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ORIGINAL ARTICLE

Robotic colorectal surgery using the Senhance® robotic system: a single center experience

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Abstract

Background The aim of this study was to evaluate the initial experience of a single robotic center with the Senhance® robotic systems (TransEnterix Surgical Inc, Morrisville, NC, USA) in colorectal surgery.

Methods We performed a retrospective analysis of prospectively collected data of patients who underwent colorectal surgery using the Senhance® robotic systems, from November 2018 to November 2020. Perioperative, intraoperative, and short-term postoperative data were assessed.

Results There were 57 patients (28 women and 29 men, mean age 61.7 ± 6.2 years [range 23–84 years]). Forty-eight (84.2%) patients underwent surgery for colorectal cancer (22 colon cancer and 26 rectal cancer) and 9 (15.8%) for benign conditions. Mean operating time was 194 min ± 57.8 min (range 90–380 min). In total, 27(47.4%) operations were performed on the colon and 30 (52.6%) on the rectum; mean length of postoperative hospital stay was 8 ± 6.2 days (range 3–48 days). There were 2 (3.4%) conversions to open surgery. No intraoperative complications occurred. Seven patients (12.3%) had postoperative complications 3 (5.3%) of whom had to be treated under general anesthesia. There was no mortality. In 48 patients operated on for colorectal cancer, the mean lymph-node harvest was 18 ± 7.9 (range 7–38 lymph nodes). In the rectal cancer group of 26 patients, the distal resection margin was 3.3 ± 1.8 cm.

Conclusions In our experience, surgery using the new Senhance® robotic system was safe and feasible in surgery of the colon and rectum. Randomized controlled trials comparing this type of colorectal surgery with laparoscopic and/or other types of robotic surgery are needed.

Keywords Colorectal surgery · Minimally invasive surgery · Robotic surgery · Senhance® robotic system

Introduction

Laparoscopic colorectal surgery was introduced 3 decades ago [1]. Despite the worldwide implementation of this minimally invasive approach in colon and rectal surgery, there is still a lot of room for debate when it comes to advantages of this type of surgery over conventional open surgery in colorectal cancer, especially related to rectal cancer treatment [2, 3]. Robotic surgery was introduced a decade later, when the Food and Drug Administration (FDA) approved

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the Intuitive's da Vinci® robotic system in the United States in 2000, shortly followed by first colorectal resections performed in early 2001 [4]. However, the analysis of true benefits of this surgery on an evidence based level is still ongoing. Furthermore, today, the Da Vinci® is no longer the only existing robotic system: case series in colorectal cancer surgery, although small, is already published, using the FDA and Conformité Européenne (European conformity; CE) mark approved Senhance® robotic system (TransEnterix Surgical Inc, Morrisville, NC, USA) [5, 6], the CE mark approved Versius® robotic system [7] and other systems that have approval for clinical use in a single country level like Microhand S® in China [8]. In the near future, a number of new robotic systems are also to be introduced.

In our center, the robotic surgery program using the Senhance® robotic system was implemented in 2018 in a multidisciplinary fashion [9] and was developed in general and colorectal surgery, gynecology, and urology. Up to date, close to 500 robotic surgeries have been performed using the Senhance® robotic system. We have published a number of video-vignettes on different colorectal procedures [10–14], describing the technical steps of this type of robotic surgery and to fill the existing gap in the literature, as reports using this robotic system in colorectal surgery are scarce.

The present study includes prospectively collected data on our first 57 colorectal robotic surgeries. To date, this is the largest study in the literature on colon and rectal surgery using the Senhance® robotic system. The aim of the study was to evaluate our initial experience performing colorectal surgery with the Senhance® robotic system.

Materials and methods

The study was approved by Klaipeda University Hospital Review board. All patients gave informed written consent.

We performed a retrospective analysis of prospectively collected data on colorectal procedures carried out over a period of 2 years, from November 2018 to November 2020, at the Klaipeda University Hospital in Klaipeda, Lithuania, using the Senhance® robotic system.

