Am J Transl Res 2022;14(7):5098-5106
www.ajtr.org /ISSN:1943-8141/AJTR0142546

Original Article

Influence of transvaginal laparoscopic surgery on sexual function, life quality and short-term efficacy of patients diagnosed with colorectal cancer

Wei Zheng[1], Mingguang Zhang[2], Xiyue Hu[2], Wei Tan[2], Shen Liu[2], Jing Ren[2], Yan Liu[1]

[1]*Department of Thoracic Surgery, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China;* [2]*Department of Colorectal Surgery, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China*

Received February 25, 2022; Accepted May 17, 2022; Epub July 15, 2022; Published July 30, 2022

Abstract: Objective: To analyze the effect of transvaginal specimen removal on sexual function, life quality and short-term efficacy of patients diagnosed with colorectal cancer. Method: We retrospectively analyzed the clinical data of 100 patients with colorectal cancer treated in the Cancer Hospital Chinese Academy of Medical Sciences from September 2017 to December 2019. Among them, 52 patients who underwent transvaginal laparoscopic mid-to-high rectal cancer radical resection without assisted abdominal incision who were chosen as the observation group, and 48 patients with conventional laparoscopic-assisted mid-to-high rectal cancer radical resection were set as the control group. Intraoperative blood loss, number of lymph nodes retrieved, operation time, time of urinary catheter removal, drainage tube removal time and postoperative hospital stay were recorded and compared between the two groups. During the process, the Visual Analogue Scale (VAS) was used to assess the pain status of both groups of patients 24 hours after the operation, and the Female Sexual Function Index was used to evaluate the sexual function quality of patients before and 3 months after surgery. Postoperative complications, 2-year survival rate and 6-month postoperative quality of life of both groups of patients were evaluated and compared. Results: In comparison with the control group, the amount of intraoperative blood loss, catheter removal time, drainage tube removal time, and length of postoperative hospital stay were significantly reduced in the observation group, while the number of lymph nodes retrieved was significantly greater. The VAS score 24 hours after operation was lower in the observation group compared with the control group, with statistical significance. There was no significant difference in postoperative sexual function and complication rates between the two groups. However, the 2-year survival rate and the quality of life 6 months after surgery were comparatively higher in the observation group. Conclusion: Natural orifice specimen extraction surgery (NOSES) is effective for transvaginal specimen removal of patients with colorectal cancer, and can significantly improve the prognosis and life quality of patients without affecting their sexual function, with a high safety profile, which is worthy of clinical promotion.

Keywords: Transvaginal specimen retrieval, laparoscopy, colorectal cancer, sexual function, quality of life, short-term efficacy

Introduction

Colorectal cancer, a common digestive tract malignancy, ranks third in cancer incidence and second in mortality worldwide according to GLOBOCAN 2018 [1]. According to the guidelines of colorectal cancer diagnosis and treatment promoted at home and abroad, the best way to treat colorectal cancer is radical resection [2]. However, traditional laparotomy, both in terms of trauma and postoperative recovery, will cause great secondary damage to patients, causing negative impacts on patients' quality of life [3]. Recently, with the continuous development of medical science and technology, laparoscopic surgery has become a promising trend in colorectal cancer treatment due to its obvious minimally invasive effect and good oncological efficacy, which has been widely carried out in clinical practice, but auxiliary incision is still required to obtain specimens [4, 5].

With the improvement of clinical surgical techniques, natural orifice specimen extraction sur-

gery (NOSES) has gradually been applied in clinical practice due to the advantages of less postoperative pain and faster recovery, which skillfully combines the "no incision" concept of natural orifice endoscopic surgery and the operating skills of laparoscopic techniques [6, 7]. In addition, it can avoid complications such as incision tumor implantation, abdominal incision infection, and incisional hernia caused by conventional laparoscopic surgery [8]. However, the procedure of transvaginal specimen collection requires incision of the posterior vaginal fornix, which has only been used in clinical practice for a few years. Whether it will increase the postoperative complications and affect the postoperative sexual function of patients is rarely reported at home and abroad [9]. In particular, doctors are concerned about the possible after-effects of surgery and women's postoperative sexual disorders.

To further seek more appropriate treatment options for colorectal cancer, a retrospective research was conducted on the data of colorectal cancer patients who underwent laparoscopic transvaginal surgery to explore the effects of natural abdominal specimen removal through vaginal incision on the short-term efficacy, prognosis, sexual function and life quality of patients.

