Laparoscopic, Endoscopic and Robotic Surgery xxx (xxxx) xxx

Contents lists available at ScienceDirect

Laparoscopic, Endoscopic and Robotic Surgery

journal homepage: www.keaipublishing.com/en/journals/laparoscopic-endoscopic-and-robotic-surgery

Robotic rectal cancer surgery: Results from a European multicentre case series of 240 resections and comparative analysis between cases performed with the da Vinci Si and Xi systems

Sofoklis Panteleimonitis [a, b, *], Oliver Pickering [b], Mukhtar Ahmad [b], Mick Harper [a], Tahseen Qureshi [b, c], Nuno Figueiredo [d], Amjad Parvaiz [a, b, d]

[a] University of Portsmouth, School of Health and Care Professions, St Andrews Court, Portsmouth, PO1 2PR, United Kingdom
[b] Poole Hospital NHS Trust, Poole, BH15 2JB, United Kingdom
[c] Bournemouth University School of Health and Social Care, Bournemouth, United Kingdom
[d] Champalimaud Foundation, Av. Brasilia, 1400-038, Lisbon, Portugal

ARTICLE INFO

Article history:
Received 19 November 2019
Received in revised form
9 December 2019
Accepted 10 December 2019
Available online xxx

Keywords:
Robotic surgery
Rectal cancer surgery
da Vinci Xi
da Vinci Si

ABSTRACT

Introduction: Robotic systems are designed to address the limitations of laparoscopic surgery, leading to a growing interest in robotic rectal surgery. However, certain technical limitations associated with the previous systems (da Vinci S & Si) have arguably slowed down its wholesale adoption. The latest robotic platform, the da Vinci Xi, addresses these limitations. This study aims to examine the short-term surgical outcomes of 240 single-docking fully-robotic rectal cancer resections and compare the outcomes of cases performed with the da Vinci Xi vs Si systems.

Materials and methods: All consecutive patients receiving robotic rectal cancer resections from three centres between 2013 and 2018 were identified from prospectively collated databases. The baseline characteristics and short-term surgical outcomes are presented and the da Vinci Xi vs Si system outcomes are analysed.

Results: A total of 240 patients were identified (124 Si, 116 Xi). Median operation-time and length-of-stay were 260 minutes and 6 days respectively. Conversion and 30-day mortality rates were 0. The da Vinci Si vs Xi system analysis shows that operation-time was lower in the Si group (230 vs 300 min, $p = 0.000$) but length-of-stay, lymph node yield and circumferential resection margin favoured the Xi group (7 vs 5 days, $p = 0.010$; 17 vs 21, $p = 0.000$; 92.7% vs 99.1%, $p = 0.020$).

Conclusion: Single-docking fully-robotic rectal cancer surgery is safe, feasible and can lead to good short-term outcomes, making it a good alternative to laparoscopic rectal cancer surgery. The new systems technological advances may result in better short-term outcomes but further larger scale observational studies are required if we are to reach such a conclusion.

1. Introduction

Despite the increasing adoption of laparoscopic colonic surgery over the last 15 years, laparoscopic rectal surgery uptake has been poor and concerns regarding specimen quality have been highlighted in the ACOSOG Z6051 and ALaCaRT trials.[1,2] Robotic systems offer a contemporary method of operating, which with their superiorly ergonomic, wristed instruments, tremor filtering and three-dimensional views address the limitations of laparoscopic surgery when operating in confined spaces such as the pelvis.[3] The growing interest in robotic rectal surgery over the last few years is evident from the increasing number of research publications on the subject.[4,5] However, the worldwide adoption of robotic systems has been arguably slowed down by certain technical limitations associated with the previous models (da Vinci S & Si).[6] These included prolonged docking times, arm clashing and difficulties in performing multi-quadrant surgery.[7] After taking into consideration feedback given from surgeons from different surgical specialities, Intuitive Surgical® introduced the da Vinci Xi® in 2014. This model included several technological advances designed to overcome the limitations of its predecessors. However, whether this improved version offers superior short-term surgical outcomes is understudied.

