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Implementation of da Vinci Xi robotic colorectal surgery by fellowship-trained surgeons using a standardised modular technique: a multicentre study from two UK units

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Abstract

Introduction: Robotic colorectal surgery is expanding across the NHS, but rapid adoption risks variability without structured training and clear reporting. We evaluated short-term outcomes from two UK units after service implementation by fellowship-trained surgeons using a standardised, modular technique.

Methods: This was a retrospective, multicentre observational study of consecutive adults undergoing robotic-assisted colorectal resection at two NHS trusts (April 2022 to July 2025). Two consultant colorectal surgeons, each having completed a modular robotic fellowship, performed all operations. Demographics, procedure type, conversion, operating time, length of stay (LOS), 30-day return to theatre, 90-day mortality, Clavien-Dindo (CD) complications and margin status were recorded. Anastomotic leak was predefined as leak requiring intervention (CD≥3). Data are presented as median (IQR) or n (%); no comparative testing was planned.

Results: This study included 184 patients, mostly with malignant disease (177/184, 96.2%). Median age was 70 years (IQR 60-76) and median BMI 27 (IQR 24-31). Operations covered right- and left-sided colonic and rectal resections; 80/184 (43%) were for rectal cancer. There were no conversions to laparoscopy or open surgery. Median operating time was 231 minutes (IQR 173–350) and median length of stay 5 days (IQR 4-8). Eleven patients (6%) returned to theatre within 30 days and there were no 90-day mortalities. Overall postoperative morbidity was low, with Clavien-Dindo grade 1-2 complications in 44 patients (24%), grade 3 in 12 (7%), and grade 4 in 1 (1%). For malignant cases, R0 resection was achieved in 175/177 (98.9%). Across all anastomoses (n=151), clinically significant leaks occurred in 4/151 (2.6%), all in the rectal cancer subgroup (4/55, 7.3%); no colonic leaks were observed. Two additional asymptomatic radiological leaks (2/151, 1.3%) resolved without intervention.

Discussion

A standardised modular approach delivered high-quality, low-complication outcomes with zero conversions, short stays, low re-operation and leak rates, and high R0 margins. These real-world data show safe, reproducible early performance with low service burden, support wider roll-out of structured robotic training, and provide credible inputs for future cost-effectiveness analyses. Prospective research should now include learning-curve metrics and extend follow-up to oncological, functional and patient-reported outcomes.

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Introduction

Over the last 23 years, robotic colorectal surgery (RCS) has expanded in the UK with up to 20% of minimally invasive surgery (MIS) being robotic assisted[1]. Further expansion is planned with the aim of increasing this to 90% in the next 10 years. This expansion is a result

of positive studies suggesting comparable, or even improved, short- and long-term outcomes compared to laparoscopic surgery[2-6]. The most recent study, the REAL randomised control trial, showed improved short- and long-term outcomes following RCS for middle and low rectal cancers[7].

Rapid increases in access to new MIS techniques will result in a need for increased training capacity. However, without a structured training pathway, there is a higher risk of exposing patients to complications during the learning curve of less experienced surgeons. In response and to reduce this risk when laparoscopic surgery was introduced, LAPCO (https://www.lapco-international.com) was created as a national training programme to provide structure to laparoscopic training and reproducible and reliable clinical outcomes[8].

The UK does not have formal mandatory training pathways or curricula. This has been highlighted as a future consideration in the Getting it right First Time Implementation of Robotic Assisted surgery in England document[9]. The European Academy of Robotic Colorectal Surgery (EARCS) set out a structured training pathway, that has been shown to produce comparable short-term oncological and clinical outcomes of trainees compared to trainers[10]. It offers experienced colorectal surgeons a minimum of 16-week standardised, competency-based approach to training. This programme includes didactic sessions, simulation models, cadaveric sessions and in vivo training. For successful completion, each candidate must pass a blind assessment of operation videos.

The aim of training should be to provide a safe and effective learning curve with reproducible clinical and oncological outcomes[10-11]. In this study, we present the short-term outcomes of RCS from two standardised and modular trained surgeons at different hospitals in the UK, who completed robotic colorectal cancer fellowships. Both were trained on a standardised modular technique for RCS that is reproducible as a learning system and offers predictable clinical outcomes.