Methods

Clinical information

We retrospectively analyzed the data of 100 patients with colorectal cancer admitted to the Cancer Hospital Chinese Academy of Medical Sciences from September 2017 to December 2019. Among them, 52 patients who underwent laparoscopic mid-to-high rectal cancer radical resection through the vagina without auxiliary incision were chosen as the observation group, and 48 patients who underwent conventional laparoscopic-assisted mid-to-high rectal cancer radical resection were selected as the control group.

Inclusion criteria: (1) patients who were pathologically confirmed with mid-to-high rectal cancer and colon cancer by colonoscopy with the tumor ≥5 cm away from the anal verge; (2) patients with chest and abdomen CT to exclude distant metastases to organs such as liver and lung; (3) patients who underwent laparoscopic rectal cancer radical surgery in our hospital; (4) patients who had no history of abdominal surgery and had not undergone neoadjuvant therapy; (5) patients with complete case data.

Exclusion criteria: (1) patients with multiple primary colorectal cancer; (2) patients with anemia, leukopenia, thrombocytopenia or hypoalbuminemia; (3) patients with uncontrolled diabetes; (4) patients with immune system diseases, connective tissue diseases or blood system diseases; (5) patients with other malignant tumors.

All patients agreed to participate in the study and signed the informed consent statement. This study was approved by the Ethics Committee of Cancer Hospital Chinese Academy of Medical Sciences (18-015/1617) and was conducted in compliance with the Declaration of Helsinki.

Surgical methods

After general anesthesia, the patient received routine catheterization and disinfection in a supine position. The five-hole method was then used: a 10 mm arc incision above the umbilicus was made as the observation hole. In addition, a 12 mm Trocar was punctured at 2 cm medial to the right anterior superior iliac spine as the main operation hole, a 5 mm Trocar was punctured at the right anterior axillary line 5 cm above the navel as an auxiliary operation hole, and a 5 mm Trocar was punctured at the left anti-McBurney point as an assistant auxiliary operation hole. The assistant's main Trocar (5 mm Trocar) was located at the left side of upper umbilical level adjacent to the lateral edge of the rectus abdominis.

(1) The observation group underwent laparoscopic radical resection of middle-to-high rectal cancer with transvaginal specimen extraction. Briefly, inferior mesenteric artery and vein were ligated and transected at root, the lymphatic and fatty tissue were dissected, and the rectum was dissected according to the principle of total mesorectal excision (TME). Then, the sigmoid mesentery was dissected about 15 cm above the upper edge of the tumor, and the mesorectum was dissected 5 cm below the lower edge of the tumor. The protective sleeve was inserted into the pelvic cavity through the main trocar. For high rectal cancer, after vagi-

nal disinfection, the surgeon made a 3 cm transverse incision at posterior vaginal fornix with an ultrasonic scalpel. Oval forceps were inserted through the vagina to pull the distal end of the protective sleeve out of the body. Subsequently, the anvil was introduced into the abdominal cavity through the protective sleeve. A small longitudinal incision was made in the bowel wall between the tumor and the proximal intended resection line. The anvil was introduced into the proximal sigmoid colon lumen and the proximal bowel was transected with a linear stapler. After that, the isolated bowel below the tumor was transected with another linear stapler. So far, the rectal tumor and the intestinal segment were completely transected. The specimen was then placed into the protective sleeve, and another assistant applied the oval forceps to clamp the specimen in the protective sleeve. The protective sleeve was tightened and slowly pulled out along with the specimen. The connecting rod of the anvil was taken out from the corner of the proximal sigmoid stump, and a circular stapler was inserted into the anus to perform end-to-end anastomosis. The posterior vaginal fornix was sutured by double-layer continuous suture with absorbable sutures. For the middle rectal cancer, the distal end of rectum was transected with a linear stapler at the pre-cut line about 5 cm from the lower edge of the tumor. Following vaginal disinfection, the posterior vaginal fornix was opened, and the distal end of protective sleeve was pulled out of the body through vagina. The specimen was then placed in the protective sleeve as the assistant clamped the rectal stump with the oval forceps through the vagina and pulled the stump out of the body. The purse-string forceps were applied extra-corporeally at the intended resection line of the sigmoid colon, and then the bowel was transected. The stapler anvil was introduced into the sigmoid colon stump and secured with a purse-string suture. After returning the sigmoid colon back to the pelvic cavity, a circular stapler was inserted trans-anally, followed by sigmoid-rectal end-to-end anastomosis.

