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Robotic left-sided colorectal resection with natural orifice IntraCorporeal anastomosis with extraction of specimen: The NICE procedure. A pilot study of consecutive cases

Ramon O. Minjares-Granillo [a, c], Bertha A. Dimas [a, c], Jean-Paul J. LeFave [a, b, c], Eric M. Haas [a, b, c, *]

[a] Department of Surgery, Division of Minimally Invasive Colon and Rectal Surgery, The University of Texas Medical School at Houston, Houston, TX, USA
[b] Division of Colon and Rectal Surgery, Houston Methodist Hospital, Houston, TX, USA
[c] South East Clinical Research Associates, Inc, Houston, TX, USA

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ABSTRACT

Background: Despite numerous benefits, only a small fraction of laparoscopic left-sided colectomy is accomplished without the need for an abdominal incision to retrieve the specimen and prepare for anastomosis. We report our early experience with a robotic approach using Natural orifice IntraCorporeal anastomosis with Extraction of specimen (NICE) to help overcome the technical limitations and challenges of this approach.

Methods: Twenty consecutive patients presented for elective sigmoid or rectosigmoid resection for benign and malignant disease and underwent the NICE procedure. Safety, feasibility and post-operative outcomes were analyzed.

Results: Intracorporeal anastomosis was accomplished in all patients. One patient required an abdominal incision to extract a bulky tumor. Mean operative time was 222 min (146–344). Mean time to first flatus and length of stay was 23 and 49 h, respectively. All but 4 patients were discharged home on post-operative day 2. One patient was readmitted with a pelvic fluid collection.

Conclusion: Robotic left-sided colorectal resection with NICE procedure is a safe and feasible minimally invasive approach and may facilitate greater adoption rates of this technique.

Introduction

Minimally invasive surgery (MIS) has become a key factor associated with successful implementation of enhanced recovery programs in patients undergoing colorectal procedures.[1] The robotic platform is a minimally invasive approach, which affords enabling technology resulting in more widespread applications for complex colorectal procedures.[2] Such applications include the ability to perform highly skilled intracorporeal techniques and maneuvers that are associated with better patient outcomes.[3]

Prior to robotic surgery for instance, only a handful of highly skilled laparoscopic surgeons have championed advanced minimally invasive techniques such as performing a right-sided and left-sided intracorporeal anastomosis (ICA).[4,5] Despite the many proven benefits including decreased opioid use and shorter LOS,[6–8] it is estimated that less than 10% of laparoscopic procedures are accomplished with formation of right-sided ICA[9] and even fewer for left-sided colorectal procedures.

With the application of robotic surgery however, there has been a surge of enthusiasm and a growth in adoption rates for right-sided ICA. In some studies, as many as 40% of robotic right-sided procedures are accomplished with ICA.[9] There is still however very little attention to robotic left-sided ICA. To date, there has been only two reports in the robotic literature regarding the utilization of natural orifice -assisted techniques to perform a left-sided colorectal resection with ICA and transrectal extraction of the specimen.[10,11] With more advanced technologies now available, the robotic platform may help overcome many of the technical challenges that have limited left-sided ICA and help to foster higher adoption rates than conventional laparoscopic approach and earlier robotic technologies.

We have recently developed a robotic step-wise approach with

* Corresponding author. 6560 Fannin Street, #1404, Houston, TX, 77030, USA.
E-mail address: ehaasmd@houstoncolon.com (E.M. Haas).

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reproducible intracorporeal techniques to complete a left-sided colorectal resection for both benign and malignant diseases with natural orifice-assisted transrectal extraction and formation of an ICA with the complete elimination of any incision other than those required for the ports. We call this the robotic NICE procedure: Natural orifice IntraCorporeal anastomosis and Extraction.

We report our initial experience with the Robotic NICE procedure in a cohort of consecutive patients presenting for elective left-sided colorectal resection for both benign and malignant disease involving the formation of a primary colorectal anastomosis.

