

Robotic Transabdominal Specimen Extraction vs Transanal Specimen Extraction for Sigmoid and Upper Rectal Cancer: A Comparative Analysis of Short-term Outcomes

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Abstract

Background

Robotic assistance now holds a well-established place in managing sigmoid colon and upper rectal cancer (SURC). Natural orifice specimen extraction surgery (NOSES) is a highly representative minimally-invasive procedure of colorectal cancer (CRC) surgery. We retrospectively compared perioperative endpoints between robot-assisted NOSES-IV (transanal specimen extraction) and TASE (transabdominal specimen extraction) in patients managed for SURC.

Methods

For 254 patients managed with robot-assisted NOSES-IV or TASE at the First Affiliated Hospital of Jiangxi Medical College, Nanchang University, clinicopathological data were collected retrospectively over the period January 2019 to January 2026. Ninety-one patients received NOSES-IV and 163 received TASE. Following propensity score matching (PSM), 83 patients were yielded per group; and their short-term perioperative outcomes were evaluated.

Results

The initial pathological condition was not significantly different in the two groups. Compared with the TASE group, the NOSES-IV group had shorter digestive tract reconstruction time ($P < 0.001$) and less intraoperative blood loss ($P = 0.022$). Patients in the NOSES-IV group also ambulated ($P = 0.029$), passed flatus ($P = 0.018$), and resumed oral intake earlier ($P = 0.038$). On postoperative days 1, 3, and 5, their C-reactive protein levels were lower ($P = 0.017$); they also had fewer incision-related complications ($P = 0.014$), shorter postoperative hospital stays ($P = 0.034$), and lower VAS (visual analog scale) scores ($P = 0.008$).

Conclusion

Robotic NOSES-IV is a safe and viable surgical option for appropriately screened patients with SURC. It reduces incisional complications and postoperative pain and accelerates recovery.

Background

Among cancers, Colorectal cancer (CRC) comes third in frequency and second in deaths [1]. Recent history has seen an increase in the number of CRC cases in China [2]. It constitutes a grave global health concern. Because early manifestations are frequently nonspecific and bodily vigilance in the general population remains limited, not until the disease has advanced does a sizeable fraction of patients

receive a diagnosis, rendering treatment more challenging. Surgical intervention is the primary treatment method [3].

Within CRC care, robotic surgery has progressively assumed a more consequential operative role [4–6]. The robotic surgical system combines high-resolution three-dimensional visualization with flexible, multi-jointed instrument arms. This configuration lends greater stability to surgical maneuvers and eases resection of diseased tissue within the narrow pelvis. It also improves preservation of nerves, blood vessels, and other critical structures and permits more effective prevention of intraoperative bleeding. Conversion to open surgery becomes less likely, and urinary and sexual function are better protected. These advantages are consequential for surgical success rates, postoperative complications, and rapid patient recovery [7–9].

Natural orifice specimen extraction surgery (NOSES) avoids an additional abdominal wall incision. The absence of such an incision accounts for fewer procedure-related complications and less postoperative pain, with a lower risk of incisional complications; treatment outcomes remain favorable [10, 11], which makes it one of the most active research areas of minimally invasive gastrointestinal surgery [12, 13]. Combining the advantages of NOSES and robotic surgery can therefore deliver more effective treatment and improve prognosis in patients with CRC [14, 15]. In our prior experience, NOSES proved a safe and workable alternative to transabdominal specimen extraction during robotic radical resection of mid-rectal cancer [16].

However, few comparative studies have been conducted on robotic-assisted transanal specimen extraction (NOSES IV) compared with TASE for sigmoid and upper rectal cancer (SURC). We took this as our starting point to conduct the present research to assess the short-term efficacy of these two surgical strategies in SURC patients.

Methods

The present analysis was built on a historical cohort design. We have clinical and pathological data on every person who has undergone complete robotic excision because of sigmoidal and high-rectum cancer at the First Affiliated Hospital of Nanchang University, and the data were recorded between January 2019 and January 2026. The patients that were enrolled were stratified into different groups according to predefined screening rules to be analyzed later. Approval from our center's Institutional Review Board (IRB) was secured for the protocol, which was implemented in strict adherence to the Declaration of Helsinki (IIT [2026] No. 613, IIT20260573). All cases had informed consent obtained prior to the operation.