(2) The control group underwent laparoscopic radical resection of sigmoid colon or rectal cancer. The exposed mesorectal canal was cut at 5 cm from the lower border of the tumor. A longitudinal incision with a length of 5-6 cm in the midline of the abdomen was cut, and an incision protective sleeve was inserted into the abdomen layer by layer to lift the tumor and the connected intestinal segment to the outside of the abdominal wall. About 15 cm from the upper edge of the tumor, the intestine was separated, and the bowel tube was cut off. The specimen was excised en bloc, and a stapler was placed at the stump of the sigmoid colon under direct vision. After the reconstruction of pneumoperitoneum, a circular stapler was placed in the anus, and end-to-end sigmoid anastomosis was performed. Subsequently, the abdominal cavity was washed, drainage was placed, and the abdomen was closed layer by layer.

Postoperatively, all patients were given antibiotics to prevent infection and parenteral nutrition support. After the recovery of exhaust and defecation, they gradually returned to normal diet, and the drainage tube was removed.

Outcome measures

(1) The intraoperative blood loss, number of lymph nodes retrieved, and operation time of both groups were recorded and compared. (2) The time of postoperative recovery of exhaust, time to eating, and postoperative length of hospital stay were recorded and compared. (3) The Visual Analogue Scale (VAS) [10] was used to evaluate the pain of patients before and 24 hours after operation. (4) The Female Sexual Function Index, which includes sexual arousal, orgasm, libido, and sexual life satisfaction (patients and their spouses), was applied to assess the quality of sexual function of patients before and 3 months after the operation [11], with higher score indicating higher quality of sexual function. (5) The postoperative complications of both groups were evaluated and compared, including anastomotic leakage, incision infection, incisional hernia and abdominal hemorrhage. (6) The 2-year survival rate of both groups were recorded and compared. All patients were followed up regularly by returning to the hospital for re-examination, telephone follow-up, text message follow-up, and door-to-door follow-up. The deadline end of study was the death of the patient or December 31, 2021. (7) The EORTC Core Quality of Life questionnaire (QLQ-C30) [12] was used to evaluate patients' life quality after 6 months of treatment. The scale includes 5 items of physical

Table 1. General information [n (%)]

Factors	Observation Group n=52	Control Group n=48	t/X^2	P
Age (years old)			0.010	0.921
≤60	33 (63.46)	30 (62.50)		
>60	19 (36.54)	18 (37.50)		
BMI (kg/m^2)			0.031	0.860
≤23	28 (53.85)	25 (52.08)		
>23	24 (46.15)	23 (47.92)		
History of smoking			0.004	0.948
YES	30 (57.69)	28 (58.33)		
NO	22 (42.31)	20 (41.67)		
Clinical stage			0.002	0.961
Stage I	29 (55.77)	27 (56.25)		
Stage II	23 (44.23)	21 (43.75)		
ASA classification			0.025	0.988
Level 1	17 (32.69)	15 (31.25)		
Level 2	15 (28.85)	14 (29.17)		
Level 3	20 (38.46)	19 (39.58)		
Tumor distance from the anal verge (cm)			0.001	0.974
≤10	28 (53.85)	26 (54.17)		
>10	24 (46.15)	22 (45.83)		

Table 2. Comparison of intraoperative blood loss, anal exhaust time and hospital stay between two groups of patients

Items	Observation Group n=52	Control Group n=48	t	P
Intraoperative blood loss (ml)	85±1.26	100±3.22	38.91	<0.001
Number of lymph nodes retrieved	26±1.18	19±2.41	34.23	<0.001
Operation time (min)	203±0.65	204±1.54	0.743	0.459

function, emotional function, role function, social function and cognitive function, with higher score indicating better life quality.

Statistical methods

Data analysis and image rendering were performed by SPSS 18.0 (IBM) and GraphPad Prism 8 software, respectively. Enumeration data were analyzed with the chi-square test, and measurement data of two groups were compared using the independent t test. Survival analysis was performed by the log-rank test, and the survival curve was drawn using the Kaplan-Meier method. P<0.05 indicated that the difference was statistically significant.

