BMC Urology

RESEARCH

Open Access

Stapled vs. manually sutured bowel anastomosis in robot-assisted radical cystectomy: a single-center retrospective analysis

Thomas Hermans[1*], Giel Schevenels[2], Steve Motmans[1], Thomas De Sutter[1] and Yannic Raskin[1]

Abstract

Background Radical cystectomy is the primary treatment for muscle-invasive bladder cancer and certain cases of high-risk non-muscle-invasive disease. Robot-assisted cystectomy techniques (RARC) have emerged as a minimally invasive alternative to traditional open surgery, offering enhanced precision and potentially improved recovery. Bowel anastomosis remains a critical step in these procedures, with manually sutured anastomosis offering a cost-effective alternative to the standard stapled technique. However, concerns remain regarding its impact on surgical outcomes.

Methods We conducted a retrospective study of 92 patients who underwent RARC in our hospital between March 2021 and November 2023. Bowel anastomosis was performed using either stapled ($n=33$) or manually sutured techniques ($n=59$). Key outcome parameters included gastro-intestinal (GI) complications, overall complications, operation duration, length of hospital stay, readmissions, and postoperative recovery metrics.

Results GI complications occurred in 23 patients (25%), with paralytic ileus being the most common (17%). The rates of GI complications were comparable between the manually sutured (27%) and stapled (21%) groups ($p=0.530$, odds ratio 1.38). The mean operation duration was 300 min for the sutured group and 313 min for the stapled group ($p=0.124$). The median hospital stay was similar at 8 days ($p=0.384$) for both groups. Readmission rates were higher in the sutured group (25% vs. 6%, $p=0.022$, odds ratio 5.28), but this was predominantly due to non-GI complications.

Conclusion This study indicates that outcomes are comparable between stapled and manually sutured bowel anastomosis in RARC, with no significant increase in overall complications, GI complications, operation duration or hospital stay if using a manually sutured anastomosis. Considering the low cost of manual suturing, this technique seems highly cost-effective and could be considered a viable alternative to existing stapling techniques.

Keywords Bowel anastomosis, Robot-assisted radical cystectomy, Stapled, Sutured, Muscle-invasive bladder cancer, Cost

*Correspondence:
Thomas Hermans
thomashermans1@gmail.com
[1]Department of Urology, Ziekenhuis Oost-Limburg, Synaps Park 1, Genk 3600, Belgium
[2]Department of Molecular Biology, ULB Neuroscience Institute, Université libre de Bruxelles (ULB), 12 rue des Profs. Jeener et Brachet, Gosselies 6041, Belgium

Introduction/Background

Radical cystectomy stands as the gold standard treatment for patients afflicted with muscle-invasive bladder cancer and select cases of high-risk non-muscle-invasive disease that are unresponsive to more conservative therapies [1, 2]. While traditional open surgery has been the historical approach, the advent of robotic-assisted techniques (RARC) has revolutionized the landscape of radical cystectomies, offering a minimally invasive alternative with enhanced precision [3].

After cystectomy, urinary diversion is required. Most commonly, a segment of the distal ileum is utilized to construct the diversion [4]. The creation of an effective bowel anastomosis is therefore a critical aspect of the surgical procedure, influencing both short-term recovery and long-term quality of life. Traditionally, this anastomosis has been executed using manual suturing. Since the 1960's medical devices for the stapling of bowel tissue have been introduced as an alternative technique, offering potential advantages in terms of reduced operative times, decreased complications, and enhanced standardization [5]. These staplers have slowly become the standard of care for bowel anastomosis.

With the rise of laparoscopic surgery, specialized intra-abdominal staplers have emerged. While stapled bowel anastomosis offers advantages in open surgery, these devices have drawbacks in minimally invasive procedures [3]. Laparoscopic, as well as robot-assisted staplers, are usually quite bulky and difficult to manoeuvre and articulate intra-abdominally [6]. Furthermore, the mechanical nature of stapling and the reduced visibility of the mesentery introduces a risk of compromised blood supply and tissue ischemia at the anastomotic site. This could contribute to an increased risk of anastomotic leaks or necrosis [7, 8]. Using the Da Vinci Fluorescence Imaging Vision System (Firefly) to identify blood supply in the bowel mesenterium with Indocyanin Green (ICG), could help to selectively avoid cutting through important mesenteric vessels [9].

Another key concern is staplers' limited adaptability to tissue variations. Unlike manual suturing, they lack tactile feedback, making them less adaptable to friable, fibrotic, or otherwise challenging bowel tissue.

The most notable disadvantage, however, lies in the cost associated with the utilization of surgical staplers. Stapling devices, though efficient, are expensive and contribute to increased overall procedural costs. This economic consideration becomes particularly pertinent in healthcare settings with constrained resources, raising questions about the cost-effectiveness of stapled bowel anastomosis compared to traditional manual suturing.

In our hospital, both stapled and manually sutured anastomosis techniques have been used in RARC. We conducted an extensive literature review and found minimal recent evidence on this topic, with most studies over 20 years old and few from the minimally invasive surgery era. Only three studies compared robot-assisted stapling with manually sutured anastomosis in RARC, showing no significant short-term disadvantages. We thus aimed to retrospectively compare our manually sutured and stapled approaches to better understand their safety, efficacy, and postoperative outcomes.

Materials and methods

Patients

We conducted an extensive analysis of all patients that underwent a robot-assisted cystectomy in our centre between March 2021 (start of RARC program) and November 2023. Patients that underwent an open ($n = 9$) or partial cystectomy ($n = 17$) were excluded, as well as patients that had to be converted to open during the procedure ($n = 1$). Other predefined exclusion criteria were if bowel anastomosis was not performed (e.g. ureterocutaneostomy, $n = 0$) or performed extracorporeally ($n = 0$), or if the procedure was performed as an emergency procedure ($n = 4$). We finally also decided to exclude one patient in which the anastomosis was performed using a laparoscopic stapler (handled by a bedside assistant). Following these selection criteria, 32 of 124 RARC patients were excluded from the analysis (Fig. 1).

Outcome parameters

As outcome parameters, we first compared duration of stay in the hospital, intensive care unit (ICU), number and duration of readmissions.

Next, we focussed on complications, both on overall complications and on gastro-intestinal (GI) complications in particular, assessing parameters such as the proportion of affected patients, number of complications per patient and Clavien-Dindo classification (CDC) grades. The comprehensive complication index, a tool to report the cumulative burden of postoperative complications on a continuous scale, was calculated per patient based on individual Clavien-Dindo scores [10]. We defined (paralytic) ileus as abdominal distension with the presence of nausea or vomiting and the absence of flatus and stools, requiring at least the cessation of oral intake. Mechanical ileus was a radiological diagnosis.

Finally, we included digestive functional parameters: time to restart oral intake, time to flatus, time to defecation and time to removal of the drain. All kinds of food ingestion, fluid or solid, beyond mere water were accepted as 'intake'. Flatulence was defined as audible bowel movements combined with experienced expulsion of gas, while defecation encompassed all forms of stool production.