Methods

We conducted a retrospective review of a small pilot series with data collected in an IRB approved data base. Consecutive patients who presented for left-sided elective colorectal surgery requiring a sigmoid or rectosigmoid resection for benign or malignant disease from June through August 2018 were included in this study. All patients received informed consent for resection, natural orifice-assisted rectal extraction of the specimen, as well as ICA. Patients presenting with malignancies where locally staged with direct proctoscopic examination and rectal cancer protocol MRI. All patients who met criteria for neoadjuvant chemoradiation therapy were excluded from this analysis. Surgical procedures were performed by a board-certified colorectal surgeon in one of three hospitals located in the Texas Medical Center (Houston Methodist Hospital, Baylor St Luke's Medical Center and The Woman's Hospital of Texas) in Houston, Texas.

Data were collected from clinical and surgical records and entered into an IRB-approved retrospective study with de-identified database. Demographic variables including age, gender, body mass index (BMI) and American Society of Anesthesiologists (ASA) classification were reported. Patient characteristics and operative data including diagnosis, surgical procedure, operative (OR) time, estimated blood loss, type of robotic system utilized, number and size of ports, type of anastomosis, completion of ICA, completion of transrectal extraction of specimen and splenic flexure mobilization were tabulated. Intra-operative complications as well as 30-day post-operative outcomes were assessed including time to first flatus, post-operative length of stay, complications, unexpected ICU admissions, readmissions and reoperations.

All patients were placed on identical perioperative enhanced recovery pathway except for the use of transversus abdominis plane (TAP) blocks with local bupivacaine (LB) that was only available and utilized in the cohort of patients performed at Houston Methodist Hospital. Salient features of the pathway include pre-operative counseling, carbohydrate loading, multimodal pain pathway, early feeding and early ambulation.

NICE technique

For the purposes of this manuscript we will refer to the performance of sigmoid or rectal resection with colorectal anastomosis as left-sided colectomy. All patients underwent a bowel prep including a complete mechanical bowel prep. Intra-operative rectal irrigation was not used. Operations were performed under general endotracheal anesthesia with the patient positioned in modified lithotomy position. The NICE procedure was performed using either the da Vinci Xi or Si robotic platforms (Intuitive Surgical, Sunnyvale, CA, USA). All cases utilized a 5 mm accessory port for the bedside assistant to assist with suction, retraction of tissue and passage of sutures. All cases required a camera port, and two robotic arms for instrumentation (Fig. 1). Based on patient and disease characteristics, some cases required a 4th robotic arm.

Following mobilization and mesenteric dissection, the proximal and distal levels of resection were identified and prepared for resection. For benign cases, the proximal and distal margins of resection were divided using the robotic scissors (Fig. 2). For malignant disease, the bowel was divided using the robotic stapler to ensure closure of the specimen. In order to facilitate transrectal extraction of the specimen and introduction of the anvil, the staple line across the rectal cuff was excised. A sized small Alexis wound retractor (Applied Medical, Rancho Santa Margarita, CA, USA) was then introduced through the rectum (Fig. 3a and b). For malignant cases, we placed the specimen in a 15 mm retrieval bag (Endo Catch II™, Covidien; Mansfield, MA, USA) inserted through the Alexis to prevent any contamination during the extraction process (Fig. 4a, b, 4c). Once the specimen was retrieved, the Alexis retractor was removed, and the circular stapler was inserted to deliver the anvil. A barbed suture of 6-inch length on a v-20 needle (V-Loc 180™, Covidien; Mansfield, MA, USA) was then used to apply a pursestring