Results

Comparison of general information

There was no significant difference in general information such as age and smoking history between the two groups (P>0.05). **Table 1**.

Comparison of intraoperative blood loss, number of lymph nodes retrieved and operation time between two groups

As compared to control group, the intraoperative blood loss in the observation group was lower, and the number of lymph nodes retrieved was greater (P<0.05). No significant difference was found in terms of operation time between the two groups (P>0.05), as indicated in **Table 2**.

Comparison of postoperative recovery of exhaust, time to eat, and length of postoperative hospital stay between the two groups

The postoperative recovery of exhaust, time to eat, and length of postoperative hospital stay were found to be significantly shorter in the

Table 3. Comparison of postoperative exhaust recovery, eating time and postoperative hospitalization days between the two groups

Items	Observation Group n=52	Control Group n=48	t	P
Time of postoperative exhaust recovery (h)	7.15±0.76	11.23±0.86	25.18	<0.001
Eating time (h)	7.02±1.15	10.05±1.18	13.00	<0.001
Length of hospital stay (d)	9.24±0.65	12.35±1.54	18.58	<0.001

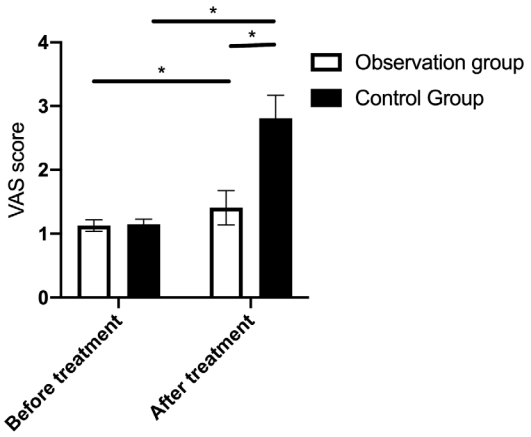

Figure 1. Comparison of VAS scores between the two groups at 24 hours after surgery. Note: * indicates P<0.05.

observation group compared with the control group (P<0.05), as shown in **Table 3**.

Comparison of VAS scores 24 hours after operation between two groups

There was no significant difference in VAS scores between the two groups before surgery (P>0.05). The VAS score of patients in the observation group 24 hours after operation was 1.41±0.27, while that in the control group was 2.81±0.36, with a significant difference between the two groups (P<0.05), as shown in **Figure 1**.

Comparison of sexual function between two groups before and 1, 2, and 3 months after surgery

Before surgery, no significant difference was observed in scores of libido, sexual life satisfaction and sexual function quality between the two groups (P>0.05). One month after surgery, the above indexes of the observation group decreased significantly and then gradually recovered to the preoperative level. While the Female Sexual Function Index in the control group presented no fluctuations at 1, 2, and 3 months after operation (P>0.05, **Figure 2**).

Comparison of incidence of complications during hospitalization

The number of patients with anastomotic leakage, incision infection, incisional hernia and abdominal hemorrhage in the observation group were 2, 1, 0, and 1 respectively, and the complication rate was 7.69%; while those of the control group were 3, 1, 1, and 1, respectively, with a complication rate of 12.50%. The two groups showed no significant difference in the incidence of short-term complications (P> 0.05). **Table 4**.

Comparison of 2-year tumor-free survival rate and 2-year survival rate

The 2-year overall survival rate of patients was 86.54% (45/52) in the observation group and 70.83% (34/48) in the control group, with a significant difference between the two groups (P<0.05), as presented in **Figure 3**.

Comparison of life quality 6 months after treatment between the two groups

Compared with the control group, the scores of physical, role, emotion, cognition and social dimensions of patients' life quality in the observation group improved significantly after treatment (P<0.05), as presented in **Table 5**.