Surgical technique

The patient was put in a supine position under general anesthesia. Through a 1 cm skin incision either supraumbilical or infraumbilical, a 10 mm trocar was introduced under direct vision and a 10 mm 30 degree camera inserted. After inspection of the abdominal cavity for possible metastatic spread, primary tumor, and adhesions, other trocars and robotic instruments were inserted and the robot docked. Performing a right hemicolectomy, we used two 5 mm trocars for robotic instruments. No assistant trocar was necessary [10] identical to our laparoscopic technique. Vascular ligation and anastomosis were performed extracorporealyl through a 5–6 cm transumbilical incision. For sigmoid colectomy and rectal procedures, after inserting the camera, two 10 and 12 mm trocars were used on the right, and one 5 mm (or 10 mm if use of articulating 10 mm instrument Radia® was planned) on the left [11–14]. The patient was put into a reverse Trendelenburg position. We did not routinely perform splenic flexure mobilization. After mobilizing the descending and sigmoid colon and, in some cases, the rectum, vascular ligation, stapling of the rectum, and anastomosis were performed using laparoscopic assistance. In sigmoid and rectal cancer surgery, a 5–6 cm transumbilical, infraumbilical, or Pfannenstiel incision was used for specimen extraction. For bowel transection, we used ECHELON (Ethicon, Somerville, NJ, USA) with a 60 mm blue cartridge. ECHELON was always introduced through the 12 mm troacar, which was inserted 2 cm medial and 2 cm below right anterior superior iliac spine. Straight ileorectal anastomosis after subtotal colectomy, straight colorectal anastomosis after sigmoid resection and partial mesorectal excision, and side-to-end coloanal anastomosis after total mesorectal excision was performed using circular 29 or 31 mm stapler (Ethicon, Somerville, NJ, USA). When performing transnal total mesorectal excision (TaTME), the procedure was started with the patient in a prone-jackknife position and the transanal part of the operation was performed in an open fashion similar as described by a French group [15]. For the robotic part, the patient was put in a reverse Trendelenburg position. While performing abdominoperineal resection and after the abdominal robotic part and creation of the stoma was completed, the perineal part was performed in a prone-jackknife position [11]. For right hemicolectomy, only straight robotic instruments were used. In the sigmoid colon and rectal surgery, we selectively used articulating 10 mm Radia® instrument. In most of our cases, we used three robotic arms; in all cases, we used Senhance® ultrasonic Lotus® for dissection. If the tumor was small and in the transverse colon or the left side, we used endoscopic tattooing. For rectal cancer cases, we assessed the quality of the specimen, distal, proximal, and circular margins and lymph-node harvest.

Complications were prospectively recorded up to 30 days postoperatively using the Clavien–Dindo classification [16].

Statistical analysis

Simple descriptive tests for statistical analysis were used. For the Gaussian quantitative variable, Student's *t* test was used.

For the non-Gaussian variable, we used the Mann–Whitney *U* test.

$P < 0.05$ were considered statistically significant.

Results

Demographic results are shown in Table 1. Forty-eight patients (84.2%) patients underwent operations for colorectal cancer (22 colon and 26 rectal), and in the remaining 9 patients, the reasons for surgery were large endoscopically not-removable colorectal adenomas (including one carcinoma in situ) in 7 patients, familial adenomatous polyposis in 1 patient, and diverticular disease in 1 patient. The mean operating time during the first 25 procedures was 3 h and 38 min, (range2 hours and 5 min–6 h and 20 min). During the last 25 procedures, it was 2 h and 53 min, (range 1 h and 30 min–5 h and 10 min).

After sigmoid colectomy or subtotal colectomy, the rectal stump just below promontory was closed using an ECHELON 60 mm stapler with one cartridge in all cases. After partial total mesorectal excision (including one Hartman type procedure) and TME (21 operations), the rectal stump was closed using one cartridge in 17 cases and two cartridges in 4 cases. When performing TaTME, the rectal stump was routinely closed using a purse-string suture.