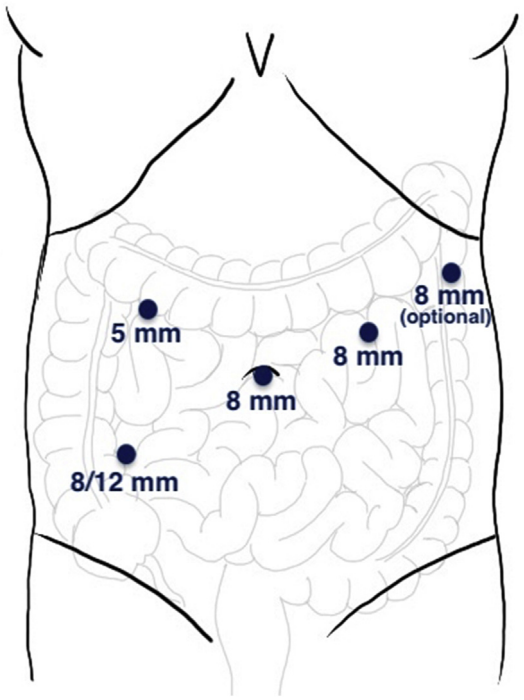

Fig. 1. Port placement.

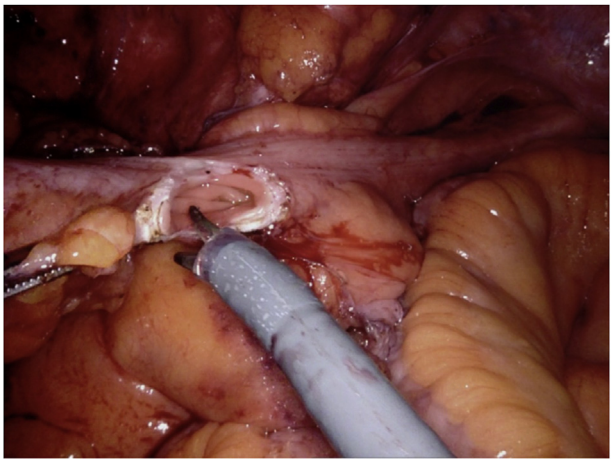

Fig. 2. For benign cases, the bowel was divided using robotic scissors.

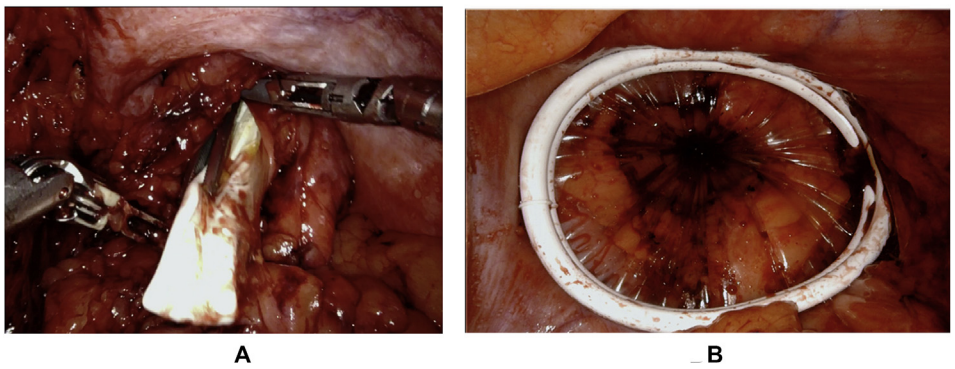

Fig. 3. **a** A wound retractor was introduced through the rectum to facilitate transrectal extraction of the specimen. **b**. Wound retractor in place and fully expanded.

stitch on the proximal bowel to secure the anvil (Fig. 5a and b). In the malignant cases we had to first excise the staple line to facilitate anvil placement. Depending on the characteristic of the rectal stump, it was either stapled or closed with a pursestring suture. After introducing the circular stapler (29 ILS circular stapler, Ethicon; Cincinnati, OH, USA) transanally, the anvil was attached to the head of the device (Fig. 6). An anastomosis was then fashioned.

After the stapled anastomosis was fashioned, both donuts were carefully examined to identify any signs of insufficient engagement of tissue. The anastomosis was thoroughly examined both by external visualization and direct endoscopic visualization. Air-insufflation testing was performed as the final inspection prior to closure. If any suspected defects or weak areas were noted, then primary oversew using interrupted absorbable suture was performed robotically.