Methods

Study design and setting

Retrospective, multicentre, observational study of consecutive patients undergoing robotic-assisted colorectal resection at two NHS trusts in England. University Hospitals Birmingham (UHB) is a major tertiary referral and teaching centre serving the West Midlands, with established robotic infrastructure and a dedicated colorectal cancer network that supports high-volume, research-active minimally invasive surgery programmes. Northampton General Hospital (NGH) is a large district general hospital and teaching site within the University Hospitals of Northamptonshire group, which introduced the da Vinci Xi system in 2022 and has since developed an expanding multidisciplinary robotic colorectal service.

Surgeons and training

Two consultant colorectal surgeons performed all operations at their respective units. Both surgeons had completed robotic colorectal cancer fellowships delivered using a standardised, modular technique. Fellowships comprised more than 30 hours of simulation and participation in over 20 cases to complete defined modules, with progress assessed using a standardised format, in keeping with published European training frameworks and consensus work on procedural standardisation[10, 12-14].

Participants

All consecutive adults undergoing robotic-assisted colorectal resection for benign or malignant colorectal disease during the study period (April 2022 to July 2025) were eligible and included.

Perioperative care and operative approach

All patients were managed with local enhanced recovery protocols. Malignant cases were discussed at the colorectal multidisciplinary team (MDT) meeting according to trust guidelines; neoadjuvant and adjuvant therapies were MDT-directed. Resections were performed in recognised anatomical planes, applying previously described standardised techniques for robotic colorectal surgery[10, 12-14]. All operations were performed using the da Vinci Xi surgical platform (Intuitive Surgical, Sunnyvale, CA, USA), which provides enhanced three-dimensional vision, wristed instruments with multiple degrees of freedom, and integrated table motion to facilitate precise dissection[13].

Data sources and variables

Data were collected retrospectively from hospital records at both sites, anonymised, and consolidated for analysis. Variables recorded included age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) grade, operation type, conversion to open or laparoscopic surgery, operative time, length of stay (LOS), 90-day mortality, 30-day return to theatre, Clavien-Dindo (CD) complication grade, and resection margin status. Anastomotic leak was defined as a leak requiring intervention or re-operation (CD≥3).

Outcomes

Primary outcomes were short-term safety and feasibility metrics, and included conversion rate, operative time, LOS, 30-day return to theatre, 90-day mortality, CD complications, and anastomotic leak. For malignant disease, margin status (R0/R1) was recorded.

Statistical analysis

Continuous data are presented as median with interquartile range (IQR). Categorical data are presented as counts and percentages. No comparative hypothesis testing was planned.

Governance

All patients provided informed consent for use of their data for analysis and research. Data were handled in accordance with the Data Protection Act 1998, with anonymisation before analysis. As this was an audit of established practice, formal research ethics approval was not required.

Results

Overall cohort

A total of 184 patients underwent robotic-assisted colorectal resection between April 2022 and July 2025 (UHB 57; NGH 127). Recruitment at UHB began in September 2023 with the start of its robotic programme. Baseline characteristics are shown in Table 1: median age 70 years (IQR 60-76), 107 (58%) male and 77 (42%) female, median BMI 27 (IQR 24-31). Procedures comprised 57 (31%) right hemicolectomies, 5 (3%) left hemicolectomies, 10 (5%) Hartmann's procedures, 49 (27%) high anterior resections, 41 (22%) low anterior resections, 18 (10%) abdominoperineal resections, one (1%) completion proctectomy and three (2%) subtotal colectomies (table 1, figure 1). Indications were predominantly malignant disease (177/184, 96.2%), with seven benign resections (3.8%).

Table 1. Baseline characteristics and short-term outcomes of complete cohort

Category	Complete cohort (n=184)
Median age (years, interquartile range)	70 (60-76)
Gender	
Male	107 (58.2%)
Female	77 (41.8%)
BMI (interquartile range)	27 (24-31)
ASA	
1	19 (10.3%)
2	102 (55.4%)
3	60 (32.6%)
4	3 (1.63%)
Operation	
Right Hemicolectomy	57 (31%)
Left Hemicolectomy	5 (2.72%)
Hartmann's Procedure	10 (5.43%)
High Anterior Resection	49 (26.6%)
Low Anterior Resection	41 (22.3%)
Abdominoperineal Resection	18 (9.78%)
Completion Proctectomy	1 (0.54%)
Subtotal Colectomy	3 (1.63%)
Benign cases	7/184 (3.8%)
Operation time (minutes, interquartile range)	231 (173-350)
Length of Stay (mays, interquartile range)	5 (4-8)
90-day mortality	0
Returned to theatre	11 (5.98%)
Anastomotic leak	4/151 (2.65%)
Clavien-Dindo Complication Score	
0	127 (69%)
1-2	44 (23.9%)
3	12 (6.52%)
4	1 (0.54%)
R1 resection	2/177 (1.13%)