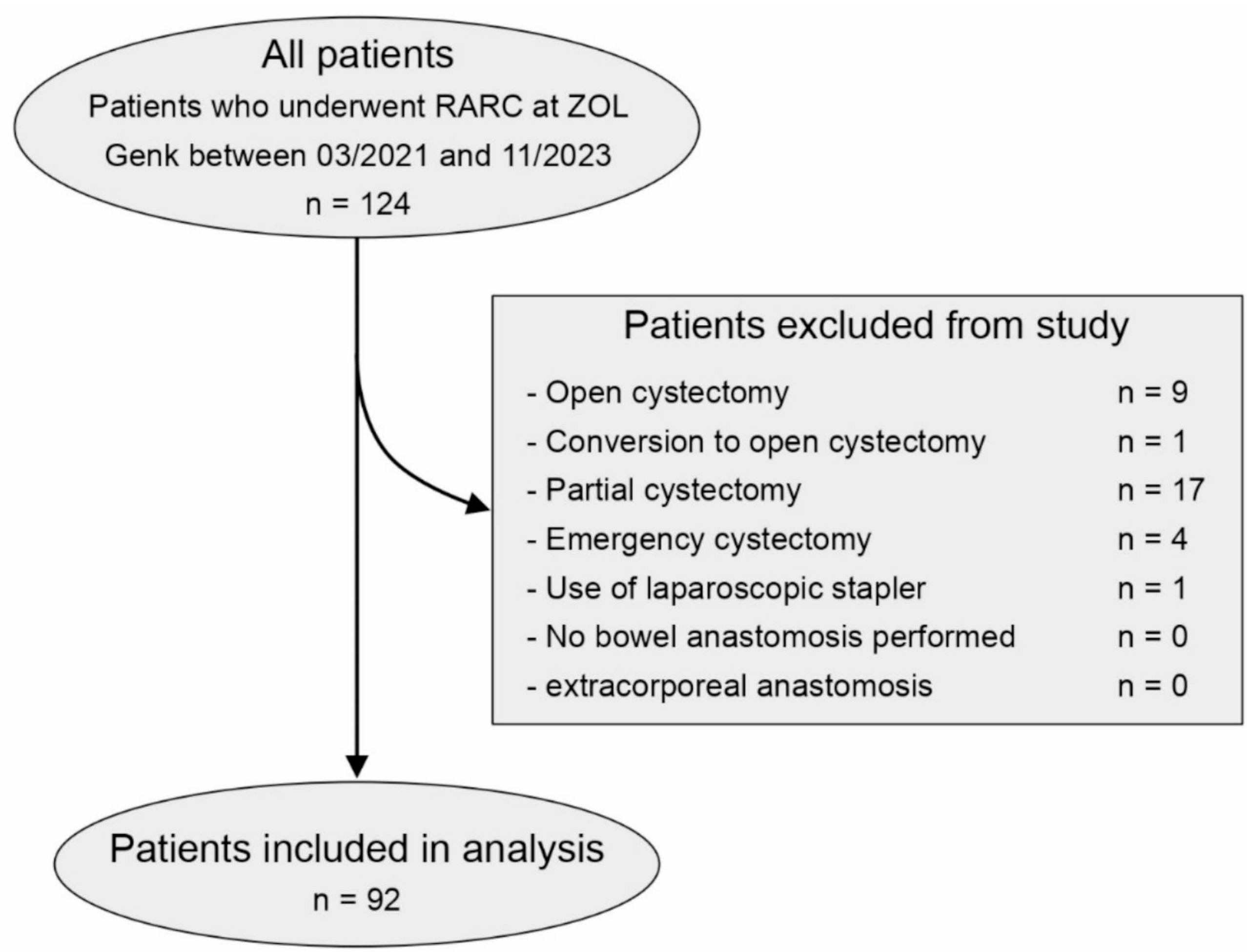

Fig. 1 Flowchart of patient selection

We predefined a limited follow-up of three months after discharge, not expecting relevant bowel-related complications after that period.

Surgical technique

All RARC procedures were carried out by the same high-volume surgeon (>500 robotic cases) in one centre. Having experience with manually sutured bowel anastomoses in open surgery, this surgeon uses both robotic stapling as well as manual suturing in RARC. Initially, the majority of patients underwent stapled anastomosis. However, over time, there was a gradual transition towards manual suturing, with the surgeon increasingly favoring this technique. Eventually, robotic stapling was reserved for specific indications (e.g. for very short ureters or a unique kidney, where a separate uretero-enteral anastomosis is easier), reflecting the surgeon's growing confidence and proficiency in manual suturing during RARC procedures.

Surgery was performed using a four-arm Da Vinci Xi surgical robot setup (Intuitive Surgery) and a 30° camera. Instruments used for dissection were a Maryland bipolar forceps, a ProGrasp forceps and curved scissors. For suturing and handling of bowel tissue a needle driver and either a normal fenestrated bipolar forceps or the Cadiere forceps as well as the ProGrasp were used.

All procedures were performed completely intracorporeally and in a standardized manner, using a 15–20° Trendelenburg position and an abdominal insufflation pressure of 9–12 mmHg. Standard protocol included a single shot of Cefazolin (Clindamycin in case of allergy to Cephalosporin) at the beginning of the operation, which was repeated after 6 h if the operation was still ongoing.

Procedures started with adhesiolysis, distal ureterectomy, clipping and frozen section of the distal ureteric ends. The subsequent steps in chronological order were cysto(prostate)ctomy, bilateral lymph node dissection (LND) if indicated, isolation of the bowel segment, bowel anastomosis and creation of the urinary diversion.

In case of ileal conduit: a 10 cm bowel fragment was isolated, the left ureter was tunneled and both ureters were implanted on the bowel segment using the Wallace plate technique (due to intraoperative factors, in

7 patients, ureters were implanted separately using the classic Bricker technique).

Neobladders were created using the Wiklund technique (modified Studer, 21) and were closed with a Monocryl 3 – 0 running suture. Urethral anastomosis was performed with a 3 – 0 Stratafix suture. In female patients, the specimen was extracted through the vagina, in males at the end of the procedure through an enlarged left trocar incision (muscle splitting). We did not standardly perform an appendectomy.

Ureteric stents were removed three weeks after surgery under a short period of antibiotic cover.

Stapled bowel anastomosis was performed with a robotic stapler (Da Vinci Xi SureForm 60 – Intuitive Surgery) using 2 cartridges for the bowel isolation and two cartridges for the bowel anastomosis, resulting in a total of four cartridges per patient. In the case of a manually sutured anastomosis, bowel and mesentery were cut robotically using cold scissors, after identifying mesenteric blood supply using indocyanin green (ICG). As displayed in Fig. 2, a one-layer bowel anastomosis was then performed end-to-end using two semicircular running Stratafix 3 – 0 15 cm PDS sutures. An additional 'goodnight-stitch' using a Vicryl 3 – 0 suture was used in case of stapled anastomosis, but not in case of manually sutured anastomosis.

Feeding regimen

Enhanced Recovery After Surgery (ERAS) protocols, as described by the ERAS society in 2013, were implemented consistently throughout the preoperative, intraoperative, and postoperative phases [11]. Preoperative bowel preparation was not performed. Postoperatively, the standard of care included removing the gastric tube at extubation, allowing only high-calorie drinks and water for the first 24 h, followed by a soft diet until the patient resumed normal bowel function. The use of opioids was avoided in most cases.

Data extraction

All relevant data was extracted from hospital records using our electronic medical record program HiX (Chipsoft) and was added into an anonymized database. No blinding was performed.

Statistics

Data analysis and visualization were performed using GraphPad Prism v.9 software. For contingency analyses, *p*-values were calculated using Chi-square tests or Fisher's exact tests (if > 20% of the expected values was < 5). For numerical between-group comparisons, data represent median with interquartile range and *p*-values were calculated using non-parametric two-sided Mann-Whitney U tests. Data for BMI and comprehensive complication index are represented as mean ± standard deviation (SD) and *p*-values were calculated using a parametric two-sided Student's t-test.

Results

Demographic results

In total, 92 patients were included in the study. 59 patients underwent a manually sutured bowel anastomosis, the other 33 patients were stapled robotically.

We did an extensive analysis of patient characteristics, comparing both patient groups (Table 1). A graphic representation of the compared parameters is shown in Fig. 3.