Discussion

With the change of social environment and living habits in recent years, the incidence of colorectal cancer is getting higher and higher, which poses a serious threat to human life and health [13]. Surgical resection is commonly used to treat colorectal cancer, of which traditional laparotomy for colorectal cancer is accompanied by multiple complications with a radical resection rate of only about 50%, which

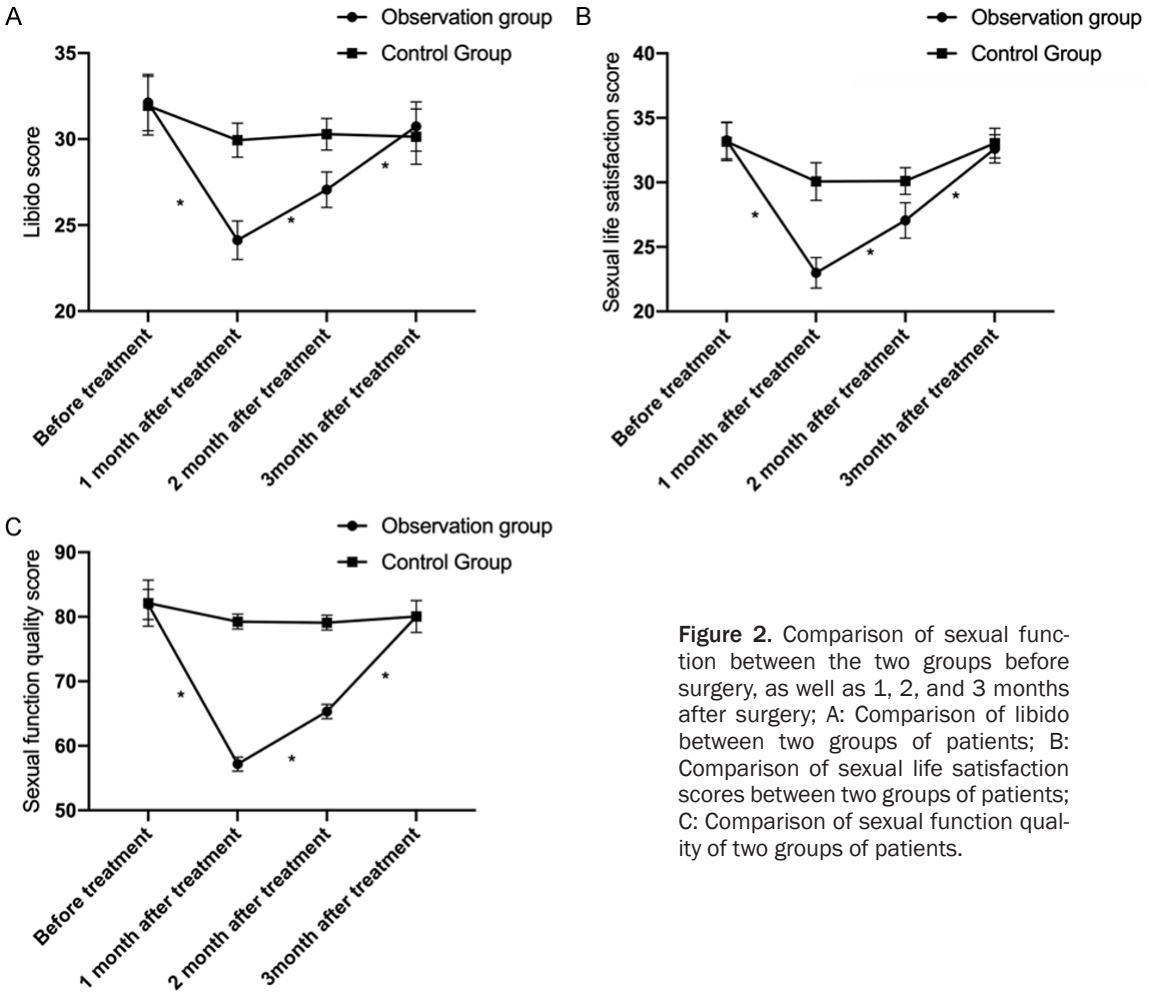

Figure 2. Comparison of sexual function between the two groups before surgery, as well as 1, 2, and 3 months after surgery; A: Comparison of libido between two groups of patients; B: Comparison of sexual life satisfaction scores between two groups of patients; C: Comparison of sexual function quality of two groups of patients.