The following conditions were used to be included: (1) 18–80 years of age; (2) endoscopic biopsy had proved primary sigmoid colon adenocarcinoma or rectal adenocarcinoma; (3) there was no distant metastasis in the preoperative evaluation or intraoperatively; (4) pre - operative imaging and colonoscopy, as well as intra - operative assessment, showed that it was a case of sigmoid colon cancer or upper rectal cancer; (5) The people concerned were fit for surgery and gave their informed consent.

Exclusion was governed by the criteria below: (1) primary colorectal cancer was multiple; (2) recurrence of the colorectal cancer; (3) with other cancers; (4) neoadjuvant chemotherapy in advance; (5) intestinal obstruction, bleeding or any other emergency that requires immediate operation; (6) open surgery; (7) previous history of anorectal surgery; (8) incomplete medical records or no follow-up.

Surgical Techniques

All surgical procedures were performed by a surgical team experienced in high-volume cases of colorectal cancer [16, 17]. The patient position, location, and trocar sites were identical to those in previous studies performed at our center [18]. The NOSES-IV and TASE procedures are similar in terms of isolation of the inferior mesenteric vessels, dissection of group 253 lymph nodes, mesentery resection, and marking of tumor margins, the major difference is in tumor resection and digestive tract reconstruction. The specific procedure was as follows: NOSES-IV group: A small gauze pad soaked in povidone-iodine was placed behind the distal rectum and the distal rectum was disinfected and irrigated thoroughly. The anus gradually dilated to 5–6 fingers. The distal rectum was incised, a povidone-iodine gauze pad was inserted and extracted through the anus, and a protective sleeve was introduced. The tumor-bearing bowel segment was grasped with oval forceps and gently drawn out through the anus within a protective sleeve. Rectal transection was performed along the premarked line above the tumor, followed by insertion of the stapler anvil and return of the bowel to the abdomen through the sleeve. Following removal of the protective sleeve, warm distilled water irrigation of the pelvic cavity was performed, and the distal rectum was closed using a linear cutting stapler. The stapler was then placed transanally for end-to-end anastomosis with the proximal bowel. TASE group: The robot was temporarily withdrawn, and a 6–8 cm incision was made layer by layer through the left lower abdominal rectus abdominis to access the peritoneal cavity. The incision was protected, and the intestinal segment containing the tumor was extracted extracorporeally through the wound. The rectum was cut along the premarked line above the tumor; the anvil of a circular stapler was positioned, and the bowel was subsequently reduced into the abdomen. Layered closure of the auxiliary incision was performed, followed by re-establishment of pneumoperitoneum and reconnection of the robotic system for completion of the end-to-end reconstruction.

Both surgical procedures involve extensive irrigation of the abdominal and pelvic cavities with a significant amount of warm distilled water. It is important to ensure that ascites samples are obtained to be cultured to identify bacteria as well as pathological examination to determine cancerous cells. Insert drainage tubes on both sides of the pelvis, then remove the robot, seal pneumoperitoneum, and close the Trocar ports.

Parameter index

Sex, age, body mass index (BMI) and the score of American Society of Anesthesiologists (ASA) were the main demographic features in the cases. The tumor location, distance to the anus, diameter of the tumor, lymph node dissection, neural invasion, lymph vascular invasion, and TNM staging were all part of

the pathological index. There was also data on surgical parameters, such as time of operation, gastrointestinal surgery (the period between specimen excision and completion of anastomosis), blood loss during surgery. White blood cell (WBC) count and C-reactive protein (CRP) were used to measure the extent of inflammatory reaction after the operation and the first ambulation time, the first anal excretion time, the first feeding time, the visual analog scale (VAS) scores, and the hospitalization time postoperatively were documented. Results of bacterial culture of ascitic fluid and cancer cells in the pathology were monitored. The Clavien-Dindo classification was applied to observed postoperative complications. Anal function at 3 months postoperatively was evaluated using the Wexner incontinence score.