There were no statistical differences between the patient groups regarding preoperative characteristics including age ($p = 0.813$), sex ($p = 0.766$), smoking history as defined in pack years ($p = 0.697$), Charlson comorbidity index (CCI; $p = 0.898$), diabetes mellitus type 2 (DM2; $p = 0.398$), vascular disease (both peripheric and coronary; $p = 0.200$), chronic kidney disease (CKD; $p = 0.501$), previous abdominal surgery (including both laparoscopic and open surgery; $p = 0.733$) and neo-adjuvant chemotherapy ($p = 0.686$; Table 1; Fig. 3a, b, d-k).

However, there were small but statistically significant differences in body mass index (BMI) and American Society of Anesthesiologists (ASA) score: patients in the stapled anastomosis group tended to have a higher BMI ($p = 0.029$) and a lower ASA score ($p = 0.030$; Table 1; Fig. 3b, c).

There were no statistical differences in main surgical indications between both groups: bladder cancer (BC; 85 patients; 92.39%; $p = 0.245$), invasive prostate cancer (4 patients; 4.35%; $p > 0.999$) or functional complaints (16 patients; 17.39%; $p = 0.195$; Table 1; Fig. 3l-n). Thirteen patients had multiple indications.

Moreover, pathological T and N staging revealed no differences between the patient groups ($p = 0.717$ and $p = 0.185$ respectively; Table 1; Fig. 3o).

Procedural data

Next, we compared procedural parameters between sutured and stapled patient groups (Table 2).

In total, 83 of 92 cystectomy patients (90.22%) received an ileal conduit as diversion, whereas 9 out of 92 (9.78%) received a neobladder as diversion. Stapled and sutured bowel anastomosis patients underwent the procedure types in comparable proportions ($p > 0.999$).

A larger proportion of the stapled patient group underwent a separate implantation of the ureters on the bowel segment, compared to the sutured group (18.75% and 1.69% respectively; $p = 0.007$). This could be explained by the fact that in a stapled anastomosis the proximal end of the bowel segment is already stapled shut, making it

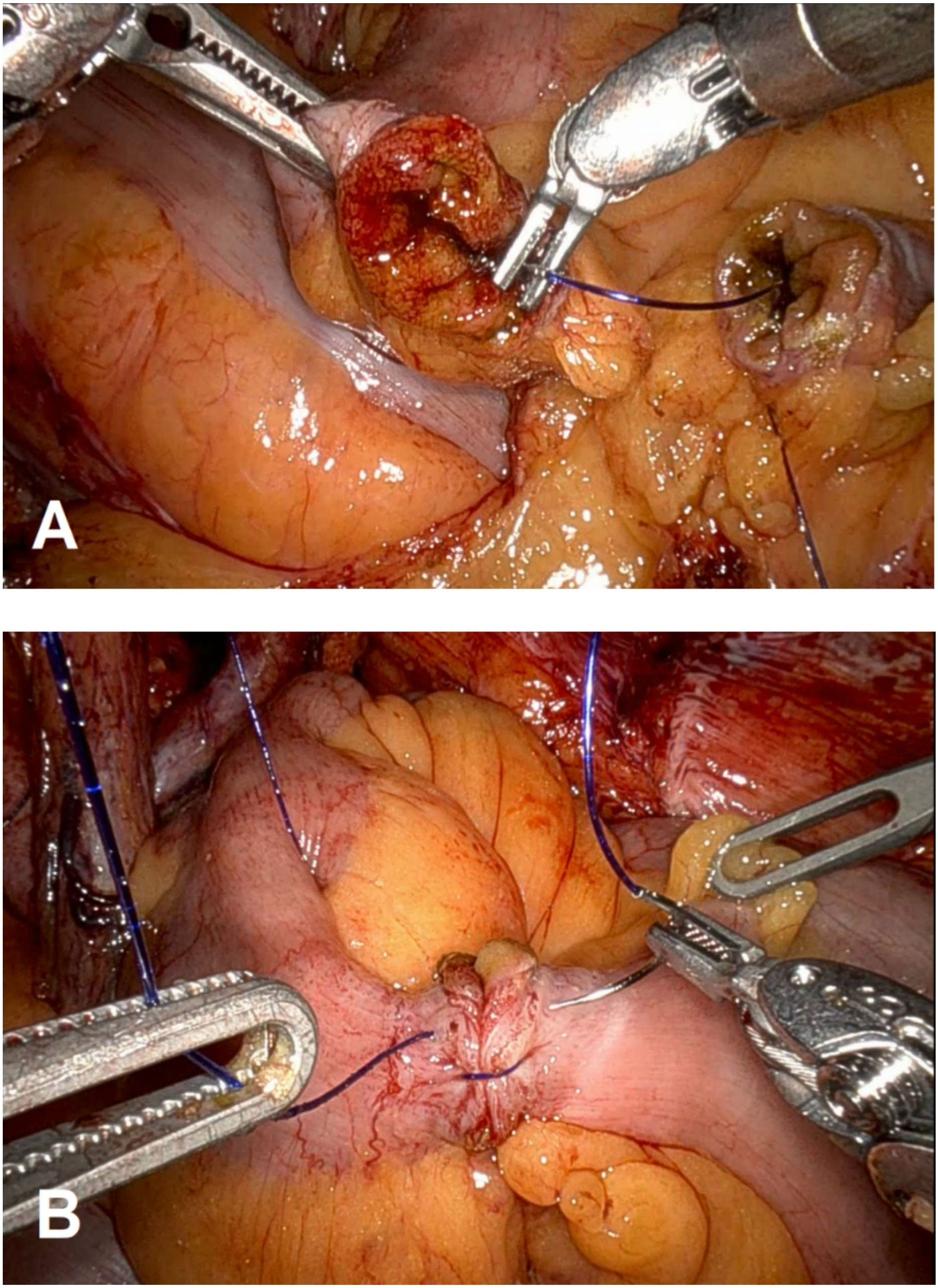

Fig. 2 In-surgery image of a manually sutured anastomosis. Both ends of the bowel are correctly positioned with the help of the third robotic arm. Suturing starts at the posterior wall with the positioning of both Stratafix PDS 3 – 0 sutures (**A**). The two semicircular running sutures ultimately rejoin each other at the anterior wall of the anastomosis and are then knotted to one another (**B**)

Table 1 Patient demographics. For binary data, the number (n) and proportion (%) of patients are listed with the odds ratio and 95% confidence interval (CI). *p*-values were calculated using Chi-square or Fischer's exact tests, as appropriate. Numerical data are listed as median and interquartile range (IQR), and *p*-values were calculated using non-parametric two-sided Mann-Whitney U tests. For BMI, data represent mean ± standard deviation (SD) and the *p*-value was calculated using a parametric two-sided student's t-test. Pathological T- and N-stage (pT and pN) as described in the cystectomy specimen. BMI: body mass index, ASA: American society of anesthesiologists, CCI: Charlson comorbidity score, DM2: diabetes mellitus type 2, CKD: chronic kidney disease, G: grade