* Corresponding author: University of Portsmouth, School of Health and Care Professions, St Andrews Court, Portsmouth, PO1 2PR, United Kingdom.
E-mail address: sofoklis_p@hotmail.com (S. Panteleimonitis).

https://doi.org/10.1016/j.lers.2019.12.002

For the study reported here, the team of surgeons have been performing robotic rectal surgery since May 2013, starting with the da Vinci Si and then with the da Vinci Xi and integrated table motion (ITM) since November 2015. The senior surgeon (Amjad Parvaiz) performing the robotic cases in Portsmouth, supervised the adoption of robotic rectal surgery at the units in Poole and Lisbon. We describe our experience of robotic rectal cancer surgery with the two systems over the last 5 years by analysing the short-term outcomes of 240 consecutive cases. In addition, we compare the short-term surgical outcomes of the da Vinci Xi rectal cancer resections with the resections performed with the da Vinci Si in order to investigate whether the technological advances offered by the Xi system are translated to superior surgical outcomes. To date, and as far as we are aware, this study represents the largest robotic rectal surgery series in Europe and the largest study comparing the outcomes of the patients receiving robotic rectal cancer surgery with the two platforms.

2. Materials and methods

2.1. Study population and participant selection

Consecutive cases from three centres, two from the UK (Portsmouth, Poole) and one from Portugal (Lisbon), who received robotic rectal cancer resection surgery between May 2013 and May 2018 were identified from prospectively maintained databases. The inclusion criteria were all elective patients deemed fit for minimally invasive surgery receiving robotic rectal surgery for adenocarcinoma of the rectum. Benign cases and colonic cancer patients were excluded. The primary objective of this study was to analyse the collective short-term outcomes of all robotic rectal cancer cases. This was in order to examine the feasibility and safety of robotic rectal surgery. The secondary objective was to examine the short-term outcomes of resections performed with the da Vinci Xi vs da Vinci Si systems.

All cancer patients involved in this study were discussed in the multidisciplinary team meeting prior to initiating any type of treatment. In general, preoperative chemoradiotherapy was given to patients with high risk for local recurrence (threatened circumferential resection margin $\leq$ 2mm or T4 in staging MRI). Neoadjuvant radiotherapy was not used where rectal cancers were considered resectable by total mesorectal excision (TME) with a good likelihood of clear margins. Patients receiving neoadjuvant chemoradiotherapy were operated at 12 weeks after completion of their treatment. A modified enhanced recovery programme was used as standard at all colorectal units in this study.[8]

All patients operated in the first unit (Portsmouth) received surgery with the da Vinci Si. Patients operated in the remaining two units (Poole and Lisbon) received surgery with the da Vinci Xi and ITM. No specific criteria were used to allocate patients to robotic surgery in each unit. Applied surgical modality was based on equipment and theatre availability, with the robotic approach being preferred following the adoption of robotic surgery in each unit. There were no specific medical contra-indications for robotic surgery that did not apply for laparoscopic surgery and any patients who were deemed unfit or unsuitable to undergo laparoscopic surgery were excluded from consideration for robotic surgery. These included patients requiring multi-visceral resections, patients with large incisional hernias requiring abdominal wall reconstruction after resection and those who could not tolerate pneumoperitoneum.

Patients included in the study had surgery performed by four colorectal surgeons. The surgeon from one of the centres (surgeon AP) represented the senior surgeon who trained the remaining three surgeons under a supervised training programme. As a result, all surgeons used the same standardised modular approach. Data collection is from the acquisition of the robotic system in each unit (May 2013, November 2015 and May 2016 for Portsmouth, Poole and Lisbon respectively) to February 2016 for Portsmouth and May 2018 for Poole and Lisbon units.

2.2. Surgical technique

Robotic rectal resections were performed using previously described standardised single-docking fully-robotic approaches for both systems.[6,9] This was possible for the da Vinci Si system by changing the port configuration and flipping the robotic arms between the stages of abdominal and pelvic dissection,[9] a step not required with the Xi system.[6] Procedures commenced with medial to lateral dissection followed by vascular control by ligating the main vessels, followed by a three-step approach for splenic flexure mobilisation.[10] TME was performed in a stepwise manner, starting with posterior mobilisation followed by right lateral, anterior and left lateral mobilisation. All patients receiving complete TME surgery (i.e. for mid- and low-rectal tumours) were given preoperative bowel preparation the day before surgery and had loop ileostomies fashioned where an anastomosis was formed. Postoperatively, all patients were managed using the enhanced recovery program described by Kehlet and Wilmore.[8] Patients were discharged home only upon safely meeting the criteria for discharge.