Statistical analysis

SPSS 27.0 served as the analytic platform. To control for confounding arising from baseline characteristics between the trial and control groups, 1:1 propensity score matching (PSM) was implemented. Propensity scores (PS) were generated for each patient through a binary logistic regression model. Matching followed a nearest-neighbor approach without replacement, with the caliper set at 0.05 and a fixed random seed for reproducibility. Postmatching covariate balance was assessed using independent-samples t tests, chi-square tests, and standardized mean differences (SMDs); $P > 0.05$ or $|SMD| < 0.1$ was considered evidence of balanced baseline characteristics between groups. The matched dataset formed the basis for all subsequent efficacy analyses. Normality of quantitative variables was examined with the Kolmogorov-Smirnov test. Normally distributed variables were expressed as mean $\pm$ SD and compared between groups by independent-samples t tests; repeated-measures data were evaluated with repeated-measures ANOVA. Non-normally distributed variables were summarized as M (IQR) and compared by Mann-Whitney U tests; their repeated measures were analyzed with generalized estimating equations (GEE), specifying a gamma distribution and log link. An exchangeable working correlation matrix was specified, and robust estimators were used to calculate standard errors. Fixed effects included group, time, and group $\times$ time interaction. Where the interaction was significant, pairwise comparisons relied on estimated marginal means (EMM). Categorical variables were reported as frequencies and compared by chi-square, Fisher exact, or Wilcoxon rank-sum tests. $P < 0.05$ was considered statistically significant.

Results

Between January 2019 and January 2026, 262 patients who underwent robotic-assisted radical resection for SURC at the First Affiliated Hospital of Nanchang University were enrolled. The group comprised 166 men and 96 women; mean age was 60.38 years and mean BMI 22.82 kg/m². ASA class II was recorded in 33 patients and class III in 229. Among the 262, 2 had preoperative lung metastases, 5 had preoperative liver metastases, and 1 was converted to open surgery intraoperatively. After these 8 patients were excluded, 254 eligible patients remained: 91 in the NOSES-IV group and 163 in the TASE group. Propensity score matching was performed on sex, age, BMI, tumor location, distance from the tumor to the anal verge, tumor diameter, TNM stage, ASA class, preoperative WBC count, and CRP level.

This yielded 83 matched pairs. After confounding was controlled, baseline clinical characteristics were comparable across groups ($P > 0.05$). (Table 1)

Table 1
Baseline characteristics comparison between NOSES-IV and TASE groups after PSM

Variable	NOSES-IV Group (n = 83)	TASE Group (n = 83)	P-value
Sex (n, %)			0.747
Male	52 (62.65%)	54 (65.06%)	
Female	31 (37.35%)	29 (34.94%)	
Age, Mean $\pm$ SD, years	61.46 $\pm$ 10.39	61.67 $\pm$ 11.63	0.899
BMI, Mean $\pm$ SD, kg/m ²	22.86 $\pm$ 2.71	22.67 $\pm$ 3.30	0.683
Tumor Location (n, %)			0.074
Sigmoid colon	26 (31.33%)	16 (19.28%)	
Upper rectum	57 (68.67%)	67 (80.72%)	
Distance from anal verge, M (IQR), cm	13 (7.90)	13 (5.00)	0.282
Tumor diameter, M (IQR), cm	3.50 (2.00)	3.50 (2.00)	0.554
TNM Stage (n, %)			0.871
Stage I	25 (30.12%)	22 (26.51%)	
Stage II	29 (34.94%)	31 (37.35%)	
Stage III	29 (34.94%)	30 (36.14%)	
Preoperative CRP, M (IQR), mg/L	1.86 (2.02)	1.63 (2.65)	0.770
Preoperative WBC, Mean $\pm$ SD, $\times 10^9$ /L	5.69 $\pm$ 1.53	5.64 $\pm$ 1.59	0.824
ASA Grade (n, %)			1.000
Grade II	7 (8.43%)	7 (8.43%)	
Grade III	76 (91.57%)	76 (91.57%)	
Note: ASA, American Society of Anesthesiologists; BMI, Body Mass Index; CRP, C-reactive protein; WBC, white blood cell			