	Total	**Sutured**	**Stapled**	**Odds ratio (95% CI)**	***p***
Preoperative characteristics					
Patients, *n* (%)	92 (100.00)	59 (64.13)	33 (35.87)		
Age, median (IQR)	71 (65.25-77)	71 (65–76)	70 (65–77)	—	0.813
Sex, *n* males (%)	74 (80.43)	48 (81.36)	26 (78.79)	1.18 (0.44–3.17)	0.766
BMI, mean (± SD)	26.73 (± 4.49)	25.97 (± 4.20)	28.09 (± 4.73)	—	0.029
ASA, median (IQR)	3 (2–3)	3 (2–3)	2 (2–3)	—	0.030
Pack years, median (IQR)	15 (0–40)	15 (0–35)	11 (0–54)	—	0.697
CCI (IQR)	5 (4–7)	5 (4–7)	5 (4-7.5)	—	0.898
DM2, *n* (%)	18 (19.57)	10 (16.95)	8 (24.24)	0.64 (0.23–1.92)	0.398
Vascular disease, *n* (%)	27 (29.35)	20 (33.90)	7 (21.21)	1.91 (0.75–4.82)	0.200
CKD stage (GFR), *n* (%)					0.501
Stage G1-G2	69 (75.00)	43 (72.88)	26 (78.79)	0.71 (0.28–1.90)	
Stage G3-G5	23 (25.00)	16 (27.12)	7 (21.21)		
Previous abdominal surgery, *n* (%)	48 (52.17)	30 (50.85)	18 (54.55)	0.86 (0.36–2.02)	0.733
Neo-adjuvant chemotherapy, *n* (%)	31 (33.70)	19 (32.20)	12 (36.36)	0.83 (0.33–1.99)	0.686
Indication for cystectomy					
Bladder cancer, *n* (%)	85 (92.39)	56 (94.92)	29 (87.88)	2.58 (0.65–10.64)	0.245
Invasive prostate cancer, *n*(%)	4 (4.35)	3 (5.08)	1 (3.03)	1.71 (0.25–22.89)	> 0.999
Functional, *n* (%)	16 (17.39)	8 (13.56)	8 (24.24)	0.49 (0.17–1.57)	0.195
Pathological stage					
pT, *n* (%)					0.717
Benign	6 (6.52)	3 (5.08)	3 (9.09)	0.54 (0.12–2.42)	
pT0	26 (28.26)	17 (28.81)	9 (27.27)	1.08 (0.44–2.66)	
pTa	3 (3.26)	2 (2.29)	1 (3.03)	1.12 (0.13–16.73)	
pT1	3 (3.26)	1 (1.69)	2 (6.06)	0.27 (0.02–2.40)	
pTis	20 (21.74)	15 (25.42)	5 (15.15)	1.90 (0.62–5.17)	
pT2	13 (14.13)	9 (15.25)	4 (12.12)	1.31 (0.38–4.10)	
pT3	16 (17.39)	10 (16.95)	6 (18.18)	0.92 (0.31–2.93)	
pT4	5 (5.43)	2 (3.39)	3 (9.09)	0.35 (0.06–1.82)	
pN, *n* (%)					0.185
pN0	72 (87.80)	51 (91.07)	21 (80.77)	2.43 (0.68–8.61)	
pN1	3 (3.66)	1 (1.79)	2 (7.69)	0.22 (0.01–1.99)	
pN2	5 (6.10)	3 (5.36)	2 (7.69)	0.68 (0.13–4.04)	
pN3	2 (2.44)	1 (1.79)	1 (3.85)	0.45 (0.02–8.96)	

easier to perform a separate uretero-enteral anastomosis than a Wallace plate.

We performed several additional robot-assisted procedures during the same session as the cystectomy, e.g. two nephroureterectomies and a partial nephrectomy (all in the stapled group), 10 female anterior pelvic exenterations (6 in the sutured and 4 in the stapled group), two perineal urethrectomies (one in each group), one proximal urethrectomy (sutured group), one adrenalectomy (sutured group), one unilateral and one bilateral inguinal hernia correction (one in each group) and two ileocecal resections (one in each group). The proportion of patients undergoing an additional operation was similar in sutured and stapled patient groups (25.42% and 31.25%; $p = 0.552$).

In total, LND was performed in 90.13% of patients, with proportionally more patients undergoing LND in the sutured group compared to the stapled group (94.92% and 78.79% respectively; $p = 0.026$). No differences were observed between sutured and stapled patients regarding nerve sparing ($p = 0.636$) or blood loss ($p = 0.607$). Of note, nerve sparing was always done bilaterally, except in 1 case.

The median operation time for the sutured patient group was 5 h, whereas surgery of the median stapled

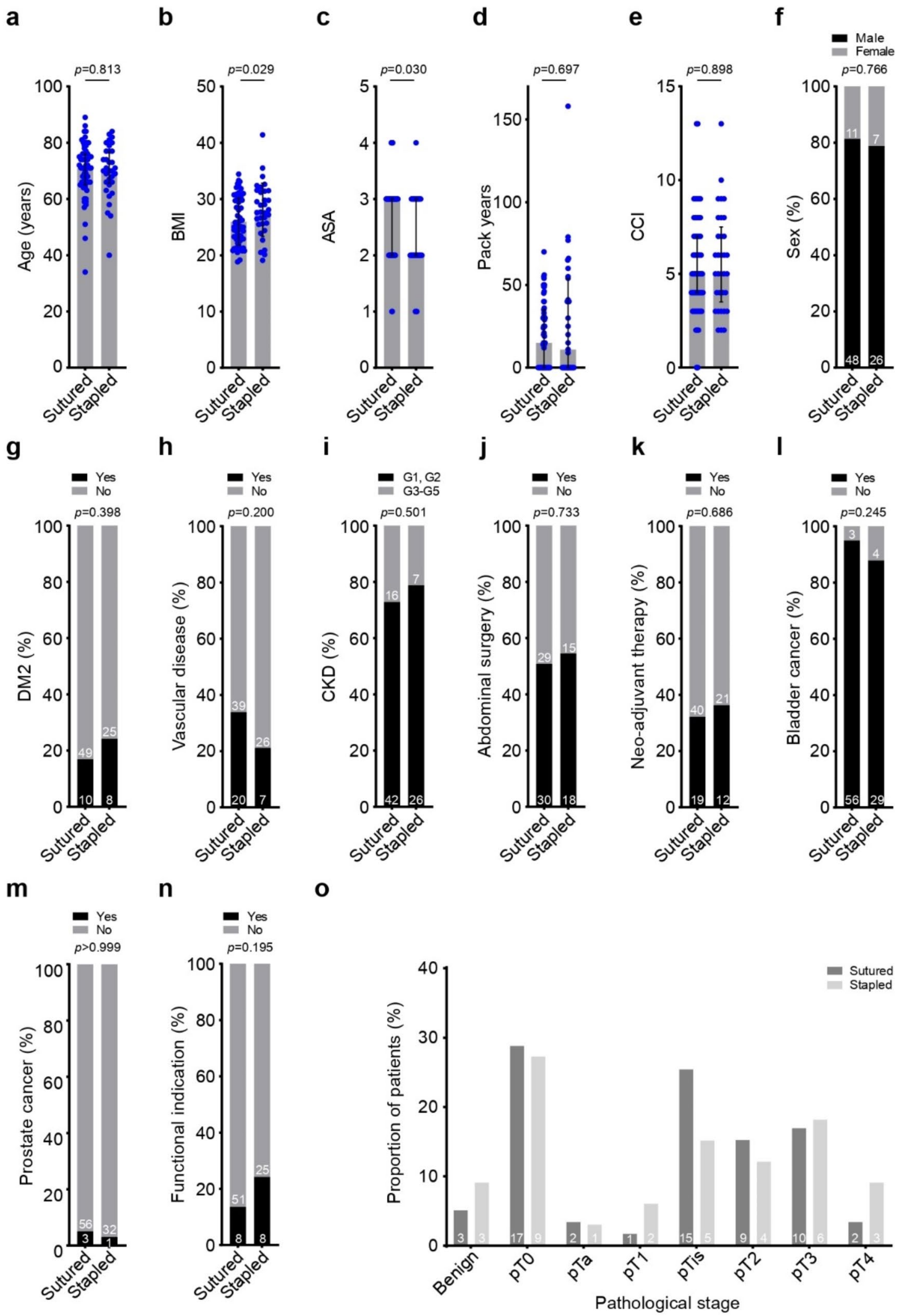

Fig. 3 (See legend on next page.)

(See figure on previous page.)