Amongst the 48 patients with colorectal cancer, 14 (29.3%) had stage I, 14 (29.3%) stage II, 17 (36.2%) stage III, and 2 (4.2%) had stage IV colorectal cancer. Robotic colorectal operations are listed in Table 1.

As listed in Table 2, 27 (47.4%) operations were performed on the colon and 30 (52.6%) were different types of rectal surgeries.

Of the 26 patients with rectal cancer, 9 (34.6%) had rectal cancer in the upper third, 7 (26.9%) in the middle third, and 10 (38.5%) in the lower third of the rectum. Patients with upper rectal cancer did not receive any neoadjuvant treatment. Amongst the remaining 17 patients with mid and low rectal cancers, 13 (76.5%) received long-course chemoradiotherapy. Twelve patients were operated on 8–12 weeks after completion of the neoadjuvant treatment, and 1 patient with endoluminal recurrence of cancer in the lower third of the rectum was operated on after 18 months after complete clinical response (he was treated with a 'watch and wait' strategy).

There were 2 (3.4%) conversions to open surgery in patients undergoing right hemicolectomy. One case was due to the unexpected location of the tumor. After mobilization of the right colon and hepatic flexure and performance of a transumbilical incision for specimen extraction, a small colonic tumor was found in the mid-transverse colon (preoperatively assessed as being close to the hepatic flexure) and, after extending the incision upwards, an extended right hemicolectomy was performed. In the other case, extension into the anterior wall of the pre-pyloric part of the stomach from the proximal transverse colon tumor was detected, and a subtotal gastrectomy was necessary in addition to the right hemicoletomy. Both of these patients had uneventful postoperative courses.

A total of 7 (12.3%) complications were recorded and 3 cases (5.3%) required intervention under general anesthesia. All patients recovered. No deaths occurred. Complications, their management, and severity according to the Clavien–Dindo classification are listed in Table 3.

In 48 patients operated on for colorectal cancer, the mean lymph-node harvest was 18 ± 7.9 (range 7–38 lymph nodes). In the rectal cancer group of 26 patients, the mean distal resection margin was 3.3 ± 1.7 cm (range 1–7 cm). The shortest distance from the tumor to the circumferential resection margin in this patient population was 0.3 cm. The mesorectal excision specimen was good (complete) in 22 cases, and intermediate (nearly complete) in the other 4 cases.

Table 1 Demographics and other descriptive data of patients undergoing colorectal surgery

Variable	Data
Number of patients	$n = 57$
Age (years)	61.7 ± 6.2 (23–84)
Sex (male: female)	29:28 (90%:10%)
Body mass index (kg/m^2)	25.6 ± 3 (19.5–35.3)
Operative time (minutes)	194 ± 57.8 (90–380)
Length of hospital stay (days)	8 ± 6.2 (3–48)
Blood loss (ml)	20 ± 54 (0–300)
Lymph nodes harvested	18 ± 7.9, (range 7–38)

Data are reported as mean ± SD (range) unless otherwizse indicated

Table 2 Type of 57 robotic colorectal operations performed with the Senhance® robotic platform

Type of operation	Number
Right hemicolectomy	16
Anterior resection with partial mesorectal excision	11
Sigmoid colectomy	10
Anterior resection with total mesorectal excision	9
Abdominoperineal resection	5
Transanal total mesorectal excision	4
Subtotal colectomy with ileorectal anastomosis	1
Anterior resection with partial mesorectal excision and end colostomy (Hartmann type)	1
Total	57

Table 3 Surgical complications after 57 robotic colorectal operations with Senhance robotic platform

Sex	Age (years)	Type of operation	Complication	Management	Clavien–Dindo classification
F	52	Abdominoperineal resection	Bleeding from perineal wound	Suturing of the bleeding vessel	Grade IIIb
M	66	Sigmoid resection	Anastomotic leakage	Resection of anastomosis, end colostomy	Grade IIIb
F	57	Right hemicolectomy	Anastomotic leakage	Resection of anastomosis, end ileostomy	Grade IIIb
M	64	Anterior resection with partial TME	Bleeding from the anastomotic staple line	Endoscopic clipping	Grade IIIa
F	75	Abdominoperineal resection	Bowel obstruction	Conservative (i/v fluids)	Grade II
M	23	Anterior resection with TME	Anastomotic leakage	Conservative (antibiotics)	Grade II
M	64	Anterior resection with TME	Wound infection (specimen extraction site)	Wound opened	Grade I