NICE results

Demographics and primary characteristics of the study patients are summarized in Table 1. A total of twenty patients (12 females and 8 males) were included in this study with a mean age of 55 (41–68). The two most common indications for surgical resection were colorectal cancer (45%) and diverticulitis (45%). The mean BMI (kg/m^2) was 29 with a range of 21–35. The majority of patients (80%) had an ASA score of II, while 20% had an ASA score of III and there were no classifications of ASA I, IV or V. Approximately one-third of the patients had previously undergone at least one prior abdominal procedure.

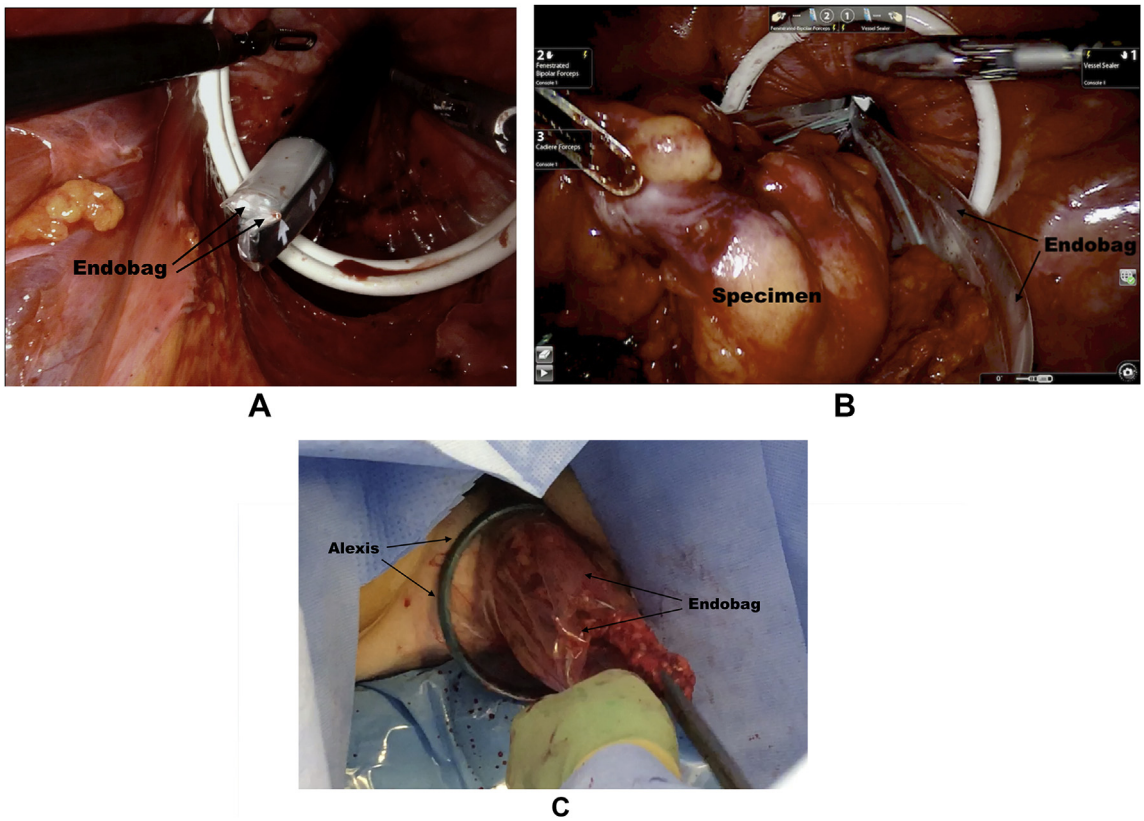

Fig. 4. **a**. A retrieval bag was inserted transrectally through the Alexis. **b**. For malignant cases, the specimen was placed in a retrieval bag to prevent any potential contamination during the extraction process. **c**. After being placed in a retrieval bag, the specimen was removed transrectally through the Alexis.