Table 4. Comparison of the incidence of adverse reactions between the two groups [n (%)]

Complication	Observation Group n=52	Control Group n=48	X^2	P
Anastomotic leakage	2 (3.85)	3 (6.25)	-	-
Incision infection	1 (1.92)	1 (2.08)	-	-
Incisional hernia	0	1 (2.08)	-	-
Abdominal bleeding	1 (1.92)	1 (2.08)	-	-
Complication rate	4 (7.69)	6 (12.50)	0.641	0.423

is difficult to meet clinical needs [14]. Since the application of laparoscopic technique in some low colorectal cancers for sphincter-preserving surgery which showed encouraging clinical results, a wealth of studies have indicated that laparoscopic colorectal cancer radical resection is in line with the principle of a radical tumor cure [15]. Although traditional laparoscopic surgery has made a great improvement over traditional open surgery, the resection of the focal tissue still has surgical trauma and prolongs abdominal incision [16].

NOSES is a novel surgical approach in the minimally invasive treatment of colorectal cancer, which further promotes the development of laparoscopic colorectal surgery [17]. Studies have revealed that NOSES can not only reduce postoperative abdominal scars and abdominal wall dysfunction, but also promote postoperative recovery [18]. In the present study, we found from the comparative evaluation of surgical conditions that the number of lymph nodes retrieved in the observation group was significantly greater than that in the control

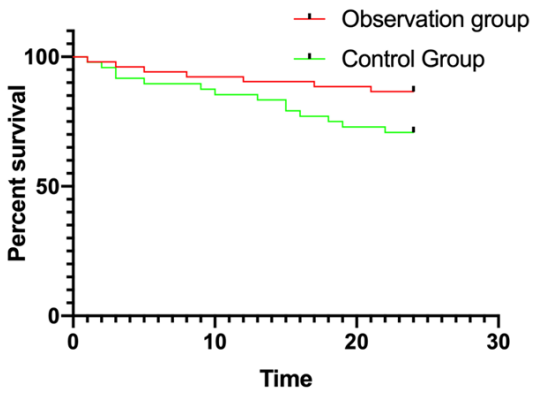

Figure 3. Comparison of the 2-year survival rates between two groups of patients. * indicates P<0.05.

group. Moreover, the intraoperative blood loss, postoperative recovery of exhaust, postoperative time to eat, and length of postoperative hospital stay in the observation group patients were significantly lower than those in the control group, suggesting that NOSES not only had better curative effects, but also contributed to faster postoperative recovery of patients. Subsequently, we further compared postoperative pain between the two groups and found that it was significantly relieved in the observation group, which indicated that NOSES caused less pain to patients than traditional laparoscopy. However, some studies have pointed out that although the NOSES technique has been widely used in clinical practice with good results, it will inevitably cause changes in the vaginal structure due to its special specimen collection method that requires incision of posterior fornix of the vagina [19, 20]. Therefore, its impact on female vaginal function and sexual function was regarded as the focus of present study. To further analyze the influence of NOSES on patients, we compared the sexual function between the two groups before and after operation, and the results showed that although the short-term sexual function of patients in the observation group was affected to a certain extent, it returned to the preoperative level 3 months after operation, suggesting that NOSES, compared with conventional laparoscopic-assisted surgery, will not increase the risk of sexual dysfunction although it is performed through an auxiliary incision in the vagina rather than the abdomen. The authors believe that although the vaginal fornix is incised for NOSES, the blood supply of the posterior vaginal wall is good with no tension after double-layer continuous suture and well-healed. Moreover, one-time operation does not affect the dilatability of the vagina. Therefore, transvaginal specimen collection is safe and feasible and less likely to affect sexual function. Consistent with our observations, past studies have also found no adverse effects on sexual function in patients who underwent natural-orifice specimen extraction [21, 22].

Then we compared the complication rate between the two groups and found that the incidence of complications in both groups was low without significant difference. Analyzing the reasons, both traditional laparoscopic colorectal cancer radical resection and NOSES surgery have the characteristics of small surgical trauma and high safety, with little impact on organ function. In particular, the NOSES procedure can uses natural orifice to remove the colorectal specimens, avoiding auxiliary abdominal incision and reducing nerve injury caused by abdominal wall incision, which conforms to the surgical concept and relatively reduces the incidence of complications [23, 24]. Moreover, we compared the prognosis between two groups and found that the 2-year survival rate as well as patients' quality of life 6 months after surgery were significantly higher in the observation group, suggesting that NOSES could effectively enhance life quality and survival rate, as well as the prognosis of patients.