Fig. 3 Patient demographics. **a-e** Bar graphs of age in years (**a**), body mass index (BMI, **b**), American Society of Anesthesiologists (ASA) score (**c**), smoking pack years (**d**), and Charlson Comorbidity Index (CCI; **e**). For **a**, **c**-**e**, Data represent median ± interquartile range and *p*-values were calculated using non-parametric two-sided Mann-Whitney U tests. For **b**, data represent mean ± standard deviation and the *p*-value was calculated using a parametric two-sided Student's t-test. **f-n** Stacked bar graphs showing proportion of patients per sex (**f**), with or without diabetes mellitus type 2 (DM2; **g**), vascular disease (**h**), chronic kidney disease (CKD; **i**), previous abdominal surgery (**j**), previous neo-adjuvant therapy (**k**), bladder cancer (**l**), prostate cancer (**m**), and benign tumour (**n**). *P*-values were calculated using Chi-square tests (**f**-**k**, **n**) or Fischer's exact tests (**l**, **m**). **o** Grouped bar graph showing proportions of patients (%) per pathological stage. For **f-o**, the numbers in the bars indicate the number of patients

patient took 12.5 min longer. However, this difference is non-significant ($p = 0.124$).

Considering both demographic and procedural data, we concluded both groups to be remarkably comparable and decided against a constriction of our patient numbers by creating a propensity score matching cohort.

Outcome parameters

We compared hospital stay, overall complications, GI complications, GI treatments and GI functional parameters. Statistical and graphical comparisons of these parameters are shown in Table 3; Fig. 4.

The duration of stay did not differ between sutured and stapled patient groups ($p = 0.384$; Table 3; Fig. 4a). Stapled patients were more likely to spend a day at the ICU, but this difference was non-significant ($p = 0.051$). In contrast, sutured patients were readmitted more frequently than stapled patients ($p = 0.022$), whereas the duration of readmission did not differ ($p = 0.654$). Only one readmission was caused by a GI complication (sutured group), whereas the others were caused by non-GI complications such as leakage of the ileo-ureteric anastomosis (3 out of 17 cases) and infectious complications (11 out of 17 cases). Remarkably, 3 patients presented with an urosepsis due to an obstructive urolithiasis (all in the sutured group).

We compared the sutured and stapled patient groups in terms of complications, occurring within a three-month period post surgery (Table 3; Fig. 4). In total the 92 patients had 169 complications. Both the proportion of patients with complications, as well as the number of complications per patient did not differ between sutured and stapled patients ($p = 0.455$ and $p = 0.615$; Table 3; Fig. 4b, c). The highest CDC grade per patient on average was II for both patient groups ($p = 0.217$). Most complications were grade ≤ 2 (55%). Most grade 3 complications were due to dislocation of either the catheter or one of the ureteric stents - or due to paralytic ileus necessitating the reinsertion of a gastric tube. The one patient with a grade 4b complication was hospitalized in the ICU because of a urosepsis with multi-organ failure due to an obstructive urolithiasis (sutured group). The one patient with a grade 4a complication had a cerebrovascular accident (CVA) at home and died afterwards (sutured group).

The grouped bar chart in Fig. 4e illustrates the distribution of CDC scores per patient group. Also, the mean comprehensive complication indices for sutured and stapled patients were similar (22.73 and 21.49 respectively; $p = 0.803$; Table 3; Fig. 4f).

Of the 169 complications, 25 were GI complications, with the proportion of patients displaying GI complications being similar (27.12% of the sutured group, and 21.21% of the stapled group; $p = 0.530$; Table 3 and Figure b). Also, the number of GI complications per patient did not differ between the patient groups ($p = 570$; Table 3; Fig. 4c). In accordance with GI complications, also the proportion of patients undergoing treatments for GI complications did not differ between the patient groups ($p = 0.650$; Table 3). There was also no difference between sutured or stapled patients regarding any of the treatment categories, with the most prevalent ones being gastric tube ($p = 0.715$) and medication ($p = 0.527$).

Of all GI complications, paralytic and mechanic ileus were the most prevalent ones (occurring in 17.39% and 5.43% of patients respectively; Table 3; Fig. 4d). Paralytic ileus was usually treated conservatively or by (re-) insertion of a gastric tube, on average for about three days. Five patients were radiologically diagnosed with a mechanical ileus, for which only one explorative laparotomy had to be performed. This particular instance involved a patient with a manually sutured bowel anastomosis, who, following a standard postoperative recovery and discharge on day 5, returned on day 8 with a blowout of the bowel anastomosis. Subsequent interventions were necessitated, including an open reconstruction of the bowel anastomosis, which unfortunately resulted in a second bowel dehiscence. Notably, this case occurred early in the adoption of sutured bowel anastomosis procedures and was an isolated occurrence, suggesting a potential learning curve challenge. All four other cases of mechanical ileus were managed conservatively.

One patient had recurrent GI bleeding from the bowel anastomosis, which was managed conservatively and resolved spontaneously.

Finally, we compared GI functional parameters including the time to oral intake, flatus, defecation, and removal of the drain (Table 3; Fig. 4g). No difference between the patient groups was detected for any of these parameters (intake: $p = 0.506$, flatus: $p = 0.550$, defecation: $p = 0.898$, drain removal: $p = 0.350$).

We reported a mortality of 3.26% (3 cases) at 3 months postop. None of the deaths were due to a GI complication and all occurred outside of the hospital. 1 Patient (stapled group) died of respiratory septic shock with an

Table 2 Procedural data. For binary data, the number (n) and proportion (%) of patients are listed with the odds ratio and 95% confidence interval (CI). *p*-values were calculated using Chi-square or Fischer's exact tests, as appropriate. Numerical data are listed as median and interquartile range (IQR), and *p*-values were calculated using a non-parametric two-sided Mann-Whitney U test. The LND *p*-value corresponds to the Chi-square test comparing no, limited, normal with extended, superextended. We defined LND patterns to conform to the 2023 EAU MIBC guideline definitions (Sect. 7.3.4) [2]. LND: lymph node dissection

	Total	Sutured	Stapled	Odds ratio (95% CI)	*p*
Operation type, *n* (%)					> 0.999
Bricker	83 (90.22)	53 (89.83)	30 (90.91)	0.88 (0.23–3.30)	
Neobladder	9 (9.78)	6 (10.17)	3 (9.09)		
LND, *n* (%)					0.015
No	10 (10.87)	3 (5.08)	7 (21.21)	0.20 (0.05–0.83)	
Limited	16 (17.39)	11 (18.64)	5 (15.15)	0.78 (0.28–2.36)	
Normal	4 (4.35)	0 (0.00)	4 (12.12)	—	
Extended	60 (65.22)	44 (74.58)	16 (48.48)	0.32 (0.13–0.81)	
Superextended	2 (2.17)	1 (1.69)	1 (3.03)	1.81 (0.09–34.95)	
Nerve sparing, *n* (%)	34 (36.96)	21 (35.59)	13 (40.63)	1.24 (0.53–3.08)	0.636
Ureter anastomosis, *n* (%)					0.007
Wallace plate	84 (92.31)	58 (98.31)	26 (81.25)	13.38 (1.93–155.70)	
Bricker	7 (7.69)	1 (1.69)	6 (18.75)		
Additional operation, *n* (%)	25 (27.47)	15 (25.42)	10 (31.25)	1.33 (0.53–3.35)	0.552
Blood loss, median (IQR)	250 (150–350)	250 (150–350)	225 (150–475)	—	0.607
Operation duration in min, median (IQR)	300 (240–330)	300 (240–315)	313 (247.5-373.8)	—	0.124

underlying COPD stage Gold 4 and another (stapled group) of dyspnea, no invasive measures were undertaken because of rapidly progressive liver metastasis and pleural metastasis, respectively. The reason for the death of the third patient (sutured group) is not documented but occurred after a CVA at home as mentioned above.