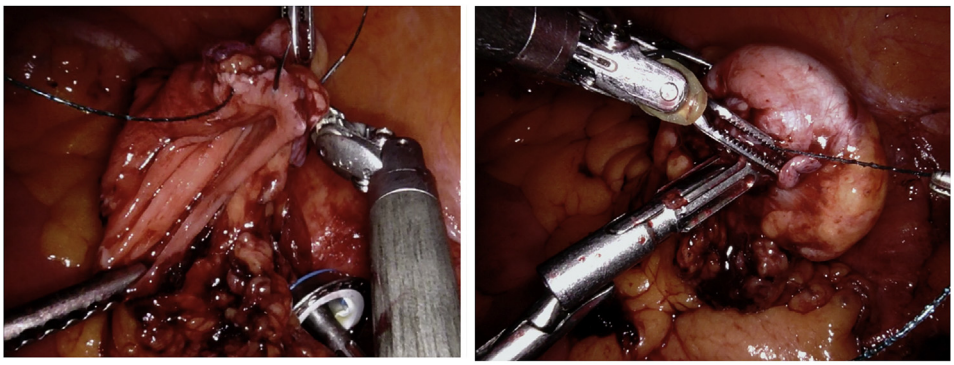

Fig. 5. a. The pursestring suture was placed into the wall of the proximal bowel.**b**. The anvil was secured by tightening the pursestring stitch.

Mean operative (OR) time was 222 ± 66 min with a range 146–344 min (Table 2). The mean OR time was 241 min for malignant disease and 203 min for benign disease. Splenic flexure mobilization was performed in all patients who underwent resection for malignant disease and 80% of patients with benign disease. The mean estimated blood loss was 50 ± 39 ml (range 15–200 ml) and there were no blood transfusions required intraoperatively and no intra-operative complications.

Evaluation of the steps required to complete the transrectal extraction and ICA were analyzed. A colorectal ICA was successfully accomplished in all 20 patients (100%) with 60% in the upper rectum and 10% in the midrectum. A mean of 67 min was required to accomplish these steps which accounted for 27% and 32% of the total OR time for benign and malignant cases, respectively. The anvil was successfully introduced transrectally and secured to the proximal bowel intracorporeally in all cases. In the majority of cases (75%) a pursestring stitch was used to secure the anvil. In the other 25% of cases an endoloop with or without a reinforcing pursestring was used (Table 3).

Natural orifice-assisted transrectal extraction was successfully achieved in all but one case. In that case, a 6 cm incision was made to extract a bulky malignant lesion of the rectosigmoid. In preparation for the anastomosis and following the extraction of the specimen, the rectal stump was stapled in 45% of the patients. In the other 55%, a pursestring suture was placed to close the rectal lumen around the spike of the circular stapler. In one patient air-insufflation test resulted in a positive leak anteriorly which was closed with interrupted sutures and did not require additional revision or diversion. Another patient received an unplanned diverting loop ileostomy following a tedious dissection in the narrow and deep male pelvis (Table 3).

The da Vinci Xi was the robotic platform utilized in the majority of cases (Table 4). All cases required a bedside assist for which a 5 mm accessory port was placed. Just over half (60%) of the cases required 4 robotic arms and 40% of cases required 3 arms. The cumulative mean length of the port incisions was 35 mm with a range of 29–41 mm.