TME total mesorectal excision

i/v intravenous

Discussion

Spinelli A et al. published the first report on Senhance® robotic colorectal surgery series in 2017 [5]. Over the period of 1.5 years, they performed 45 colorectal resections, and 66% of them for colorectal malignancies. Of those 45 patients, 12 underwent rectal resections and 33 were colonic resections. Despite this relatively small rectal surgery cohort, they demonstrated the safety and feasibility of the Senhance® robotic system both in colon and rectal surgery. In 2018, a large volume Senhance® robotic surgery center in Siegen, Germany, presented their initial experience with various abdominal procedures, but amongst them were just a few colonic resections for benign conditions [17]. After this system was approved by the FDA in the United States in 2018, only one paper reported two cases of colonic resections with this system [18] in USA. A very important paper was published by a group in Siegen on 12 Senhance® robotic sigmoid colectomies for diverticular disease [19]. They had to convert 2 of 12 operations to laparoscopy, but these conversions did not change their described procedure steps of the robotic intervention, exact position of robotic arms and instruments, and camera during each docking step. We used part of their experience in our practice, but our approach did not involve routine splenic flexure mobilization. It therefore made one step of their procedure unecessary. It would be of use in the future to have published series suggesting such a roadmap for other standard colorectal operations, especially in rectal cancer surgery which is, in general, technically more demanding. We tried to perform all colorectal operations with the Senhance® system just to ensure that using this system has no limitations, Right hemicolectomy [10], sigmoid colectomy 14), anterior resection with TME [12], abdominoperineal resection [11], and TaTME [13] were successfully performed. The video-vignettes included descriptions of our standardized approach to each surgical procedure. A Japanese group suggested interesting techniques for seemingly well-described Senhance® procedures. A 4-robotic arm D3 right hemicolectomy for right-sided transverse colon cancer was successfully performed, and all operational steps were performed intracorporeally including lymph-node dissection [21]. They even implemented single-port access surgery (plus two additional ports) to perform a sigmoid colectomy for cancer [22]. For ileocaecal resection, an original port placement was used [23], in the same article 'ideal' port placement,, not demanding requiring an additional port for an assistant, which is in fact what we used for all our right hemicolectomies, was suggested. The last and largest series prior to our data were published recently by a group from Taiwan, [6] reporting 46 colorectal resections (39 [84.8%] for colorectal cancer) using Senhance® robotic system. Thirty (65.2%) patients underwent rectal procedures. Despite that, some authors conclude that rectal cancer surgery with this robotic system does not seem to be promising. It is necessary to emphasize that they used only straight robotic instruments. That may be the reason for their conclusions, but at the same time, it should be noted that, to date, many rectal surgery procedures, worldwide,have been successfully performed laparoscopically, where only straight instruments are used.

We selectively implemented the use of the articulating Senhance® 10 mm instrument Radia® and found it advantageous. Especially with the 5 mm version on the market today [23], it is a way to overcome the shortcomings of

straight instrument robotic Senhance® surgery in rectal cancer. Our experience starting from the operating time, including blood loss and ending with quality of surgery (surgical complications, lymph-node harvest, and distal and circumferential resection margins) should not allow us to limit this type of robotic surgery to the colon alone.

Limitations of our study include the small numbers and retrospective analysis of our prospective database. Furthermore, we did not compare the results with other techniques (open or laparoscopy) or other robotic systems.

In our center with high-volume experience in laparoscopic colorectal surgery, we demonstrated a reduction of total operation time from on an average of 3 h and 38 min during the first 25 procedures to on an average of 2 h and 53 min during the last 25 procedures. This demonstrates that with reasonable previous experience in laparoscopic colorectal surgery, adoption of robotic Senhance® colorectal surgery is not difficult.