To sum up, the application of NOSES in colorectal cancer has a good clinical effect and can significantly improve the prognosis and life quality of patients with little side effects on their sexual function and it has high safety, which is worthy of clinical promotion. However, this study still has certain limitations. First, the present study is a single-center clinical data analysis, and the sample size is relatively small. Related research on colorectal cancer surgery through natural orifice still needs multi-center and large-scale clinical validation. Second, this study is a retrospective analysis with relatively short follow-up time, and certain limitations existed in analyzing patients' postoperative survival. We will further conduct multiple clinical trials with large samples in future research and extend the follow-up time in order to obtain more convincing data.

Disclosure of conflict of interest

None.

Table 5. Comparison of quality of life between two groups

Factors	Observation Group n=52	Control Group n=48	t	P
Physical function	72.75±2.06	62±2.35	18.79	<0.001
Role function	73.44±2.17	60.81±2.54	32.76	<0.001
Emotional function	73.66±2.29	60.46±2.61	23.48	<0.001
Cognitive function	73.59±2.05	61.09±2.43	22.09	<0.001
Social function	73.26±2.38	61.28±1.97	20.42	<0.001

Address correspondence to: Yan Liu, Department of Thoracic Surgery, National Cancer Center/National Clinical Research Center for Cancer/Cancer Hospital, Chinese Academy of Medical Sciences and Peking Union Medical College, Beijing 100021, China. Tel: +86-010-87787152; E-mail: liuyan@cicams.ac.cn

References

[1] Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA and Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. CA Cancer J Clin 2018; 68: 394-424.

[2] Sheng S, Zhao T and Wang X. Comparison of robot-assisted surgery, laparoscopic-assisted surgery, and open surgery for the treatment of colorectal cancer: a network meta-analysis. Medicine (Baltimore) 2018; 97: e11817.

[3] Devoto L, Celentano V, Cohen R, Khan J and Chand M. Colorectal cancer surgery in the very elderly patient: a systematic review of laparoscopic versus open colorectal resection. Int J Colorectal Dis 2017; 32: 1237-1242.

[4] Miyanari S, Ueno Y, Hirano T, Otani K, Simomura F, Taga S and Yano K. Strategies of treatment for obstructive colorectal cancer and compared with non-obstructive cancer. Gan To Kagaku Ryoho 2020; 47: 2338-2340.

[5] Khalilov ZB, Kalinichenko AY, Azimov RK, Chinikov MA, Panteleeva IS and Kurbanov FS. Minimally invasive surgery for colorectal cancer in advanced age patients. Khirurgiia (Mosk) 2018; 76-81.

[6] Giglio MC, Luglio G, Sollazzo V, Liccardo F, Peltrini R, Sacco M, Spiezio G, Amato B, De Palma GD and Bucci L. Cancer recurrence following conversion during laparoscopic colorectal resections: a meta-analysis. Aging Clin Exp Res 2017; 29: 115-120.

[7] Wang S, Tang J, Sun W, Yao H and Li Z. The natural orifice specimen extraction surgery compared with conventional laparoscopy for colorectal cancer: a meta-analysis of efficacy and long-term oncological outcomes. Int J Surg 2022; 97: 106196.

[8] Zhang H, Hu H, Huang R, Guan Z, Zheng M, Xu C, Li Z, Wang Y, Zhang W, Yu L, Jin Y, Tang Q, Wang G and Wang X. Natural orifice specimen extraction surgery versus conventional laparoscopic-assisted resection for colorectal cancer in elderly patients: a propensity-score matching study. Updates Surg 2021; 13: 2247-2257.

[9] Masubuchi S, Okuda J, Yamamoto M, Inoue Y, Tanaka K and Uchiyama K. Natural orifice specimen extraction in laparoscopic colorectal cancer surgery: a case series study. Int J Surg Case Rep 2021; 78: 204-209.

[10] Sung YT and Wu JS. The Visual Analogue Scale for Rating, Ranking and Paired-Comparison (VAS-RRP): a new technique for psychological measurement. Behav Res Methods 2018; 50: 1694-1715.

[11] El Haddad R, Svabik K, Masata J, Koleska T, Hubka P and Martan A. Women's quality of life and sexual function after transvaginal anterior repair with mesh insertion. Eur J Obstet Gynecol Reprod Biol 2013; 167: 110-113.