Post-operative outcomes are presented in Table 5. The medium time to first flatus after surgery was 23 h (10–60) with 80% of patients passing flatus on POD 1. None of the patients required insertion of a nasogastric tube or had a post-operative ileus. The mean length of hospital stay was 49 ± 15 h (range 22–94 h) and 75% of patients were discharged home on POD 2 (range 1–4). There was one readmission for a patient who developed a pelvic fluid

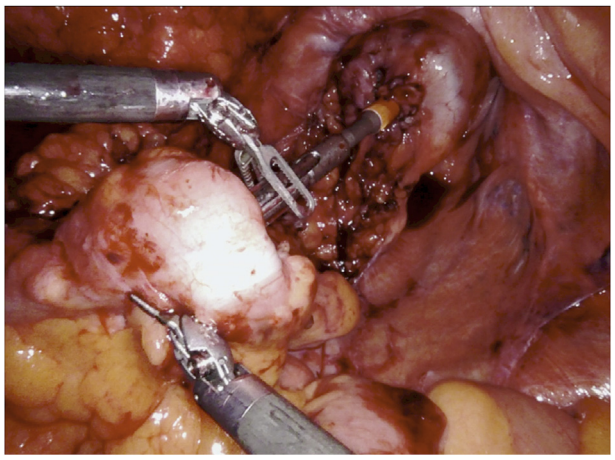

Fig. 6. After introducing the circular stapler transanally the anvil was delivered and attached to the head of the device.

Table 1
Demographic and patient characteristics.

Characteristics	Value (n = 20)
Age, mean (range), years	55 (41–68)
Gender, No. (%)	
Female	12 (60%)
Male	8 (40%)
BMI, mean (range), kg/m^2	29 (21–35)
ASA, No. (%)	
I	0
II	16 (80%)
III	4 (20%)
Previous abdominal surgery, No. (%)	
Upper	3 (15%)
Lower	4 (20%)
None	13 (65%)
Diagnosis, No. (%)	
Diverticulitis	9 (45%)
Colorectal cancer	9 (45%)
Endometriosis, colon lesion	2 (10%)
Location of malignant lesion, No. (%)[a]	
Sigmoid	4 (44%)
Upper rectum	5 (56%)
TNM Stage, No. (%)[a]	
I	5 (55%)
II	2 (22%)
IIIc	1 (11%)
IIIb	1 (11%)
Negative margins (distal, proximal, radial), No. (%)[a]	9 (100%)
Size of lesion, mean (range), cm[a]	4.2 (0.7–9)
Number of lymph nodes extracted, mean (range)[a]	18 (11–29)

[a] Data from patients with malignant disease (n = 9).

Table 2
Operative time.

Variable	Mean (range)
Overall operative time, min (n = 20)	222 (146–344)
Operative time by diagnosis, min	
Colorectal neoplasm (n = 10)	241 (155–344)
Benign disease (n = 10)	203 (146–338)
Total operative time of NICE steps, min	
Colorectal neoplasm	67 (49–103)
Benign disease	66 (37–115)
Percentage of total operative time devoted to NICE steps	
Colorectal neoplasm	32% (20–38)
Benign disease	27% (21–38)

collection consistent with an abscess which was drained with interventional radiology. There were no patients who required transfer to ICU or re-operative intervention. At a mean follow up of 5.8 weeks, there were no sphincter-related complications and no strictures or anastomotic abnormalities identified on endoscopic evaluation of the anastomosis (Fig. 7).

In patients with colon and rectal cancer a mean of 18 lymph nodes (range 11–29) were identified and evaluated. All specimen margins were negative including distal and circumferential margins (Table 1).

Discussion

We present our early experience with robotic Natural-orifice assisted IntraCorporeal anastomosis with rectal Extraction of specimen which we term the NICE procedure. This technique completely eliminates the need for an abdominal wall incision other than those required for the ports themselves. First described as a laparoscopic approach over twenty years ago,[12] multiple reports have cited significant advantages including less pain, shorter length of stay, fewer complications, better cosmesis, and elimination of potential hernia at the extraction site.[13] Yet despite these reported benefits,[6–8,14–16] only a handful of surgeons are known to routinely offer this approach.

