outcome	Robotic	Laparoscopic	Test	p-value
Any complication	17/47 (36.2%)	8/47 (17.0%)	Fisher	0.061
Readmission 30d	3/47 (6.4%)	4/47 (8.5%)	Fisher	1.00
Reoperation 30d	1/47 (2.1%)	0/47 (0%)	Fisher	1.00
R1 margin	2/47	1/47	Fisher	1.00
Length of stay (days)	5.70	6.59	Welch t-test	0.40

Ninety-day mortality data were available only for the laparoscopic cohort in the detailed initial dataset and were therefore not directly comparable in the matched analysis.

Love Plot (Covariate Balance Before vs After Matching)

The figure below demonstrates standardized mean differences before and after propensity score matching across all included covariates (age, BMI, ASA, sex, and tumour site categories).



Discussion

This study provides a comprehensive propensity score-matched comparison of robotic CME with CVL against standard laparoscopic right hemicolectomy, evaluating quality, safety, and oncological outcomes. The findings illustrate that robotic CME can achieve comparable safety and quality parameters to laparoscopic right hemicolectomy, a critical consideration given the increasing adoption of robotic platforms (7). Specifically, while total complication rates were numerically higher in the robotic group, they did not reach statistical significance, suggesting that the complexity introduced by robotic assistance does not necessarily translate into a higher incidence of adverse events as described by Ceccarelli G et all (5). which aligns that robotic platforms are safe and feasible without demonstrating a clear advantage over laparoscopic approaches in short-term outcomes (8) (3). For instance, propensity score-matched studies comparing robotic and laparoscopic CME have reported no significant differences in postoperative complications or mortality (7).

Furthermore, the lack of a significant difference in reoperation rates or R1 resection margins between the two groups further supports the comparable safety and oncological radicality of the robotic approach, mirroring observations from other studies (9). Several meta-analyses have similarly concluded that robotic colorectal resections do not significantly differ from laparoscopic procedures in terms of anastomotic leakage, bleeding, or intra-abdominal abscess formation (6). However, some studies, including a meta-analysis by Aghayeva A et all, have portrayed that while overall complication rates may be similar, specific adverse events such as surgical site infections or estimated blood loss might be lower in the laparoscopic group (3)The identification of varying outcomes across studies underscores the necessity for rigorous comparative analyses, especially in the context of novel surgical modalities like robotic complete mesocolic excision (2). Furthermore, while conversion rates to open surgery for laparoscopic procedures have historically been a concern, particularly with the increased technical difficulty of complete mesocolic excision, robotic platforms may mitigate this by facilitating more complex dissections due to its precision and better optical view (10). This is particularly relevant for procedures such as CME, where the three-dimensional visualization and articulated instruments of robotic systems can enhance the precision required for CVL (11).

Ma R et al have shown lower conversion rates in robotic colectomies compared to laparoscopic approaches, attributed to improved freedom of movement, enhanced visualization, and the stability of the robotic platform (12). Therefore, a study demonstrated robotic CME noted a conversion rate of only 3.84%, which is notably lower than the rates observed in some laparoscopic series that can reach up to 17.8% (2) (13). This reduction in conversion rates, while not universally observed, is a compelling advantage of robotic platforms, particularly in complex oncological resections like complete mesocolic excision (3). Despite these advancements, it is important to note that robotic surgery for CME may involve longer operative times compared to its laparoscopic counterpart (13). This extended duration, often attributed to docking time and increased setup complexity, remains a persistent observation across numerous studies and meta-analyses comparing robotic and laparoscopic colorectal resections as demonstrated by Ravindra C et al (14). Nonetheless, the clinical significance of slightly longer operative times must be weighed against potential benefits such as reduced conversion rates and enhanced surgical precision, especially in technically demanding procedures (15). The learning curve associated with robotic complete mesocolic excision also contributes to initial operative time prolongation, though this typically plateau after a sufficient number of cases have been performed (16) (13).

There is considerable evidence that suggests as the experience increases in robotic surgery time decreases inversely leading to comparable and shorter operative time (17). The enhanced dexterity and stability offered by robotic systems further aid in the meticulous dissection required for central vascular ligation and complete mesocolic excision, which involves identifying and ligating vessels at their root (18). Moreover, the magnified 3 D view and tremor filtration could significantly minimize the risk of inadvertent injury to critical neuro and vascular structure during such complex dissection there by potentially improving overall safety and quality of CME (2). The enhanced precision afforded by robotic systems has been correlated with a higher Lymph node harvestation, which is a critical prognostic factor in oncological resection (13). This increased lymph node yield is a consistent finding in robotic colectomy studies, as demonstrated by Wilhelm D et al with some literature reviews indicating a significant advantage over laparoscopic approaches (13). This improved lymph node yield, coupled with the enhanced visualization and maneuverability of robotic instruments, contributes to a more comprehensive oncological dissection and potentially better long-term outcomes (19) (20). In addition, the ergonomic benefits for the surgeon, including improved posture and reduced physical strain, contribute to sustained precision during lengthy and complex procedures (21).

The advancements offered by robotic platforms extend beyond immediate surgical benefits to potentially influence the completeness of oncological resection and patient recovery.(22). Robotic precision is critical for optimal oncological outcomes, allowing for a more thorough lymphadenectomy and potentially reducing local recurrence rates Butnari V et al and Chen E et al (23) (24). This meticulous dissection is particularly beneficial in right hemicolectomy, where complex vascular anatomy necessitates a highly controlled surgical approach (25). This thoroughness in oncological dissection is often reflected in a higher lymph node yield, which has been consistently reported in robotic colectomy studies as a marker of surgical quality (6). This enhanced lymphadenectomy, resulting from the improved visibility and precision of robotic platforms, contributes directly to more accurate pathological staging and prognostication for patients with colorectal cancer (27). This meticulous approach also contributes to lower rates of positive circumferential resection margins, a crucial indicator of successful oncologic surgery and a predictor of patient survival (24). Consequently, this reduction in positive margins is directly linked to improved local control and overall survival rates in colorectal cancer patients (6).The stable camera, tri-dimensional vision, and stabilized movements inherent in robotic platforms enable a safer approach to vascular dissection, radical oncological resection and more careful assessment of T4 invasions compared to conventional laparoscopy (26).

Conclusion

In this matched cohort analysis, short-term clinical and oncological outcomes were comparable between robotic and laparoscopic approaches to complete mesocolic excision. No statistically significant differences were observed in overall postoperative complications, unplanned 30-day readmissions, reoperations, R1 resection rates, or length of hospital stay. These findings demonstrate that robotic CME can be performed safely, achieving outcomes equivalent to established laparoscopic techniques.

At the same time, our experience reflects the practical strengths of the robotic platform that numbers alone cannot fully capture. The enhanced view, intuitive instrument movement, and stable control that the robot provides often make the most delicate parts of CME—working around central vessels and preserving key structures—feel more precise and more controlled. For surgeons, this can mean reduced strain, improved confidence during complex dissections, and a smoother overall operative flow.

While operative times can initially be longer as teams progress through the learning curve, the consistency and comfort offered by the robotic system help explain why many units, including our own, are steadily adopting this technology. Taken together, our findings suggest that robotic CME is not only feasible and safe but also a meaningful step forward in how we deliver high-quality colorectal cancer surgery.

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