Figure 1: Procedural mix

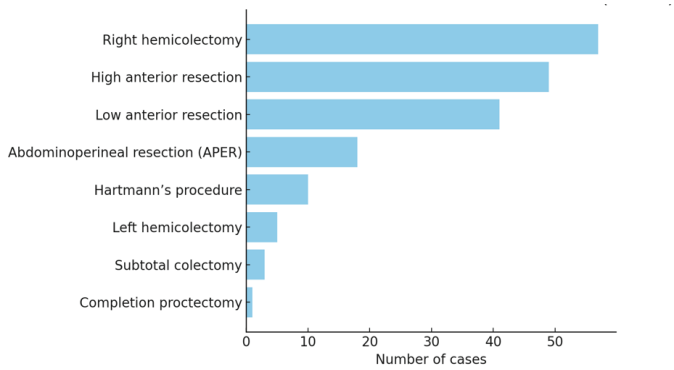

Table 2. Baseline characteristics and short-term outcomes of rectal cancer resections

Category	Rectal cancer resections (n=80)
Median age (years, interquartile range)	66 (60-75)
Gender	
Male	57 (71.3%)
Female	23 (28.8%)
Median BMI (interquartile range)	27 (24-31)
ASA	
1	10 (12.5%)
2	45 (56.3%)
3	25 (31.3%)
4	0
Operation	
Hartmann's Procedure	7 (8.8%)
High Anterior Resection	18 (22.5%)
Low Anterior Resection	37 (46.3%)
Abdominoperineal Resection	18 (22.5%)
Operation time (minutes, interquartile range)	270 (195-420)
Length of Stay (mays, interquartile range)	7 (4-9)
90-day Mortality	0
Returned to Theatre	7 (8.75%)
Anastomotic leak	4/55 (7.3%)
Clavien Dindo Complication Score	
0	50 (62.5%)
1-2	23 (28.8%)
3	6 (7.5%)
4	1 (1.25%)
R1 resection	1/80 (1.25%)

Clinical outcomes

There were no conversions to laparoscopy or open surgery. Median operating time was 231 minutes (IQR 173–350) and median length of stay was 5 days (IQR 4–8). There was no 90-day mortality. Eleven patients (6%) returned to theatre within 30 days for colonic conduit ischaemia, parastomal hernia, retracted stoma, port-site hernia or abdominal wall collection. Overall, 44 patients (24%) had Clavien-Dindo (CD) grade 1-2 complications, 12 (7%) grade 3 and 1 (1%) grade 4. R0 resection was achieved in 175/177 (98.9%) malignant cases.

Rectal cancer subgroup

Eighty patients (43% of the cohort) underwent rectal cancer surgery (table 2). Compared with the overall cohort, this subgroup was slightly younger (median 66 vs 70 years) and more often male (71% vs 58%). Low anterior resection accounted for 37 cases (46%). Median operating time was 270 minutes (IQR 195–420) and median length of stay 7 days (IQR 4–9). Seven patients (9%) returned to theatre. R0 resection was achieved in 79/80 (98.8%) cases.

Anastomotic leak outcomes

Across all anastomoses (n=151), clinically significant leaks requiring intervention occurred in 4/151 (2.6%); all four were in the rectal cancer subgroup (4/55, 7.3%), with no colonic leaks (0/96). Two additional asymptomatic radiological leaks were detected on contrast enema at two months (2/151, 1.3%); neither required treatment, both resolved on repeat imaging at four months, and both patients subsequently underwent ileostomy reversal.