2.3. Data collection and outcome assessment

All data was collected from prospectively maintained databases, with the baseline characteristics and short-term surgical outcomes of all elective patients receiving robotic rectal cancer surgery being retrospectively collected and analysed. Baseline characteristics analysed included age, body mass index (BMI), gender, American Society of Anaesthesiologist (ASA) grade, neoadjuvant radiotherapy, operation performed and pathological T stage. Perioperative data included operative time, estimated blood loss (EBL) and conversion to open (defined as any incision needed to either mobilise the colon or rectum or ligate the vessels). Postoperative clinical data examined included length of stay (LOS), 30-day readmission, 30-day reoperation, 30-day mortality and clinical anastomotic leak (defined as an anastomotic leak requiring re-intervention such as a drain or further surgery). It should be noted that all patients requiring TME had defunctioning loop ileostomies, and therefore a low number of clinical anastomotic leaks is expected. Pathological data examined included lymph node yield and circumferential resection margin (CRM) clearance. Unfortunately, operative time was not recorded in the Portuguese centre.

2.4. Statistical analysis

Data was analysed using IBM SPSS version 24 (SPSS Inc., Chicago, IL, USA). Non-parametric data was expressed as median with interquartile range (IQR) and parametric data as mean with standard deviation. Baseline demographic and clinical characteristics were compared using χ^2 test or Fishers exact test for categorical variables, Mann–Whitney U test for non-parametric continuous variables and t test for parametric continuous variables. p values of <0.05 were considered statistically significant.

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Univariate binary logistic regression analysis was performed on all patients receiving elective robotic rectal cancer surgery to assess whether robotic platform (da Vinci Si or Xi) affected CRM clearance. Following this, a multivariate model was applied were platform used was adjusted for all clinically relevant variables (age, gender, BMI, ASA grade, pathological T stage, neoadjuvant radiotherapy). For the purpose of binary logistic regression missing values were replaced with the series mean (10 for ASA, 3 for T stage, 12 for BMI).

2.5. Ethical considerations

All included patients signed an informed consent allowing their data to be used for retrospective analysis and research. The requirements for anonymization of personal dataset by the Data Protection Act 1998 were satisfied. According to the Health Research Authority, this study did not require their approval due to its status as a clinical audit.

3. Results

3.1. Total cohort

A total of 240 patients received robotic rectal cancer surgery (124 Si, 116 Xi). Baseline characteristics and short-term surgical outcomes are summarised in Tables 1 and 2. The majority of the cases were male (66.7%), ASA grade II (77.0%) and received anterior resections (86.7%). Sixty-six (27.5%) patients received neoadjuvant radiotherapy. Median operative time was 260 minutes and median LOS was 6 days. There were no conversions to open, or 30-day mortality. Four clinical anastomotic leaks were documented and R0 clearance rate was 95.8%.

Table 1
Baseline characteristics of robotic rectal cancer resections

	Robotic rectal cancer resections ($n = 240$)
Median age (IQR), years old	69 (60–75)
Median BMI (IQR), kg/m^2	27 (24–30)
System, *n*(%)	
Si	124 (51.7)
Xi	116 (48.3)
Centre, *n*(%)	
Portsmouth (Si)	124 (51.7)
Poole (Xi)	80 (33.3)
Lisbon (Xi)	36 (15.0)
Gender, *n*(%)	
Male	160 (66.7)
Female	80 (33.3)
ASA grade, *n*(%)	
I	17 (7.4)
II	177 (77.0)
III	35 (15.2)
IV	1 (0.4)
Procedure, *n*(%)	
Anterior resection	208 (86.7)
APER	29 (12.1)
Hartman's	2 (0.8)
Panproctocolectomy	1 (0.4)
Neoadjuvant radiotherapy, *n*(%)	66 (27.5)
Pathological T stage, *n*(%)	
0	12 (5.1)
1	29 (12.2)
2	77 (32.5)
3	104 (43.9)
4	15 (6.3)

ASA: American Society of Anaesthesiologist; APER: Abdominoperineal resection.