Discussion

Background

The increasing use of robotics in urological surgery poses challenges of cost-effectiveness for urologists worldwide. As mentioned by the international robotic cystectomy consortium, the use of intracorporeal urinary diversion in RARC has increased and using this technique could reduce GI complications [10]. The sutured ileo-ileal anastomosis technique is well-known in GI surgery and is considered safe [12–18]. However, an extensive literature search showed that there is almost no recent evidence on this topic. Most studies comparing both techniques are more than 20 years old and only very few are from the era of minimally invasive surgery [12–16]. Comparisons between robot-assisted staplers and robot-assisted manually suturing have been made, but there are almost no studies from the field of urology [17, 18]. We only found three studies reporting on robotically sutured ileo-ileal anastomosis within the urological field: one prospective feasibility study and two retrospective studies, showing no significant short-term disadvantages of using the manually suturing technique, compared to stapling [19–21].

Loertzer et al. in 2018 were first to describe a technique for robotically sutured bowel anastomosis in a prospective series of 48 patients. They found it feasible with a low complication rate [19].

Expanding on these findings, in 2020 Aljabery et al. compared 89 robot-sewn ileo-ileal anastomoses with 66 stapled anastomoses in a single-centre retrospective analysis of RARC patients between 2012 and 2018 [20]. They did not detect significant differences in operative time, median hospital stay and gastro-intestinal complication rate.

In 2023, a similar study conducted by Tulone et al. retrospectively compared double-layered hand-sewn with stapled intestinal anastomosis in 195 patients undergoing radical cystectomy [21]. They found a higher incidence of grade 1 Clavien-Dindo complications in the sutured group for both ileal conduit and neobladder procedures. There were no other significant differences in complication rates or return of bowel function. However, the sutured group showed a shorter length of stay in the ileal conduit subgroup (10 days vs. 13 days, $p < 0.001$) as compared to the stapled group.

Results

We performed a retrospective analysis of all RARC procedures in our center since the start of the robotic cystectomy program in 2021, including 92 patients, of which 59 received a robotically sutured anastomosis and 33 received a robotically stapled anastomosis. Both groups were remarkably similar in demographic and procedural parameters. Demographic, procedural and outcome data were consistent with data found in literature [22–24].

We did not observe any significant difference between sutured and stapled patient groups regarding overall

Table 3 Outcome parameters. For binary data, the number (n) and proportion (%) of patients are listed with the odds ratio and 95% confidence interval (CI). *p*-values were calculated using Chi-square or Fischer's exact tests, as appropriate. Numerical data are listed as median with interquartile range (IQR), and *p*-values were calculated using non-parametric two-sided Mann-Whitney U tests. For the comprehensive complication index, data are listed as mean with standard deviation (SD) and the *p*-value was calculated using a parametric two-sided student's t-test. Complications up to three months post surgery were included. GI: gastro-intestinal, GT: gastric tube. TPN: total parenteral nutrition. ICU: intensive care unit

	Total	Sutured	Stapled	Odds ratio (95% CI)	*p*
Hospitalization					
Length of stay in days, median (IQR)	8 (6-10.75)	7 (6–10)	8 (5.5–13)	—	0.384
ICU stay in days, median (IQR)	1 (0–1)	0 (0–1)	1 (0–1)	—	0.051
Readmission, *n* (%)	17 (18.48)	15 (25.42)	2 (6.06)	5.28 (1.22–24.31)	0.025
Readmission stay in days, median (IQR)	7 (2.5-8)	7 (2–8)	7.5 (7–8)	—	0.654
Complications (all)					
Complications, *n* (%)	169 (100)	109 (64.50)	60 (35.50)		
Patients with complications, *n* (%)	63 (68.48)	42 (71.19)	21 (63.64)	1.41 (0.58–3.31)	0.455
Number of complications per patient, median (IQR)	1 (0–3)	1 (0–3)	1 (0–3)	—	0.615
CDC grade, median (IQR)	II (I-II)	II (I-IIIa)	II (I-II)	—	0.1736
CDC grade per patient, median (IQR)	II (0-IIIa)	II (0-IIIa)	II (0-II)	—	0.217
CDC grade, *n* (%)					
I	36 (39.13)	22 (37.29)	14 (42.42)	0.81 (0.33–2.02)	
II	44 (47.83)	29 (49.15)	15 (45.45)	1.16 (0.49–2.80)	
IIIa	23 (25.00)	18 (30.51)	5 (15.15)	2.46 (0.83–6.56)	
IIIb	6 (6.52)	5 (8.47)	1 (3.03)	2.96 (0.37–35.88)	
IVa	3 (3.26)	1 (1.69)	2 (6.06)	0.27 (0.02–2.40)	
IVb	1 (1.09)	1 (1.69)	0 (0.00)	—	
V	3 (3.26)	1(1.69)	2 (6.06)	0.27 (0.02–2.40	
Comprehensive complication index, mean (± SD)	22.29 (± 22.47)	22.73 (± 20.57)	21.49 (± 25.95)	—	0.803
GI complications					
GI complications, *n* (%)	25 (100)	18 (72.00)	7 (28)	—	
Patients with GI complications, *n* (%)	23 (25.00)	16 (27.12)	7 (21.21)	1.38 (0.51–3.54)	0.530
Complication, *n* (%)					
Peritonitis	1 (1.09)	1 (1.69)	0 (0.00)	—	
Bleeding at anastomosis	1 (1.09)	1 (1.69)	0 (0.00)	—	
Paralytic ileus	16 (17.39)	11 (18.64)	5 (15.15)	1.28 (0.42–3.60)	
Mechanical ileus	5 (5.43)	3 (5.08)	2 (6.06)	0.83 (0.16–4.88)	
Dehiscence	1 (1.09)	1 (1.69)	0 (0.00)	—	
Total blowout	1 (1.09)	1 (1.69)	0 (0.00)	—	
GI treatments					
GI treatments, *n* (%)	31 (100)	22 (70.97)	9 (29.03)		
Patients with GI treatments, *n* (%)	22 (23.91)	15 (25.42)	7 (21.21)	1.27 (0.46–3.26)	0.650
GI treatment					
Gastric tube, *n* (%)	15 (16.30)	9 (15.25)	6 (18.18)	0.81 (0.26–2.65)	0.715
GT reinsertion duration in days, median (IQR)	3 (1-4.25)	3 (1.5–4.75)	3 (0-6.5)		0.729
Medication, *n* (%)	12 (13)	9 (15.25)	3 (9.09)	1.80 (0.51–6.53)	0.527
Explorative laparotomy, *n* (%)	1 (1.09)	1 (1.69)	0 (0.00)	—	> 0.999
TPN, *n* (%)	3 (3.26)	3 (5.08)	0 (0.00)	—	0.550
GI functional outcome parameters					
Time to intake in days, median (IQR)	1 (1–1)	1 (1–2)	1 (1–1)		0.506
Time to flatus in days, median (IQR)	3 (2–4)	3 (2–4)	3 (2–4)	—	0.550
Time to defecation in days, median (IQR)	5 (4–6)	5 (4–6)	5 (4–7)	—	0.898
Time to drain ex in days, median (IQR)	4.5 (3–6)	4 (3–6)	5 (3.25–7.75)	—	0.350

complications, GI-specific complications and GI-specific postoperative course.