The surgical efficacy measures of the NOSES-IV cohort and TASE cohort are compared in Table 2. The results showed no marked difference in total operative time (130.00 (45.00) min vs. 138.00 (55.00) min, $P = 0.816$) between the two groups; however, the NOSES-IV group had a shorter gastrointestinal

reconstruction time (42.00 (11.00) min vs. 58 (14.00) min, $P < 0.001$) and less intraoperative blood loss (80.00 (50.00) ml vs. 100.00 (100.00) ml, $P = 0.022$) than the TASE group. Regarding postoperative recovery, the NOSES-IV group had earlier times to first ambulation (27.00 (11.00) h vs. 31.00 (12.00) h, $P = 0.029$), first flatus (61.00 (11.00) h vs. 63.00 (14.00) h, $P = 0.018$), and first oral intake (68.00 (12.00) h vs. 72.00 (13.00) h, $P = 0.038$) than the TASE group, and a shorter postoperative hospital stay (8.00 (2.00) d vs. 9.00 (4.00) d, $P = 0.034$).

Table 2 also compared the safety of NOSES-IV and TASE. No bacteria were detected in postoperative peritoneal lavage fluid in either group, or no malignant cells were found in postoperative peritoneal drainage fluid. In the NOSES-IV group, 8 postoperative complications occurred: 5 anastomotic leaks and 3 cases of pneumonia. No intestinal obstruction or incisional complications occurred. In the TASE group, 20 postoperative complications occurred: 7 anastomotic leaks, 1 case of anastomotic bleeding, 4 cases of pneumonia, 1 intestinal obstruction, and 7 incisional complications (3 incisional infections, 3 cases of fat liquefaction, and 1 incisional hematoma; no incisional dehiscence, incisional hernia). The NOSES-IV group had a significantly lower rate of incision-related complications than the TASE group ($P = 0.014$); other postoperative complications showed no significant between-group difference ($P = 0.243$). It should be emphasized that all the above postoperative complications improved after symptomatic clinical treatment, and no deaths occurred in either group.

Table 2
Comparison of perioperative procedural and recovery indicators between NOSES-IV and TASE groups after PSM

Outcome Measure	NOSES-IV Group (n = 83)	TASE Group (n = 83)	P-value
Total operative time, M (IQR), min	130.00 (45.00)	138.00 (55.00)	0.816
Reconstruction time, M (IQR), min	42.00 (11.00)	58.00 (14.00)	< 0.001
Estimated blood loss, M (IQR), mL	80.00 (50.00)	100.00 (100.00)	0.022
Time to first flatus, M (IQR), h	61.00 (11.00)	63.00 (14.00)	0.018
Time to ambulation, M (IQR), h	27.00 (11.00)	31.00 (12.00)	0.029
Time to oral intake, M (IQR), h	68.00 (12.00)	72.00 (13.00)	0.038
Postoperative hospital stay, M (IQR), d	8.00 (2.00)	9.00 (4.00)	0.034
Harvested lymph nodes, n (%)			0.199
≤ 12 nodes	24.00 (28.92%)	17.00 (20.48%)	
> 12 nodes	59.00 (71.08%)	66.00 (79.52%)	
Neural invasion, n (%)	33.00 (37.96%)	37.00 (44.59%)	0.530
Vascular/lymphatic invasion, n (%)	35.00 (42.17%)	38.00 (45.78%)	0.639
Positive surgical margins, n (%)	0	0	
Ascites bacterial culture, n	0	0	
Ascites cytology (malignant cells), n	0	0	
Incision-related complications, n (%)	0	7.00 (8.44%)	0.014
Surgical site infection	0	3.00 (3.61%)	
Fat liquefaction of incision	0	3.00 (3.61%)	
Incisional hematoma	0	1.00 (1.20%)	
Incisional hernia	0	0	
Wound dehiscence	0	0	
Other postoperative complications, n (%)	8.00 (9.64%)	13.00 (15.66%)	0.243
Anastomotic leak	5.00 (6.02%)	7.00 (8.43%)	
Anastomotic bleeding	0	1.00 (1.20%)	
Pulmonary infection	3.00 (3.61%)	4.00 (4.82%)	

Outcome Measure	NOSES-IV Group (n = 83)	TASE Group (n = 83)	P-value
Intestinal obstruction	0	1.00 (1.20%)	
Clavien-Dindo grade $\geq$ 3 complications (n)	0	0	

Table 3 contrasts postoperative inflammatory and pain measures between the NOSES-IV and TASE arms. Across postoperative days 1, 3, and 5, WBC counts remained statistically comparable between arms ($P = 0.100$). CRP levels ($P = 0.017$) and VAS scores ($P = 0.008$), however, were lower in the NOSES-IV arm.