[12] Husson O, de Rooij BH, Kieffer J, Oerlemans S, Mols F, Aaronson NK, van der Graaf WTA and van de Poll-Franse LV. The EORTC QLQ-C30 summary score as prognostic factor for survival of patients with cancer in the "Real-World": results from the population-based profiles registry. Oncologist 2020; 25: e722-e732.

[13] Luo R, Zheng F, Zhang H, Zhu W, He P and Liu D. Robotic natural orifice specimen extraction surgery versus traditional robotic-assisted surgery (NOTR) for patients with colorectal cancer: a study protocol for a randomized controlled trial. Trials 2021; 22: 121.

[14] Tang Q, Zhu Y, Xiong H, Sheng X, Hu Z, Hu H, Huang R, Zhang Q, Yuan Z, Xie L, Gao Z, Wang Y, Wang G and Wang X. Natural orifice specimen extraction surgery versus conventional laparoscopic-assisted resection in the treatment of colorectal cancer: a propensity-score matching study. Cancer Manag Res 2021; 13: 2247-2257.

[15] Lin J, Lin S, Chen Z, Zheng B, Lin Y, Zheng Y, Liu Y and Chen SQ. Meta-analysis of natural orifice specimen extraction versus conventional laparoscopy for colorectal cancer. Langenbecks Arch Surg 2021; 406: 283-299.

[16] Chang SC, Lee TH, Chen YC, Chen MT, Chen HC, Ke TW, Tsai YY, Fingerhut A and Chen WT. Natural orifice versus conventional mini-laparotomy for specimen extraction after reduced-port laparoscopic surgery for colorectal cancer: propensity score-matched comparative study. Surg Endosc 2022; 36: 155-166.

[17] Yao H, Li T, Chen W, Lei S, Liu K, Liu B and Zhou J. Role of robotic natural orifice specimen extraction surgery in colorectal neoplasms. Sci Rep 2021; 11: 9818.

[18] Guan X, Liu Z, Longo A, Cai JC, Tzu-Liang Chen W, Chen LC, Chun HK, Manuel da Costa Pereira J, Efetov S, Escalante R, He QS, Hu JH, Kayaalp C, Kim SH, Khan JS, Kuo LJ, Nishimura A, Nogueira F, Okuda J, Saklani A, Shafik AA, Shen MY, Son JT, Song JM, Sun DH, Uehara K, Wang GY, Wei Y, Xiong ZG, Yao HL, Yu G, Yu SJ, Zhou HT, Lee SH, Tsarkov PV, Fu CG and Wang XS; International Alliance of NOSES. International consensus on natural orifice specimen extraction surgery (NOSES) for colorectal cancer. Gastroenterol Rep (Oxf) 2019; 7: 24-31.

[19] Gundogan E, Kayaalp C, Gokler C, Gunes O, Bag M and Sumer F. Natural orifice specimen extraction versus transabdominal extraction in laparoscopic right hemicolectomy. Cir Cir 2021; 89: 326-333.

[20] Liu Z, Efetov S, Guan X, Zhou H, Tulina I, Wang G, Tsarkov P and Wang X; International Alliance of Natural Orifice Specimen Extraction Surgery (IANOSES). A multicenter study evaluating natural orifice specimen extraction surgery for rectal cancer. J Surg Res 2019; 243: 236-241.

[21] Zou X, Zhang G, Xue Y, Yuan Y, Xiao R, Wu G, Wang X, Wu Y, Long D, Yang J, Xu H, Liu F and Liu M. Transumbilical multiport laparoscopic nephrectomy with specimen extraction through the vagina. Urol Int 2014; 92: 407-413.

[22] Wolthuis AM, Fieuws S, Van Den Bosch A, de Buck van Overstraeten A and D'Hoore A. Randomized clinical trial of laparoscopic colectomy with or without natural-orifice specimen extraction. Br J Surg 2015; 102: 630-637.

[23] Chin YH, Decruz GM, Ng CH, Tan HQM, Lim F, Foo FJ, Tai CH and Chong CS. Colorectal resection via natural orifice specimen extraction versus conventional laparoscopic extraction: a meta-analysis with meta-regression. Tech Coloproctol 2021; 25: 35-48.

[24] Karagul S, Kayaalp C, Sumer F, Ertugrul I, Kirmizi S, Tardu A and Yagci MA. Success rate of natural orifice specimen extraction after laparoscopic colorectal resections. Tech Coloproctol 2017; 21: 295-300.