With the progression of technologies including the robotic XI platform, robotic stapler and the vessel seal device, there has been renewed interest in completion of an ICA during minimally invasive surgery with a surge of reports and courses.[17] These have focused almost exclusively on right-sided resections with ileocolic anastomosis and on the many benefits of this approach versus extracorporeal anastomosis.[18,19] We theorized that such benefits could be accentuated in left-sided ICA due to the added benefit of complete elimination of the extraction site incision by utilizing natural orifice as a means to extract the specimen and introduce the anvil of the circular stapler. We set to investigate the safety and feasibility of this approach in a pilot of consecutive patients presenting with benign as well as malignant disease as this has yet to be reported in the robotic literature.

Table 3
Intraoperative outcomes.

Outcome	Value (n = 20)
Mean estimated blood loss, mean (range), ml	50 (15–200)
Splenic flexure takedown performed, No. (%)	18 (90%)
Specimen extraction technique, No. (%)	
Transrectal extraction	19 (95%)
Transabdominal mini-incision	1 (5%)
Method of closing rectal cuff, No. (%)	
Stapled	9 (45%)
Purse-string/Endoloop	11 (55%)
Method of securing the anvil, No. (%)	
Purse-string	15 (75%)
Endoloop	1 (5%)
Endoloop plus suture reinforcement	4 (20%)
Primary anastomosis, No. (%)	20 (100%)
Location of anastomosis, No. (%)	
Upper rectum	12 (60%)
Mid rectum	2 (10%)
Low rectum	6 (30%)
Ileostomy creation, No. (%)	1 (5%)
Intraoperative complications	0

Table 4
Robotic characteristics.

Characteristics	Value (n = 20)
Robot version, No. (%)	
da Vinci Si	2 (10%)
da Vinci Xi	18 (90%)
Number of total robotic ports, No. (%)	
Three	8 (40%)
Four	12 (60%)
Total number of 5 mm accessory ports, mean (range)	1 (1–1)
Total cumulative size of port incisions, mean (range), mm	35 (29–41)

The patients in our study were relatively young and healthy and presented mainly with colorectal cancer and diverticulitis. Patients presented consecutively and were only excluded if they had locally advanced rectal cancer as we did not want to investigate in the background of neoadjuvant chemoradiation. One patient in the series required an incision for extraction of a bulky tumor and therefore was not completed with a transrectal extraction. In this case, we felt forcing the specimen through the rectum may result in trauma and therefore modified our approach by making an abdominal wall incision for extraction. We felt it was important to include this case to highlight potential limitations of rectal extraction. One patient underwent a diverting loop ileostomy following a low anastomosis at surgeon discretion. Some authors have suggested that transrectal extraction of specimen should be avoided in those with BMI greater than 30 kg/m^2 due to bulky mesentery,[11,20–22] however we did not exclude any patients based on BMI and did not encounter any sphincter injury or difficulty with the extraction process in the higher BMI patients.

The mean length of the procedures was approximately 40 min longer for malignant disease (241 min) when compared to benign disease (203 min). This can be attributed to the additional time required for oncologic lymph node dissection and deeper pelvic dissection. All but two patients in the cohort underwent a robotic splenic flexure mobilization. These times are similar to those reported by Choi GS (260 min) in his report of robotic cases but nearly 100 min longer than those reported by Franklin ME using purely laparoscopic techniques.[5,10] It has been well documented that robotic platform is associated with longer operative times[23] and is one of the limitations of this approach.

Approximately 30% of the total case time was utilized to perform the various steps of the NICE portions of the procedure. The anvil

Table 5
Postoperative outcomes.