Table 3
Comparison of postoperative inflammation levels and pain intensity between NOSES-IV and TASE groups after PSM

Outcome Measure	NOSES-IV Group (n = 83)	TASE Group (n = 83)	P-value
Postoperative CRP, M (IQR), mg/L			0.017
Day 1	28.09 (17.55)	39.98 (28.98)	
Day 3	61.60 (37.87)	81.01 (46.22)	
Day 5	30.43 (18.74)	40.95 (50.97)	
Postoperative WBC count, M (IQR), $\times 10^9/L$			0.100
Day 1	7.28 (2.05)	7.43 (2.70)	
Day 3	8.32 (2.57)	8.75 (3.29)	
Day 5	6.03 (1.98)	6.38 (2.87)	
VAS Score, M (IQR)			0.008
Day 1	2.00 (1.00)	3.00 (1.00)	
Day 3	2.00 (1.00)	2.00 (1.00)	
Day 5	1.00 (1.00)	2.00 (1.00)	
Note: Day 1, first day after surgery; Day 3, third day after surgery; Day 5, fifth day after surgery.			

Table 4 reveals a negligible difference in anal function recovery between the two study cohorts at the three-month postoperative assessment interval.

Table 4
Comparison of Wexner scores between NOSES-IV and TASE groups after PSM

Type of incontinence	NOSES-IV Group (n = 83)	TASE Group (n = 83)	P-value
Solid	1 (0–2)	0 (0–2)	0.683
Liquid	1 (0–2)	1 (0–2)	0.791
Gas	1 (0–2)	1 (0–2)	0.624
Wears pad	1 (0–1)	0 (0–1)	0.512
Lifestyle alteration	1 (0–2)	1 (0–1)	0.587
Total score	4 (2–7)	3 (2–6)	0.548

Discussion

At present, robotic surgery holds an irreplaceable position in CRC surgery, compared with conventional laparoscopic surgery, it can be performed more safely and efficiently [19, 20]. NOSES has advanced minimally invasive gastrointestinal surgery in meaningful ways, yet further evolution and more varied clinical use appear probable [21, 22]. Robotic NOSES-IV is an emerging approach for SURC. The anatomy here—a redundant mesentery, a high tumor, a roomy abdominal cavity—fits the technique naturally, and that anatomical redundancy can be turned into an operation without an abdominal incision. This study tests whether robotic NOSES-IV is non-inferior to robotic TASE in short-term outcomes.

The comparison of the research data showed that there was a great difference in various clinical indicators between the NOSES-IV and TASE cohorts. The incision length is one of the fundamental and intuitive measures of the extent of surgical minimal invasiveness, and it has a positive relationship with postoperative pain [23]. According to the initial idea of NOSES-IV where the tumor lesion is removed by extraction via anus, this method of surgery does not require any accessory incisions on the abdominal wall thus maintaining its integrity, does not require transecting small blood vessels and prevents intraoperative wound bleeding and contamination. This also prevents prolonged noxious stimuli due to damage of structures like muscles, fascia and nerves. Gastrointestinal reconstruction can be achieved within the abdomen cavity of the patient with the aid of flexibility, stability, precision and clarity of robotic surgical system. Therefore, the smaller incision of NOSES-IV as compared to the TASE procedure provides the basis of less postoperative pain, fewer analgesics usage, and fewer complications, including wound infection, incisional hernia, and fat liquefaction.

Intraoperative blood loss and operative time are the primary indicators of surgical quality. The NOSES-IV group had less intraoperative blood loss, which can be explained by the better maneuverability of the robotic system in mesenteric dissection, vessel skeletonization and ligation, lymphadenectomy, and nerve preservation within the limited pelvic space [24], as well as the anatomy of SURC helped, and so did the absence of an abdominal assist incision. Compared with TASE, NOSES-IV group required less time to reestablish the digestive tract, but the total operating time was similar between the two groups.

Although NOSES-IV makes intestinal anastomosis more efficient, it takes longer time for transanal specimen extraction and robotic-arm docking. CRP registers surgical trauma and systemic inflammation with considerable sensitivity [25]. On postoperative day 1, 3 and 5, CRP levels were lower in NOSES-IV cohort than that in TASE cohort, probably because of smaller incision and less blood loss in NOSES-IV cohort, leading to less release of inflammatory mediators; minimally invasive manipulation leads to milder pain reaction and stress level [26]. Previous studies have confirmed that higher postsurgical CRP concentrations accompany a greater risk of disease recurrence in CRC patients [27, 28], which may indicate that patients in NOSES-IV group have better prognosis, that said, our study did not examine this question, and it still requires extensive verification in future studies. Lack of significant difference in postoperative leukocyte count between the two cohorts might be related to the delayed leukocyte response and the effect of different factors.

Regarding the postoperative recovery, in the NOSES-IV group, it is possible to observe that the first ambulation time, the time of first flatus and the time of the first food intake are less than the first ones, while no significant delay in the recovery of anorectal function at 3 months postoperatively. This means that the NOSES-IV procedure does not cause a higher injury of the anus or any other part of the intestine, but this fact is indirectly shown by the fact that the specimen can be obtained through the transanal canal. Simultaneously, due to its better maintenance of the abdominal cavity and lesser intra-abdominal loss of fluids and temperature during surgery, it has less adverse effects on the intra-abdominal conditions and hence contributes to the quicker restoration of the gastrointestinal tract. It was found that when the incision of the abdomen is shorter, the passage of the first flatus is more likely to occur [29], as the patients of the NOSES-IV group do not suffer so much after the operation, they may tolerate the post-operative period easier and even start walking sooner, which will contribute to the process of the return of the gastrointestinal movement and digestion.

Finally, attention was focused on the safety of the surgery. The occurrence of postoperative complications indicates an unfavorable oncological prognosis [30]. NOSES-IV group has less complication rates related to incision than TASE group and this is not associated with the increase in other postoperative complications which is good news. Also, the results of ascites bacterial culture and pathological test were negative across both arms, the two populations were comparable in terms of pelvic lymph node dissection and positive surgical margins were not reported.

Certain limitations inherent in this study should be acknowledged, such as selection bias inherent to retrospective cohort studies and the number of patients is small in one center, these factors make the results less convincing. Thus, we also wish that more centers will work together closely to carry out this project, and now we are carrying out prospective studies on robotic NOSES-IV and TASE.

Conclusion

In conclusion, provided that bowel–mesenteric length, tumor size and stage, anal function, patient metabolic status, and intraoperative eversion feasibility are suitable, robotic NOSES-IV achieves better

short-term postoperative outcomes than robotic TASE: shorter incisions, less blood loss, milder pain response, and a lower incidence of incision-related complications. These advantages facilitate earlier postoperative recovery. Robotic NOSES-IV is a security and operability mini-invasive technique, and we hope that with the progress of times and technology and more clinical studies, this technique will be further developed and promoted to benefit more colorectal cancer patients.

Abbreviations

ASA American Society of Anesthesiologists

BMI Body Mass Index

CRC Colorectal Cancer

CRP C Reactive Protein

NOSES-IV Natural Orifice Specimen Extraction Surgery

TASE Transabdominal Specimen Extraction

VAS Visual Analog Scale

WBC White Blood Cell

Declarations

Conflicts of Interest: No author has any relevant competing interests to declare.

Author Contributions: Tai-yuan Li and Shan-ping Ye conceived the study. Data collection and analysis were conducted by A-long Luo, Tai-yuan Li, Fang zheng Min, Jin-yi Zuo and Yong Zou. Shan-ping Ye and A-long Luo wrote the first draft, Tao Yu and Shan-ping Ye revised manuscript.

Ethics approval: The project was conducted under the principles set out in the Declaration of Helsinki, with approval granted by the Ethics Review Committee of the First Affiliated Hospital of Nanchang University (IIT [2026] No. 613, IIT20260573).

Consent to participate: Written informed consent was provided by every case.

Consent to publish: Not applicable.

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