Conclusions

In our experience, robotic surgery using the Senhance® robotic system was safe and feasible in surgery of the colon and the rectum. Randomized controlled trials comparing this type of colorectal surgery with laparoscopic and/or other type of robotic surgery are needed.

Author contributions NES and AD conceived the idea of the study. NES, VK, AD, VE, OD, VJ, TJ, ES, and RM designed the article methodology and gathered the data. VK, ES, AD, and NES performed the data analysis and drafted the article. NES, VK, ES, VJ, and TJ conducted screening of articles and data extraction. All authors critically reviewed subsequent drafts. Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

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Availability of data and materials Available upon reasonable request.

Code availability Not applicable.

Declarations

Conflict of interest The authors declare that there is no conflict of interest.

Ethical approval The study was approved by Klaipeda University Hospital Review Board.

Consent to participate All patients gave written informed consent.

References

1. Jacobs M, Verdeja JC, Goldstein HS (1991) Minimally invasive colon resection (laparoscopic colectomy). Surg Laparosc Endosc 1:144–150
2. Stevenson AR, Solomon MJ, Lumley JW, Hewett P, Clouston AD, Gebski VJ, Davies L, Wilson K, Hague W, Simes J, ALaCaRT Investigators (2015) Effect of laparoscopic-assisted resection vs open resection on pathological outcomes in rectal cancer: the ALaCaRT randomized clinical trial. JAMA 314(13):1356–1363
3. Fleshman J, Branda M, Sargent DJ, Boller AM, George V, Abbas M, Peters WR Jr, Maun D, Chang G, Herline A, Fichera A, Mutch M, Wexner S, Whiteford M, Marks J, Birnbaum E, Margolin D, Larson D, Marcello P, Posner M, Read T, Monson J, Wren SM, Pisters PW, Nelson H (2015) Effect of laparoscopic-assisted resection vs open resection of stage II or III rectal cancer on pathologic outcomes: the ACOSOG Z6051 randomized clinical trial. JAMA 314(13):1346–1355
4. Weber PA, Merola S, Wasielewski A, Ballantyne GH et al (2002) Telerobotic-assisted laparoscopic right and sigmoid colectomies for benign disease. Dis Colon Rectum 45(12):1689–1699
5. Spinelli A, David G, Gidaro S, Carvello M, Sacchi M, Montorsi M, Montroni I (2017) First experience in colorectal surgery with a new robotic platform with haptic feedback. Colorectal Dis. https://doi.org/10.1111/codi.13882
6. Lin CC, Huang SC, Lin HH, Chang SC, Chen WS, Jiang JK (2020) An early experience with the senhance surgical robotic system in colorectal surgery: a single-institute study. Int J Med Robot. https://doi.org/10.1002/rcs.2206
7. Dixon F, O'Hara R, Ghuman N, Strachan J, Khanna A, Keeler BD (2020) Major colorectal resection is feasible using a new robotic surgical platform: the first report of a case series. Tech Coloproctol 6:1–5
8. Luo D, Liu Y, Zhu H, Li X, Gao W, Li X, Zhu S, Yu X (2020) The MicroHand S robotic-assisted versus Da Vinci robotic-assisted radical resection for patients with sigmoid colon cancer: a single-center retrospective study. Surg Endosc 34(8):3368–3374
9. Samalavicius NE, Janusonis V, Siaulys R, Jasenas M, Deduchovas O, Venckus R, Ezerskiene V, Paskeviciute R, Klimaviciute G (2020) Robotic surgery using Senhance® robotic platform: single center experience with first 100 cases. J Robot Surg 14(2):371–376
10. Samalavicius NE, Smolskas E, Deduchovas O, Janusonis V, Dulskas A (2019) Robotic right colectomy using the new Senhance® robotic platform: a three-trocar technique—a video vignette. Colorectal Dis 21:1092–1093
11. Samalavicius NE, Smolskas E, Deduchovas O, Janusonis V, Dulskas A (2019) Robotic abdominoperineal resection for pT2N0M0 low rectal cancer using the Senhance® TransEnterix robotic platform—a video vignette. