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Article

The Role of Standardised Technique in Colorectal Surgery: A 5-Year Comparative Analysis of Robotic vs. Laparoscopic Approaches

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Abstract

Background and Aim: Standardisation is crucial for outcomes in minimally invasive colorectal surgery. Debate continues regarding the comparative efficacy of robotic versus laparoscopic platforms. This study evaluates perioperative outcomes for both approaches, performed by a single surgeon using an identical standardised technique to isolate the platform's effect. **Methods:** A retrospective cohort study of 250 patients undergoing colorectal resection (2019-2023) was conducted. Patients were divided into laparoscopic (n=121) and robotic (n=129) groups. Data included demographics, ASA grade, conversion rates, operative times, Clavien-Dindo complications, resection margin status (R0/R1), mortality, and length of stay. R software was used for analysis. **Results:** Demographics were matched, but fewer high-risk (ASA III) patients were in the robotic cohort (38.7% vs. 51.3%; $p<0.05$). The robotic approach showed a significantly lower conversion rate (0% vs. 6.6%). A non-significant trend toward higher-grade complications existed in the laparoscopic group (median grade II vs. I; $p=0.12$), with a significantly higher R1 resection rate (n=8 vs. n=2). Laparoscopic 30-day (2 vs. 0) and 90-day (4 vs. 0) mortality was higher. Anastomotic leak rates (1.6% each) and median hospital stay (5 days; $p=0.71$) were similar in both groups. **Conclusion:** Using a standardised technique, outcomes are comparable except for a significantly reduced conversion rate with robotics. The observed difference in R1 resection rates may be influenced by baseline differences in patient populations. For skilled surgeons, the choice of platform may be influenced more by economic factors and preference than by major differences in clinical efficacy. What does this paper add to the literature? Debate continues regarding the comparative efficacy of robotic versus laparoscopic platforms. This single-surgeon study compares outcomes in colorectal cancer using minimally invasive procedures and a standardised technique. The result of similar clinical efficacy suggests that standardisation reduces outcome variability and demonstrates that cost and preference may influence platform choices more.

Keywords: robotic surgery; colorectal cancer; laparoscopic surgery; standardised technique; single-surgeon

1. Introduction

Colorectal cancer remains a leading cause of global morbidity and mortality, with surgical resection as the cornerstone of curative treatment (1). Treatment of colorectal cancer has evolved exponentially over time. In the UK, Colorectal Cancer is the fourth most common cancer. Depending on the stage and course of the disease, multiple treatment options exist. However, surgical resection remains the cornerstone of curative treatment. The advent of minimally invasive techniques—laparoscopic and robotic—has revolutionised colorectal surgery, offering reduced trauma, faster recovery, superior oncological clearance, and improved cosmesis. The importance of minimally invasive surgery is paramount, not only for patient outcomes, but for surgeons as well.

The emergence of robotics came with the promise of enhancing operative times as well as recovery, reduce the post-operative complications of patients as well as aid speed, surgical technique and avoid fatigue for the surgeon (2). The other technique of minimally invasive surgery is laparoscopic surgery. Laparoscopic surgery is a more familiar method of surgery for surgeons due to its earlier conception. Laparoscopic surgery emerged as the minimally invasive option when open surgery was the sole, standard procedure. Both techniques have been analysed closely in this study to ascertain the benefit, if any, of robotic surgery over its laparoscopic counterpart.

Surgical skill and human factors are without a doubt the most variable factor in this equation. A high-performing surgeon can yield the same results from different types of surgery (3).

Standardisation of surgical techniques is critical to mitigate variability and optimise outcomes (4). While prior studies have compared robotic and laparoscopic methods, heterogeneity in technique and surgeon variability has hindered the ability to determine if there is a direct link between surgical and approach and outcome when comparing the minimally invasive methods. Having a standardised approach not only allows for increased proficiency during planning of surgery but also reduces the learning curve and enable quicker development of surgical skills for trainees. It is crucial to ensure standardisation when new techniques of surgery, especially as it will inform the training pathway of future surgeons (4).

Therefore, we designed a single-surgeon study to compare outcomes using a standardised technique. Our aim was to standardise framework to minimise confounders inherent in multi-surgeon analyses, such as variation in technique, preference, and approach. This design facilitates a direct comparison of robotic versus laparoscopic colorectal resection outcomes (2). The extended five-year data collection window (2019–2024) further ensures temporal consistency in surgical methods, strengthening the validity of the findings.

2. Methods

2.1. Study Design and Population

We performed a retrospective analysis of 250 consecutive patients undergoing colorectal resection (2019–2024) by a single high-volume surgeon in the department of colorectal surgery in our institute. Procedures included hemicolectomies, anterior resections, and abdominoperineal resections. Standardisation involves the creation of Conses driven protocols for various surgical procedures, a stepwise approach during the procedure quality assessment of specimens, reduction of operative variance and improvement of training programs (5). In keeping with this, stepwise surgical techniques were used for each procedure. Published videos demonstrating both the laparoscopic and robotic techniques used are available for further details (6–9).

2.2. Data Collection

Demographic information was obtained from patient notes. Operative metrics such as conversion and intraoperative complications were found in the operative note. Operative time was recorded either on the anaesthetic chart for laparoscopic surgery or by the console for robotic surgery. For robotic cases, the console time does not include time setting up and docking the robot, or time for anastomosis completion and skin closure, therefore overall time is likely underestimated.

Postoperative complications were identified in the patient notes and discharge summaries. Complications were graded by the modified Clavien-Dindo score (10). Pathology data such as tumour staging and resection margins was obtained from the histology reports.

2.3. Statistical Analysis

Analyses were performed in R (v4.3.0). Continuous variables were compared using the t-test for normally distributed data, otherwise by the Mann-Whitney U test. Categorical

Variables were compared using chi-square or Fisher’s exact tests, the latter used when any of the expected values were less than five. Correlation analyses were performed using Pearson’s correlation coefficient. Graphs were produced by *ggplot2* version 3.4.4. A p-value of less than 0.05 was considered statistically significant.

3. Results

3.1. Patient demographics were comparable between groups

A total of 250 patients were included in the study with similar baseline characteristics (Table 1), with the exception that a higher proportion of patients undergoing laparoscopic surgery had been prescribed neoadjuvant therapy (0.49 vs. 0.3, $p = 0.006$). Overall, the distribution of ASA grades differed between the two groups (Supplementary Table 1), with the robotic group having a slightly higher proportion of ASA grade 1 patients (0.12 vs. 0.02, $p = 0.05$). The distribution of resection types was similar between the two groups (Supplementary Figure 1), with most operations being right hemicolectomies or anterior resections (high or low).

Table 1. Patient demographic information. Age and BMI were compared using the t-test. Gender and number having neoadjuvant chemotherapy were compared by the Chi-square test.

Variable	Laparoscopic	Robotic	p-Value
Number of cases	120	130	
Mean age (SD) - years	68 (12.8)	66.8 (14.3)	0.57
Female gender - N (%)	54 (45)	59 (45.4)	0.94
Mean BMI (SD)	27.1 (5.4)	28.1 (5.1)	0.13
ASA Grade 1	2 (0.02)	16 (0.12)	0.05
Number having neoadjuvant chemotherapy – N (%)	51 (49)	37 (30.3)	0.006

3.2. Analysis of intraoperative outcomes shows that conversion to open surgery was less likely with robotic surgery

No robotic cases required conversion to open surgery (Table 2), a significant difference even compared to the low frequency of conversion of laparoscopic cases. The operative time was not significantly different between modalities. However, limited data was available in the laparoscopic group due to unavailability of the anaesthetic records, on account of the age of the cases.

We had hypothesised at the beginning of the study that operative time for the robotic cases would show a downward trend over time, due to the increased experience of the surgeon and the wider surgical team. However, this was not the case and operative time tended to either not change or even to increase (Supplementary Figure 2).

Table 2. Intraoperative outcomes data. Number converted to open surgery was compared by Fisher’s exact test. Mean operative time was compared by t-test. Only 46 data points were available for the laparoscopic group whereas all 130 robotic cases had this data recorded in the console.

Variable	Laparoscopic	Robotic	
Number converted to open surgery (%)	7 (5.8)	0 (0)	0.005
Mean operative time in minutes (SD)	223 (71)	200 (74)	0.07

3.3. Generic postoperative outcomes were not different between modalities

We analysed a range of postoperative outcomes including the length of hospital stay, the requirement for reoperation, mortality statistics, and the proportion experiencing a postoperative complication. None of these domains showed a significant difference between laparoscopic and robotic surgery (Table 3).

Table 3. Comparing generic postoperative outcomes. Length of stay data was compared with Mann-Whitney U test. Reoperations and mortality were analysed with Fisher’s exact test. Number with any postoperative complication was compared by the Chi-square test.

Variable	Laparoscopic	Robotic	p-Value
Median length of stay (IQR) - days	5 (4)	5 (4)	0.51
Number reoperated in 30 days (%)	4 (3.3)	10 (7.7)	0.17
Number died in 30 days (%)	2 (1.7)	0 (0)	0.23
Number with any postoperative complication (%)	29 (24)	42 (32)	0.20

3.4. Severity and nature of postoperative complications were similar between surgical modalities

Data were collected on postoperative complications and broadly categorised (Supplementary Table 2). There was no overall difference in the types of complications experienced by patients having laparoscopic vs. robotic surgery. Secondly, the severity of complications was graded using the Clavien-Dindo score. A comparison of the distribution of severities found no significant difference between the two groups (Figure 1 and Supplementary Table 3).

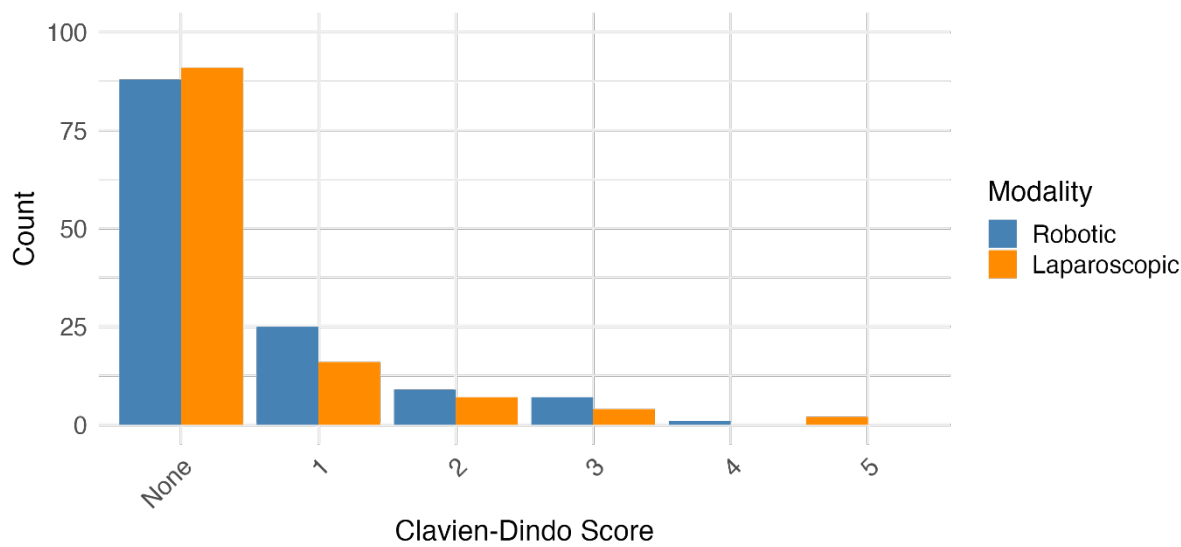


Figure 1. No significant difference in severity of postoperative complications. Complications were graded by the modified Clavien-Dindo score. A Fisher’s Exact test was used to assess for difference between the overall distribution and was not significant ($p = 0.35$).

4. Robotic surgery was more likely to achieve complete resection of tumours

Most operations in this study were performed for the treatment of colorectal cancer. A key outcome of this surgery is complete histological resection of the tumour denoted as “R0” on the pathology report. In our dataset, robotic surgery was more likely to result in tumour-free margins

than laparoscopic surgery (99.2 % vs. 92.5 %, $p = 0.013$) (Figure 2A). The staging of tumours as defined by the pathology reports did not differ significantly between groups (Supplementary Table 4). The number of lymph nodes harvested is also important and a minimum of 12 nodes is generally recommended (11). Both groups achieved this threshold but on average the laparoscopic technique harvested more lymph nodes (21.1 vs. 18.0 nodes, $p = 0.003$) (Figure 2B).

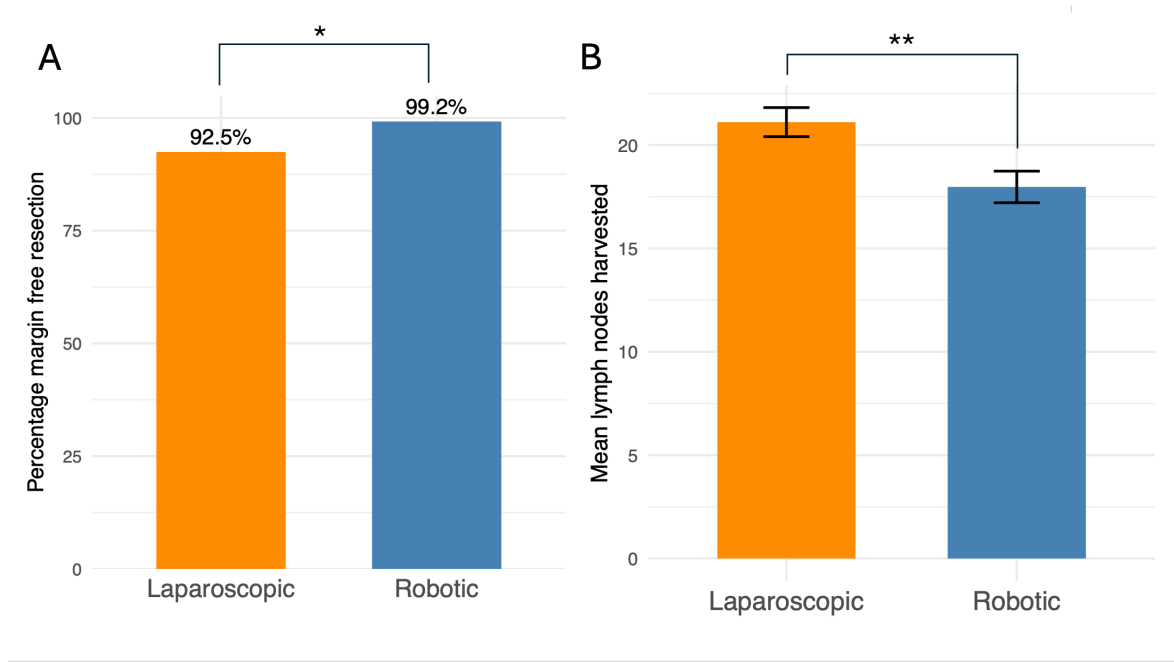


Figure 2. Robotic surgery was more likely to completely resect tumours despite harvesting fewer nodes. (A) The proportion of surgeries that achieved clear margins (“R0”) on pathology reports was compared by a Fisher’s exact test. N = 125 for the robotic group and 106 for the laparoscopic group. (B) The mean number of lymph nodes harvested in each resection is compared between the two groups. The error bars represent standard error of the mean. N = 109 in the laparoscopic group and 119 in the robotic group. This discrepancy is because for a small number of noncancerous lesions, either lymph node or margin data was not reported.

5. Discussion

Our single-surgeon study analysis shows that both minimally invasive techniques provide similar postoperative outcomes in the management of colorectal malignancies with robotic surgery having more favourable intraoperative outcomes than laparoscopic. Our findings show that when using a standardised technique and limiting confounding factors by focusing on the results of a single surgeon, outcomes are comparable between both surgical modalities.

Operation times and conversion rates to open surgery are key intra-operative outcome markers, as conversion is linked to longer hospital stays, post-operative ileus, increased morbidity, and higher overall costs (12,13). The laparoscopic group had a conversion rate of 5.8% and the robotic group had a significantly lower conversion rate of 0%. Additionally, our R0 rates were 92.5% and 99.2% for laparoscopic and robotic surgery respectively.

The literature reported a 17.9 +/- 10% conversion rate from laparoscopic to open surgery during elective colorectal resection (15), whereas our laparoscopic group's rate is notably lower. Other studies also report lower complication and conversion rates with robotic surgery (16,17). This could be due to increased precision, articulating instruments and 3D clearer field of vision due to stereoscopic optics of robotic surgeries, which proves particularly useful in complex surgeries that would otherwise lead to open surgery.

Although our patient selection was comparable in age, gender and BMI; the data suggests that the laparoscopic group had more advanced disease than the robotic group, which is a confounding factor that may have led to our increased conversion rate.

Whilst our intraoperative outcomes were favourable towards the robotic surgery, operation times and post-operative outcomes such as complications, length of stay and mortality showed no difference between both modalities.

There was no difference in operative time between the two modalities, although it is possible that robotic surgery takes longer when considering the set up and closure time not included in this study. An important caveat was that operative time data was limited in the laparoscopic group. Furthermore, there was no evidence that robotic surgery becomes faster with the surgeon's experience, at least in the first few years of operating. It remains possible that with a longer period of training or developments in the equipment itself that operative time could improve. Although right hemicolectomies appeared to get slower over time, this is likely to be due to a transition from extracorporeal to intracorporeal anastomoses throughout the study.

The current research is mixed in its findings regarding operative times for robotic procedures. Whilst, Yang et al., 2021 found no significant difference in times and thus replicated our findings, other studies found that there were faster times in the laparoscopic group compared to the robotic in their meta-analyses. This could be associated with the time required for setting up and docking time as well as the learning curve of starting robotic surgery (16–18).

A comprehensive assessment of perioperative outcomes was undertaken, evaluating 30-day mortality, postoperative complications, length of hospital stay, and 30-day re-operation rates. No significant differences were observed between the robotic and laparoscopic cohorts, suggesting comparable short-term surgical effectiveness and safety profiles for both techniques (19). Although the study was underpowered to establish statistical significance, the absence of mortality in the robotic cohort is notable.

While the overall severity of complications, as classified by the Clavien-Dindo system, was similar between groups, it is noteworthy that only the laparoscopic cohort experienced complications of grade III or higher. This discrepancy is likely attributable to baseline differences in patient population characteristics, wherein a greater prevalence of advanced disease within the laparoscopic group may have increased susceptibility to major morbidities.

Nonetheless, other observational studies and meta-analyses have compared robotic and laparoscopic surgery approaches in terms of complication rates and have found that both approaches have comparable post operative complication rates. Gahunia *et al.* (2025) reported superiority of robotic surgery to the laparoscopic approach in terms of conversion rates especially in obese individuals and male patients with low rectal tumours while reporting comparable outcomes in complication rates and blood loss (20). Furthermore, Askild *et al.* (2022) also reported comparable post operative complication rates including Clavien-Dindo grades 1-5 for robotic versus laparoscopic approaches, 35.9% compared to 31.2% respectively (21). Robotic surgery is still in the early phases of recognition and acceptability, but it would be prudent to say that it is equally safe when compared to the laparoscopic approach.

Regarding oncological efficacy, the laparoscopic group was associated with a higher lymph node yield. Despite this, no concomitant difference in pathological staging was identified, a finding consistent with the results reported by Yang et al. (2021) (22). This contrasts with the systematic analysis by Waters et al. (2020), which concluded a higher lymph node harvest was achievable with robotic assistance, highlighting an ongoing discourse within the literature (19).