3.2. da Vinci Si vs Xi system data analysis

3.2.1. Baseline characteristics

There was a total of 124 and 116 rectal resections performed with the da Vinci Si and Xi systems respectively.

There were no significant differences in any of the baseline characteristics between the two cohorts as demonstrated in Table 3.

3.2.2. Peri-operative outcomes

The peri-operative outcomes of the two groups are summarised in Table 4. Median operation time was greater in the da Vinci Xi group (230 vs 300 min, $p = 0.000$). EBL was higher in the da Vinci Xi group (10 vs 20 ml, $p = 0.000$). There were no conversions to open in either cohort.

3.2.3. Post-operative outcomes

LOS was shorter in the da Vinci Xi group (7 vs 5 days, $p = 0.010$). There was no difference in any of the remaining clinical outcomes between the two groups (30-day readmission, reoperation, mortality and anastomotic leak). In terms of pathological outcomes, lymph node yield (17 vs 21, $p = 0.000$) and R0 clearance rate (92.7% vs 99.1%, $p = 0.024$) were higher in the Xi cohort. Table 5 summarises the post-operative outcomes.

3.2.4. Logistic regression analysis for CRM clearance

Univariate logistic regression analysis infers that robotic platforms have an impact on CRM, with the Xi system associated with a lower risk of achieving a R1 resection (OR: 0.111 [95% CI: 0.014–0.891], $p = 0.039$). This was still the case in multivariate analysis (OR: 0.092 [95% CI: 0.011–0.764], $p = 0.027$) when other clinically relevant factors were adjusted for (age, gender, BMI, neoadjuvant radiotherapy, ASA grade, pathological T stage), as demonstrated in Table 6.

4. Discussion

Laparoscopy has revolutionised colonic surgery but its adoption has been much less successful for rectal cancer surgery. This could be attributed to the inherent limitations of laparoscopic instruments when operating in narrow spaces such as the pelvis, which were highlighted in two large multi-centre randomised control trials (ACOSOG Z6051 & ALaCaRT) comparing laparoscopic to open rectal resections.[1,2] In both studies the oncological equivalence of laparoscopic to open rectal surgery is debated, raising suspicion of the safety of laparoscopic rectal surgery. Robotic systems were designed to address these limitations and may provide the solution to minimally invasive surgery for rectal cancer resections.

In this study we present the data of 240 robotic rectal cancer cases over a period of 5 years. By applying a standardised, modular approach to surgery, fully-robotic single-docking robotic surgery was performed with good short-term surgical outcomes. The absence of any conversions (conversion rate was 11.3% and 9% in the ACOSOG Z6051 & ALaCaRT trials respectively) and relatively low number of clinical anastomotic leaks, 30-day readmissions and reoperations is testimony to the successful implementation of the robotic rectal surgery programme in the three units participating in this study.[1,2] In addition, the R0 resection rate was 95.8%, in contrast to 87.9% and 93% in the ACOSOG Z6051 & ALaCaRT trials.[1,2] This data shows that robotic rectal surgery is safe and could be used as an alternative to laparoscopic rectal surgery in similar sample populations.

To date there have been multiple studies comparing the short-term outcomes of laparoscopic vs robotic rectal surgery with

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Table 2
Short-term outcomes of robotic rectal cancer resections

	Robotic rectal cancer resections ($n = 240$)
Median operative time in minutes (IQR)	260 (210–310)
Median estimated blood loss in ml (IQR)	20 (10–20)
Conversion to open, *n*	0
Median length of stay in days (IQR)	6 (4–8)
30-day readmission, *n*(%)	19 (7.9)
30-day reoperation, *n*(%)	12 (5.0)
30-day mortality, *n*(%)	0
Clinical anastomotic leak, *n*(%)	4 (1.9)
Median lymph node yield in number (IQR)	19 (14–25)
R0 clearance, *n*(%)	230 (95.8)