As the surgeon, at the outset of this study, had notably less experience with sutured anastomosis compared to stapled anastomosis, a learning curve effect may be expected. This could cause a negative bias towards the sutured anastomosis patient group. In this light, observing comparable outcomes for sutured and stapled

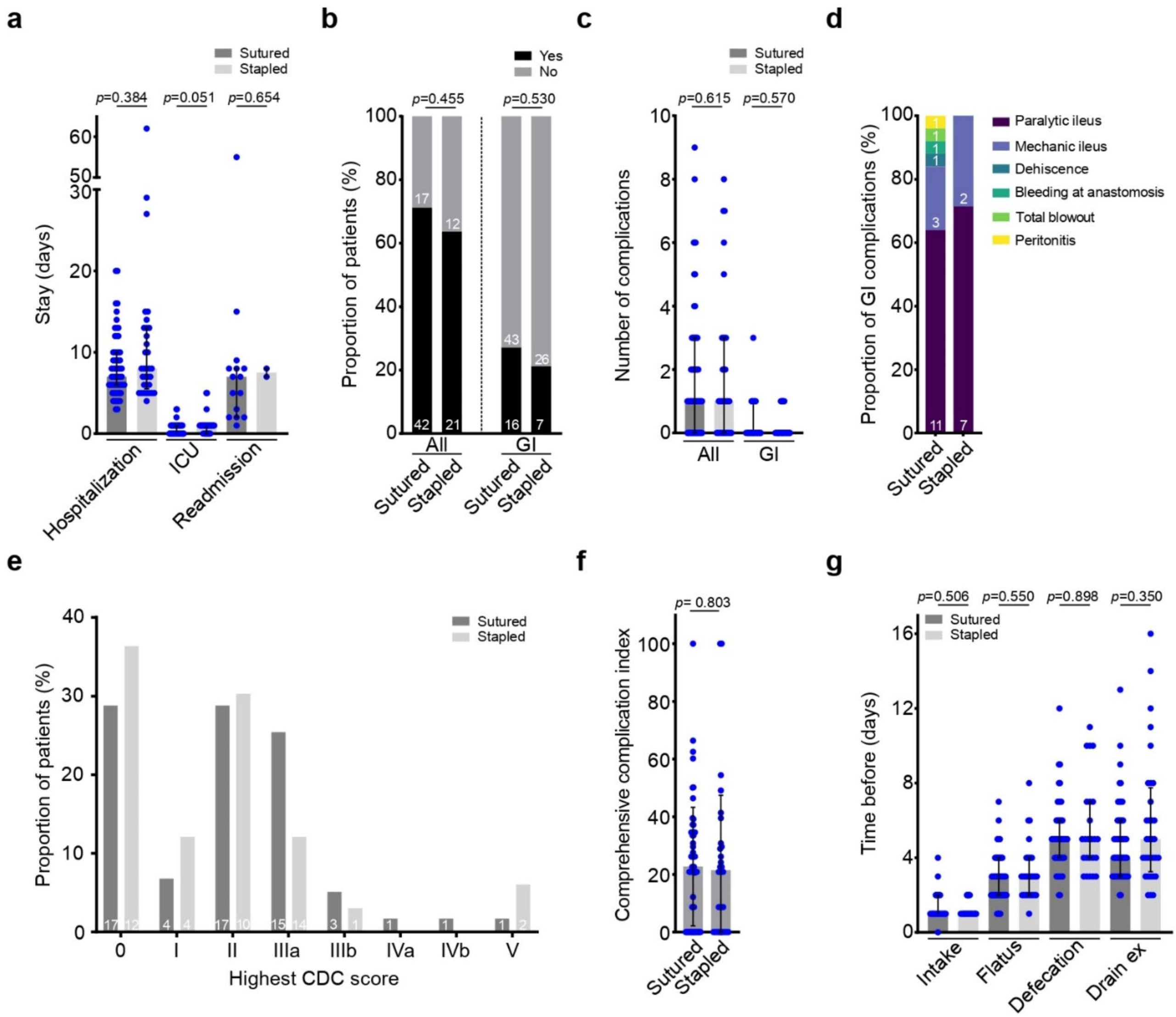

Fig. 4 Outcome parameters. **a** Bar graphs of stays in days. **b** Stacked bar graph showing proportion of patients (%) with complications (all; left), or gastrointestinal complications (GI; right). **c** Bar graph showing the number of total (all; left) and GI (right) complications. **d** Stacked bar graph showing proportions of GI complications (%). **e** Comparative bar graph showing the distribution of the highest Clavien Dindo classification (CDC) scores per patient. **f** Bar graph of comprehensive complication index. **g** Bar graph of time before intake, flatus, defecation and drain removal. For **a**, **c** and **g**, data represent median ± interquartile range, and *p*-values were calculated using non-parametric two-sided Mann-Whitney U tests. For **b**, *p*-values were calculated using Chi-square tests. For **f**, data represent mean ± standard deviation and the *p*-value was calculated using a parametric two-sided Student's t-test. For **b**, **d** and **e**, the numbers in the bars indicate the number of patients. ICU: intensive care unit

patients adds to the notion that the more cost-effective suturing approach constitutes a potent alternative for existing stapling techniques. Additionally, despite this potential learning curve effect, we did observe a slight, albeit non-significant, reduction in total operation duration of about 13 min in the sutured group compared to the stapled patients.

Our findings align well with those from the above-mentioned studies. As was the case in Aljabery's study, we observed a higher readmission rate in the sutured anastomosis group, but this could not be allocated to GI-related complications. We reported a 3.26% mortality rate at 3 months postop, which is consistent with data found in literature [23, 24].

Cost analysis

Robot-assisted staplers used in our department (Da Vinci Sureform 60) cost €252 per cartridge. The stapler (including seal and trocar reducer) costs €492 per procedure. Using 4 cartridges per bowel anastomosis (some surgeons use 3), total cost in our centre amounts to €1500–2000 per procedure, which is comparable to European averages [9]. Although we rarely use laparoscopic staplers, handled by a bedside assistant, we investigated their pricing. At our hospital, a Covidien Endo GIA Ultra cartridge costs about €180–200, and the stapler itself is priced at €400. This results in a total cost per procedure of €1200–1500, which is marginally lower than that of robot-assisted staplers. When comparing to a total material cost of €12,000–16,500 per procedure, stapler-related costs represent a significant part of the total material costs.

By comparison, a manually sutured bowel anastomosis in our centre, using two barbed Stratafix PDS sutures, costs about €54, a factor 30 less than using a robotic stapler [25].

This substantial cost difference between using robotic staplers and manually suturing bowel anastomosis makes a compelling argument in favor of manually suturing techniques.

Limitations

As this study is a single-center retrospective cohort study, it has several inherent limitations such as limited sample size, lack of standardization, lack of external validation, and most importantly a possible selection bias. Factors such as surgeon preference, patient anatomy, or comorbidities may have influenced the choice of anastomosis technique, potentially confounding the results. We tried to compensate for confounding variables by comparing both groups extensively in terms of demographic and procedural data. Another constraint is that patient monitoring was limited to three months post operation.

To mitigate these limitations, future studies could consider larger, multi-center cohorts with propensity score matching or a prospective, randomized controlled trial design.

Conclusion

In conclusion, our study confirms that robotically sutured ileo-ileal anastomosis in robot-assisted radical cystectomy yields comparable outcomes to stapled techniques, with no significant difference in overall complications, GI complications, GI functional outcomes or operation duration. Moreover, a cost analysis reveals a substantial financial advantage in favor of manual suturing, highlighting the importance of considering cost-effectiveness in surgical decision-making.

Abbreviations

ASA	American society of anesthesiologists
BMI	Body mass index
CCI	Charlson comorbidity index
CDC	Clavien-Dindo Classification
CKD	Chronic kidney disease
COPD	Chronic obstructive pulmonary disease
CVA	Cerebrovascular accident
DM2	Diabetes mellitus type II
ERAS	Enhanced recovery after surgery
GI	Gastro-intestinal
GT	Gastric tube
ICG	Indocyanin green
ICU	Intensive care unit
LND	Lymph node dissection
MIBC	Muscle invasive bladder cancer
RARC	Robot-assisted radical cystectomy
TPN	Total parenteral nutrition

Acknowledgements

Not applicable.