Variable	Value (n = 20)
Length of hospital stay, mean (range), hours	49 (22–94)
Time to first flatus, mean (range), hours	23 (10–60)
Postoperative complications, No. (%)	1 (5%)
Surgical site infection, No. (%)	1 (5%)
Anastomosis leakage	0
Readmissions, No. (%)	1 (5%)
Unexpected ICU admission	0
Reoperations	0
Abnormalities in postoperative evaluation of anastomosis	0

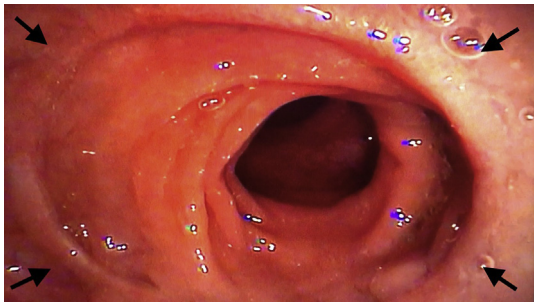

Fig. 7. Flexible sigmoidoscopy showing the area of anastomosis 41 days after surgery (diverticulitis).

was secured to the colon by utilization of a pursestring suture in nearly all cases and was greatly facilitated by the wristed robotic instrumentation. In one case we were able to effectively secure the anvil with an endoloop as first described by Franklin ME et al.[24] but we found that this technique was not reliable as the sole measure in the majority of cases. The open rectal stump was prepared for the anastomosis by either stapling across the tissue or closing it with a pursestring suture. In cases involving the mid or low rectum, we preferred to staple across the tissue and in those involving the upper rectum, we preferred to apply a pursestring suture to avoid the linear staple line during the ensuing circular stapled anastomosis. In nearly all cases we reinforced the anastomosis with interrupted vicryl sutures based on the quality of the anastomosis and stapler donuts. One case had a positive air leak test that resolved with placement of interrupted sutures. On average, 15 min was consumed with placement of these interrupted sutures which was felt to be very feasible using robotic platform.

For both benign and malignant disease, we placed a small Alexis wound retractor through the rectum in preparation for specimen retrieval. The Alexis can be delivered with the aid of a ringed forceps or Kocker and retrieved with gentle traction. We felt the Alexis facilitates atraumatic extraction by providing a uniform stretch to the tissue as well as prevent direct contact to the rectal mucosa of the surgical specimen. For malignant cases, we also placed the specimen in a retrieval bag similar to those described by Park JS and others.[25] The safety of natural orifice rectal extraction of malignant disease has been examined in the laparoscopic NOSE literature and determined to be safe when limited to non-bulky and non-penetrating disease with the use of a retrieval bag.[11,21,26,27] Authors have suggested that tumors greater than 3–5 cm or those without extension to the serosa (T4) are not good candidates for rectal extraction.[11,21,22]

Although limited to a pilot of twenty patients, outcome measures were very favorable in this analysis. The great majority of patients passed flatus on POD 1 or 2. The mean length of stay was 49 h and 75% of patients were discharged home on POD 2. There was one readmission for a patient who developed a pelvic abscess that required image-guided drain placement. None of the patients required ICU stay or re-operative intervention. There were no episodes of superficial surgical site infection, wound seroma or hematoma as would be expected when no extraction incision is required. The mean cumulative length of the port-site incisions was 35 mm which is about half of the length of a typical extraction incision. It stands to reason that laparoscopic literature has reported significantly lower opioid use in comparative studies which translates into earlier return of bowel activity and lower lengths of stay.[28,29]

This study carries limitations that should be addressed. It was designed as a pilot study and therefore the total cohort is relatively low. Additionally, there is no comparison arm to elucidate meaningful comparative outcomes measure such as total opioid consumption and return of bowel function between the groups. Since this was a novel approach for the author, some of the outcomes may be negatively influence by the ease of learning curve associated with these steps such as total length of procedure. The procedures were performed at one medical center by one surgeon and therefore, further investigation with larger cohort, comparison arm, and multiple centers would help overcome many of these stated shortcomings.

Conclusion

The robotic platform can facilitate the successful completion of colorectal resection with Natural orifice IntraCorporeal anastomosis with Extraction of the specimen. We term this the NICE procedure and with further utilization and investigation, the benefits of complete elimination of any abdominal incision other than those required for the ports will be elucidated.

Conflicts of interest

The authors declare no conflicts of interest.

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