Table 3
Baseline characteristics of da Vinci Si vs Xi system cases

	Si ($n = 124$)	Xi ($n = 116$)	*p* value
Median age (IQR), years old	68 (62–76)	69 (60–77)	0.115[m]
Median BMI (IQR), kg/m^2	27 (24–30)	28 (24–31)	0.221[m]
Gender, *n*(%)			
Male	86 (69.4)	74 (63.8)	0.361[c]
Female	38 (30.6)	42 (36.2)	
ASA grade, *n*(%)			
I	10 (8.5)	7 (6.3)	0.467[c]
II	93 (78.8)	84 (75.0)	
III	15 (12.7)	20 (17.9)	
IV	0	1 (0.9)	
Procedure, *n*(%)			
Anterior resection	109 (87.9)	99 (85.3)	0.253[c]
APER	12 (9.7)	17 (14.7)	
Hartman's	2 (1.6)	0	
Panproctocolectomy	1 (0.8)	0	
Neoadjuvant radiotherapy, *n*(%)	30 (24.2)	36 (31.0)	0.236[c]
Pathological T stage, *n*(%)			
0	5 (4.0)	7 (6.2)	0.246[c]
1	18 (14.5)	11 (9.7)	
2	45 (36.3)	32 (28.3)	
3	51 (41.1)	53 (46.9)	
4	5 (4.0)	10 (8.8)	

ASA: American Society of Anaesthesiologist; APER: Abdominoperineal resection.
[m] Mann–Whitney *U*.
[c] Chi square.

contradictory results.[5,11–19] The majority of the evidence consists of small scale retrospective comparative studies but more recently the results of the ROLARR trial were published, a multi-centre randomised control trial comparing robotic and laparoscopic rectal resections which found no difference in the short-term outcomes of the two arms.[20] However, this trial was performed when robotic rectal surgery was in its infancy and the da Vinci Xi was unlikely to be used in any of the trial's centres considering recruitment ended in September 2014. In the ROLARR trial conversion rate was 12.2% for the laparoscopic and 8.1% for the robotic cohorts ($p = 0.16$), which is considerably higher than the conversion rate observed in our study and may be explained in part by the fact that many of the surgeons were still in the early stages of their learning curve for robotic rectal surgery.[21]

Despite the increasing adoption of robotic rectal cancer surgery, the da Vinci Si system presented several technical limitations that were recognised by surgeons performing robotic rectal resections. These mainly entailed a difficult and complex docking process, repeated arm clashing and difficulties in performing multi-quadrant surgery. The issue of multi-quadrant surgery with the da Vinci Si has been addressed by colorectal surgeons with a variety of methods, leading to multiple robotic rectal resection techniques, such as the hybrid-approach and dual docking approach. In our centre in Portsmouth we managed to perform single docking fully robotic surgery with the da Vinci Si, but this required changing the port configuration and flipping the robotic arms between the stages

Table 4
Peri-operative outcomes of da Vinci Si vs Xi system cases

	Si ($n = 124$)	Xi ($n = 116$)	*p* value
Median operative time in minutes (IQR)	230 (204–300)	300 (240–330)	0.000[m,b]
Median estimated blood loss in ml (IQR)	10 (0–20)	20 (20–20)	0.000[m,b]
Conversion to open, *n*	0	0	

[m] Mann–Whitney *U*.
[b] Statistically significant.

Table 5
Post-operative clinical and pathological outcomes of da Vinci Si vs Xi system cases

	Si ($n = 124$)	Xi ($n = 116$)	*p* value
Median length of stay in days (IQR)	7 (5–12)	5 (3–8)	0.010[m,d]
30-day readmission, *n*(%)	10 (8.1)	9 (7.8)	0.930[c]
30-day reoperation, *n*(%)	4 (3.2)	8 (6.9)	0.242[f]
30-day mortality, *n*(%)	0	0	
Anastomotic leak, *n*(%)	4 (3.6)	0	0.123[f]
Median lymph node yield in number (IQR)	17 (13–23)	21 (16–27)	0.000[m,d]
R0 clearance, *n*(%)	115 (92.7)	115 (99.1)	0.024[f,d]

[m] Mann–Whitney *U*.
[c] Chi-square.
[f] Fishers exact test.
[d] Statistically significant.