Within our study, the similar findings between the postoperative outcomes and operative times of both modalities supports our claim that standardisation is the key driver in ensuring consistent patient outcomes as opposed to differing surgical modalities. The work of a single surgeon remained unaffected using different modalities despite the technical advantages offered using robotic procedures even after developing proficiency over the years using the technique.

Standardisation in surgery and how it ultimately affects outcomes has been a topic of much debate. It allows for a more consistent high-quality care and ensures that a reduction in the complication rate could be achieved (5). Robotic surgery is no different to these integral components of standardisation. Along with standardisation of surgical technique, a structured training program is imperative in achieving optimum results. Coleman *et al.* (2011) demonstrated that through their National Training Program for Laparoscopic Colorectal Surgery (LapCo) that a standardised training program achieves optimum results without compromising patient safety (23). Similarly, Koc *et al.* (2024) demonstrated that using a structured and standardised pathway for robotic colorectal surgery, they were able to achieve favourable short term oncological and clinical outcomes (4). Furthermore, a structured training program also elucidates the significant reduction in the time to overcome learning process without doing any patient harm as reported by Panteleimonitis *et al.* (2021), where different surgeons were able to achieve competency and overcome the learning process in a short matter of time while achieving good oncological and safe clinical outcomes (24).

A primary limitation of this study is its retrospective design. The collation of data was contingent upon the availability and completeness of historical patient records. Notably, critical variables such as operative times were frequently absent, potentially due to omissions in initial data entry. A prospective study design would mitigate these issues of missing data and facilitate the collection of more granular perioperative metrics, such as estimated blood loss, time to first flatus, and time to first oral intake, which are established indicators of bowel recovery (22).

Baseline differences in the populations of both cohort groups that suggest the slightly worse postoperative outcomes such as the 30-day mortality rate and higher operative times were due to confounding factors rather than the implication that robotic surgery is safer than laparoscopic. The robotic group contained a greater proportion of healthier patients with 13% of patients having an ASA Grade 1 compared to just 0.02% in the laparoscopic group. They also had fewer patients that required neoadjuvant therapy (28% patients compared to 43% in the laparoscopic group) suggesting that their malignancies were less advanced.

Although distinct patterns of complications were observed between the operative cohorts, the present study was not powered to determine a statistically significant association between complication type and surgical approach. Future research with larger sample sizes is warranted to elucidate these trends.

As a cohort of patients treated by a single surgeon within a single institute, this study provides significant strength by controlling for technical variability and standardising the surgical approach, though this may limit the generalisability of the findings. Nevertheless, this highly standardised methodology enables a valuable comparison of intraoperative and postoperative outcomes. It underscores the critical principle that robotic and laparoscopic platforms are tools to facilitate minimally invasive surgery, and that the surgeon's standardised technique is paramount for achieving consistent results (4,24,25). This work thus offers a foundational understanding to guide future clinical management and inform the priorities of larger, multi-centre research (26).

Patients benefit from either approach and the decision of whether to use laparoscopic or robotic techniques cannot be easily approached from the perspective of clinical outcomes. To assess which patients benefit more from either technique, other factors such as patient or surgeon preferences and cost-benefit analyses rather than clinical outcomes alone should be used. A 2023 metanalysis found a 17% increase in median hospitalisation cost for the robotic group (27). Amidst the growing concerns regarding cost-effectiveness in the NHS, such research would be very useful in assessing whether centres that do not have robotic machines yet, would benefit from them.

6. Conclusions

Robotic colorectal resection demonstrates trends toward improved intraoperative and pathological outcomes compared to laparoscopy, though perioperative morbidity remains comparable. Standardisation mitigates technical variability, demonstrating that for skilled surgeons,

the choice of platform may be influenced more by economic factors and preference than by major differences in clinical efficacy.

Supplementary Materials: The following supporting information can be downloaded at the website of this paper posted on Preprints.org.

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Conflicts of Interest: The authors declare no conflicts of interest.

Ethics: No identifiable patient information was used in this study.

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