Discussion

Robotic colorectal curgery is becoming increasingly adopted worldwide and there has been a large increase in uptake in the UK over the last few years. Some of the advantages of a robotic platform include angulated instruments with “wrists” allowing multiple degrees of freedom, three-dimensional views, a stable camera platform controlled by the operator, better fine movement control and reduction in tremor. This allows for a more meticulous dissection and is particularly beneficial when operating in narrow spaces such as low in the pelvis. There

has been a learning curve to using the robotic platform, but studies are beginning to show improved medium to long term outcomes compared to the original laparoscopic techniques[2-4]. The REAL trial published outcomes of over 1000 rectal cancer patients with over 500 patients in the robotic and laparoscopic arm[7]. Patients undergoing RCS had a lower 3-year locoregional recurrence rate, 3- year disease-free survival and better urinary, sexual and defecation function[6-7]. Systematic reviews and meta-analyses of the literature currently suggest comparable long-term outcomes of RCS versus laparoscopic surgery with some evidence that robotic rectal surgery results in lower estimated blood loss, increased lymph nodes dissected, reduction in CRM involvement, improved recovery post-operatively and reduced hospital stay[15-16]. These comparable findings are consistent even when neo-adjuvant therapy is utilized[17]. There is also an increasing body of evidence that functional outcomes are at least comparable if not improved compared to laparoscopic surgery[18]. There does, however, appear to be some evidence that RCS requires more theatre time[5].

This two-centre series reports 184 consecutive robotic colorectal resections performed by two fellowship-trained surgeons who led programme implementation at their respective hospitals. Both were industry-accredited robotic colorectal surgeons, fully trained in laparoscopy, and had completed standardised modular fellowships with additional hands-on exposure during senior training. The case mix covered right- and left-sided resections, with 43% for rectal cancer. Median length of stay was 5 days (7 for rectal surgery), and there was no 90-day mortality. Across 151 anastomoses, four clinically significant leaks occurred, all after rectal cancer surgery, aligning with published rates[12, 16, 19]. Post-operative morbidity was low, with 172/184 (93%) recording Clavien–Dindo 0–2. An R0 resection was achieved in 175/177 (98.9%) malignant cases, supporting the feasibility of precise pelvic dissection. Overall, these outcomes are consistent with the wider literature and indicate safe, effective set-up of robotic services at both units[3, 7].

Standardisation has been shown to improve results in minimally invasive colorectal surgery. A Danish study reported reductions in anastomotic leak, length of stay and readmissions following adoption of a standardised technique[19]. LAPCO similarly demonstrated gains from structured laparoscopic training. The EARCS pathway offers a templated approach to RCS with trainee outcomes comparable to proctors and has delivered a European consensus on standardising robotic TME[14]. The European Society of Coloproctology also advocates a modular, competency-based approach to in-theatre training[20].

This study has several limitations. Its retrospective, observational design risks selection and information bias, and short-term follow-up precludes assessment of functional recovery and longer-term oncological safety. Important oncological variables (e.g. tumour stage, lymph-node yield) and readmission rates were not captured, limiting comparison with published series. Only two surgeons and two centres were included, which constrains generalisability and introduces centre-level effects; peri-operative pathways (including enhanced recovery and neoadjuvant strategies) also varied. The absence of a contemporaneous laparoscopic or open comparator prevents causal inference regarding the robotic approach, and no cost, theatre efficiency or patient-reported outcome data were collected. Finally, outcomes may have been influenced by learning-curve and time-trend effects across the study period. Despite these constraints, the data support the feasibility of a standardised modular training approach.

National training curricula should embed competency-based assessment with proficiency-based progression and prospectively track learning curves using standardised metrics that account for case complexity, supervision and proctoring. Reporting itself needs standardisation: centres should use a common minimum dataset for the “learning environment”, including theatre set-up, docking and console times, turnover, team composition and experience, anaesthetic protocols and ERAS adherence, alongside harmonised definitions for complications (e.g. anastomotic leak) and risk-adjusted outcomes. Qualitative work on implementation barriers, theatre efficiency and team ergonomics should sit beside quantitative analyses of safety, oncological quality, functional recovery and patient-reported outcomes, with linkage to registries for long-term follow-up and cost-effectiveness. This combined approach would enable fair

benchmarking across units, clarify the true shape of the learning curve, and guide scalable adoption of robotic colorectal surgery within standard NHS pathways.

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