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Table 6
Univariate and multivariate logistic regression for CRM of robotic rectal cancer resections ($n = 240$)

	OR	Univariate			OR	Multivariate		
		95% CI lower	95% CI upper	*p* value		95% CI lower	95% CI upper	*p* value
Platform (Xi vs Si)	0.111	0.014	0.891	0.039[a]	0.092	0.011	0.764	0.027[a]
Age	1.030	0.966	1.099	0.362	1.020	0.944	1.102	0.613
Gender (male vs female)	0.484	0.136	1.723	0.263	0.436	0.116	1.636	0.219
BMI	0.952	0.809	1.121	0.556	0.947	0.792	1.132	0.550
Neoadjuvant radiotherapy	1.806	0.493	6.617	0.372	2.056	0.525	8.048	0.301
ASA grade (I-II vs III)	0.694	0.141	3.408	0.653	0.719	0.118	4.373	0.720
Pathological T stage (T0-2 vs T3-4)	0.407	0.103	1.612	0.200	0.339	0.081	1.423	0.140

OR: odds ratio; CI: confidence interval; ASA: American Society of Anaesthesiologist.
OR represents the odds ratio of performing an R1 resection.
[a] Statistically significant.

of abdominal and pelvic dissection.[9] The da Vinci Xi has a redesigned patient cart with new overhead instrument arm architecture, coupled with a laser target system making docking much easier, quicker and enabling multi-quadrant surgery without having to reposition the patient cart or change the port configuration. Furthermore, the da Vinci Xi comes with thinner longer arms equipped with newly designed joints that offer a greater range of freedom of motion, therefore reducing arm clashing. The ITM allows for the table to be moved while the patient cart is docked, facilitating robust splenic flexure mobilisation since the patient can be moved from the head down to the head up position without undocking the robot, displacing the transverse colon downwards and therefore assisting in separating the omentum from the transverse colon.

Another major contribution has been the introduction of the robotic stapler for intracorporal division of the rectal tube following resection. The versatile design of this equipment with fully wristed manipulations performed from the surgeon console greatly facilitates low rectal tube division and improves sphincter preservation rates. These technological advances have made the da Vinci Xi an even more attractive tool for robotic rectal surgery, facilitating robotic splenic flexure mobilisation and the single-docking fully-robotic approach. This has led to two studies comparing the da Vinci Si and Xi systems by assessing the number of splenic flexure mobilisations and fully-robotic single-docking approaches performed with each system.[7,22] Both studies concluded that there were more splenic flexure mobilisations performed in the da Vinci Xi cohort's and Morelli et al also reported a higher number of fully-robotic procedures (100% vs 23%) for the Xi system.[7]

However, using splenic flexure mobilisations and fully-robotic procedures as reported outcomes and markers of success present a significant limitation, since procedures may have been performed with the hybrid-approach or splenic flexures not mobilised for reasons other than the platform deployed, such as training purposes, clinical need or surgeon choice. In our cohort we routinely used the fully-robotic approach for all cases and splenic flexure mobilisation was completed routinely in all resections requiring a colorectal or coloanal anastomosis.

In comparing the short-term surgical outcomes of the da Vinci Si and Xi we found that operative time and EBL was higher for the Xi group (see Table 4) but LOS, lymph node yield and CRM favoured the Xi group (see Table 5). The increased operative time is in direct contrast to what we would expect when considering the technological advances of the Xi system and available literature.[7,23] This could be attributed to the fact that the Xi cases include twenty training cases with the remaining ($n = 60$) performed by surgeons in the early stages of their robotic surgery experience.