Author contributions

The study was conceptualized and the study protocol was written by TH and YR. TH and SM gathered all retrospective data into an extensive database. GS performed all statistical analyses and created relevant figures and tables. The manuscript was written by TH and was then read and corrected by GS, SM and YR. All authors (TH, GS, SM, TDS and YR) read and approved the reviewed and final versions.

Funding

No external funding was received for this study. Publication charges and open access fees were paid via the urology department's third-party funds account, which in turn is privately sponsored by patients and benefactors.

Data availability

The datasets generated and analysed during the current study are not publicly available due to privacy concerns but are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

This study was approved by the Ethical Committee of Ziekenhuis Oost-Limburg (Comité Medische Ethiek ZOL Genk, ID Number Z2024049). As a retrospective, non-interventional study, the requirement for participant informed consent was waived by the committee in accordance with Belgian legislation (Law of 7 May 2004 on human experiments, relevant royal decrees, and the program law).

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Received: 22 June 2024 / Accepted: 27 March 2025
Published online: 11 April 2025

References

1. Gontero P, Compérat E, Masson-Lecomte A et al. Non-muscle-invasive Bladder Cancer (TaT1 and CIS) EAU Guidelines on. 2023.
2. Updated. 2023 EAU guidelines on muscle-invasive and metastatic bladder cancer. Edn. presented at the EAU Annual Congress Milan 2023. ISBN 978-94-92671-19-6.
3. Menon M, Hemal AK, El-Tabey NA, et al. Nerve-sparing robot-assisted radical cystoprostatectomy and urinary diversion. BJU Int. 2003;92(3):232–6. https://doi.org/10.1046/j.1464-410x.2003.04329.x.
4. Chesnut GT, Rentea RM, Leslie SW. Urinary Diversions and Neobladders. StatPearls. 2023 Jul 25. PMID: 32809318.
5. Gaidry AD, Tremblay L, Nakayama D, Ignacio RC. The history of surgical staplers: A combination of Hungarian, Russian, and American innovation. Am. Surg. 2019; 1;85(6):563–566. PMID: 31267894.
6. Teo NZ, Chi J, Ngu Y. A comparison between the Da Vinci Xi endowrist stapler and a conventional laparoscopic stapler in rectal transection: A randomized controlled trial. Int J Med Robot. 2023;19(3):e2501. https://doi.org/10.1002/rcs.2501.
7. Chekan E, Whelan RL. Surgical stapling device-tissue interactions: what surgeons need to know to improve patient outcomes. Medical devices: evidence and research. Med devices (Auckl). 2014 Sep 12:7305–18. https://doi.org/10.2147/MDER.S67338

8. Ho YH, Ashour MA. Techniques for colorectal anastomosis. World J Gastroenterol. 2010;16(13):1610–21. https://doi.org/10.3748/wjg.v16.i13.1610.
9. Licari LC, Bologna E, D'annunzio S, et al. Exploring the applications of indocyanine green in Robot-Assisted urological surgery: A comprehensive review of Fluorescence-Guided techniques. Sensors. 2023;23(12):5497. https://doi.org/10.3390/s23125497.
10. Vetterlein MW, Klemm J, Rink M, et al. Improving estimates of perioperative morbidity after radical cystectomy using the European association of urology quality criteria for standardized reporting and introducing the comprehensive complication index. Eur Urol. 2020;77(1):55–65. https://doi.org/10.1016/j.eururo.2019.08.011.
11. Cerantola Y, et al. Guidelines for perioperative care after radical cystectomy for bladder cancer: enhanced recovery after surgery (ERAS®) society recommendations. Clin Nutr. 2013;32(6):879–87. https://doi.org/10.1016/j.clnu.2013.09.014.
12. Korolija D. The current evidence on stapled versus hand-sewn anastomoses in the digestive tract. Minimally invasive therapy & allied technologies. Minim Invasive Ther Allied Technol. 2008;17(3):151–4. https://doi.org/10.1080/13645700802103423.
13. Cajozzo M, Compagno G, DiTora P, Spallitta SI, Bazan P. Advantages and disadvantages of mechanical vs. manual anastomosis in colorectal surgery. A prospective study. Acta Chir Scand. 1990;156(2):167–9.
14. Catena F, La Donna M, Gagliardi S, Avanzolini A, Taffurelli M. Stapled versus hand-sewn anastomoses in emergency intestinal surgery: results of a prospective randomized study. Surg Today. 2004;34(2):123–6. https://doi.org/10.1007/s00595-003-2678-0.
15. Gonzalez EM, Selas PR, Gonzalez JS, et al. Results of surgery for cancer of the rectum with sphincter conservation. A randomized study on instrumental versus manual anastomosis. Acta Oncol. 1989;28(2):241–4. https://doi.org/10.3109/02841868909111255.
16. Castro P, Marcela V, Antunes, et al. Hand-sewn versus stapler esophagogastric anastomosis after esophageal ressection: systematic review and meta-analysis. Arq Bras Cir Dig. 2014;27(3):216–21. https://doi.org/10.1590/s0102-67202014000300014.
17. Guadagni S, Palmeri M, Minichilli F, et al. Ileo-colic intra-corporeal anastomosis during robotic right colectomy: a systematic literature review and meta-analysis of different techniques. Int J Colorectal Dis. 2021;36(6):1097–110. https://doi.org/10.1007/s00384-021-03850-9.
18. Hur H, Kim JY, Cho YK, Han SU. Technical feasibility of Robot-Sewn anastomosis in robotic surgery for gastric cancer. J Laparoendosc Adv Surg Tech A. 2010;20(8):693–7. https://doi.org/10.1089/lap.2010.0246.
19. Loertzer P, Siemer S, Stöckle M, Ohlmann CH. Robot-sewn Ileoileal anastomosis during robot-assisted cystectomy. World J Urol. 2018;36(7):1079–84. https://doi.org/10.1007/s00345-018-2237-3.
20. Aljabery F, Jancke G, Skoglund P, Hallbook O. Stapled versus robot-sewn ileo-ileal anastomosis during robot-assisted radical cystectomy: a review of outcomes in urinary bladder cancer patients. Scand J Urol. 2021;55(1):41–5. https://doi.org/10.1080/21681805.2020.1843534.
21. Tulone G, Pavan N, Simonato A, et al. Double-Layered Hand-Sewn versus stapled intestinal anastomosis in patients who underwent ileal urinary diversion in radical cystectomy: A comparative and cost effective study. Urol Int. 2023;107(10–12):901–9. https://doi.org/10.1159/000532129.
22. Hussein AA, May PR, Guru KA, et al. Outcomes of intracorporeal urinary diversion after robot-assisted radical cystectomy: results from the international robotic cystectomy consortium. J Urol. 2018;199(5):1302–11. https://doi.org/10.1016/j.juro.2017.12.045.
23. Tyritzis SI, Hosseini A, Wiklund NP, et al. Oncologic, functional, and complications outcomes of robot-assisted radical cystectomy with totally intracorporeal neobladder diversion. Eur Urol. 2013;64(5):734–41. https://doi.org/10.1016/j.eururo.2013.05.050.
24. Clement KD, Pearce E, Aboumarzouk OM, et al. Perioperative outcomes and safety of robotic vs open cystectomy: a systematic review and meta-analysis of 12,640 cases. World J Urol. 2021;39(6):1733–46. https://doi.org/10.1007/s00345-020-03385-8.
25. Mjaess G, Diamand R, Verhoest G, et al. Cost-analysis of robot-assisted radical cystectomy in Europe: A cross-country comparison. Eur J Surg Oncol. 2023;49(8):1511–8. https://doi.org/10.1016/j.ejso.2022.07.023.

Publisher's note