When considering EBL, our results show that the observed difference between the two systems is of no clinical significance (10 vs 20 ml) and is more likely to be attributed to the way EBL was measured in each unit rather than any real difference. However, it is worth noting is that EBL was minimal in both systems, which is in agreement with other published reports that demonstrate an improved blood loss in robotic vs laparoscopic rectal cancer surgery.[5,24,25]

Median LOS was shorter in the da Vinci Xi cohort with results inferring that a reduction in LOS could be attributed to a reduction in post-operative morbidity. This is supported by two recent studies published by the Cleveland clinic group who reported that LOS, readmission rate and mortality effectively predict complications.[26,27] However, differences in the enhanced recovery protocols between the units of this study are likely to influence the observed differences in LOS. The da Vinci Si cases took place in an earlier chronological time scale, were epidural catheters were applied more routinely as part of the enhanced recovery protocol. Subsequently, our results would now favour a single shot spinal infiltration of marcaine and diamorphine prior to anaesthesia for analgesia and avoid epidural catheters, which could lead to earlier mobilisation of patients and therefore a speedier recovery. Examining the relevant published literature, from the three studies comparing the surgical outcomes of da Vinci Si and Xi rectal resections,[7,22,23] one study demonstrated a shorter LOS in the Si group (5.1 vs 6.2 days; $p = 0.001$),[23] one study reported a shorter LOS in the Xi group (although this did not reach statistical significance: 8.0 vs 6.5 days; $p = 0.077$),[7] and one study found no difference at all (5.7 vs 6.0 days).[22]

Lymph node yield and R0 clearance were higher in the da Vinci Xi group (see Table 5). A higher lymph node yield was also found in the Xi group in the study reported by Ozben et al,[23] although this was not the case in multivariate analysis. Anastomotic leak, 30-day readmission, reoperation and mortality rates did not differ between the two groups. Differences in R0 clearance, which are confirmed in univariate and multivariate regression analysis in our study population, could be partly due to the slimmer arm design of the console. This reduces arm clashing, which can potentially hinder the precise dissection of the mesorectum when operating in the deep pelvis.

The advances in the da Vinci Xi system have undoubtedly made single-docking fully-robotic rectal surgery more attainable and are likely to obliterate the need for hybrid- or dual-docking procedures. In our experience colorectal surgeons report finding the da Vinci Xi system to be a more forgiving, user-friendly console that is easier to learn when compared to the Si system. However, whether this translates to improved short-term outcomes is yet to be established.

Limitations of this study include the retrospective nature of the study and the fact that minor post-operative complications were not recorded (Clavien-Dindo 1–2). This is because minor complication data is harder to accurately record and can be easily missed.

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Considering further limitations, the surgeons operating with the da Vinci Si system had a significantly larger minimally invasive colorectal surgery experience which could skew the results reported. Moreover, the chronological order differences in data collection between the two groups (May 2013 to February 2016 for the da Vinci Si system vs November 2015 to May 2018 for the Xi system) present significant observational bias in this study and differences in outcomes could be confounded by advances in peri-operative management. Finally, the fact that there was only one kind of robotic system present in each participating centre presents further observation bias. This is because differences in outcomes could be attributed to differences in the care provided between the study's participating centres, rather than in the robotic systems themselves.

The main strengths include that data was collected form three centres from two countries and is contemporary data, rather than data collected as part of a trial that inevitably includes an element of performance bias in surgical trials.[28,29] Further strengths are that this study, as far as is known, is the largest of its kind and includes the largest European case series of single-docking fully-robotic rectal cancer resections.

5. Conclusions

In conclusion, single-docking fully-robotic rectal cancer surgery is safe and effective and can lead to good short-term surgical outcomes, making it a good alternative option to laparoscopic rectal cancer surgery. The new system's technological advances facilitate better intraoperative control of operative fields, which in turn may result in better short-term outcomes, but further larger scale observational studies are required if we are to reach such a conclusion.

Declaration of Competing Interest

Mr Sofoklis Panteleimonitis, Dr Oliver Pickering, Mr Mukhtar Ahmad, Dr Mick Harper, Prof Tahseen Qureshi and Dr Nuno Figueiredo have no conflicts of interest or financial ties to disclose. Prof Amjad Parvaiz is a proctor for European Academy of Robotic Colorectal Surgery, which is funded by Intuitive Surgical®.

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Please cite this article as: Panteleimonitis S et al., Robotic rectal cancer surgery: Results from a European multicentre case series of 240 resections and comparative analysis between cases performed with the da Vinci Si and Xi systems, Laparoscopic, Endoscopic and Robotic Surgery, https://doi.org/10.1016/j.lers.2019.12.002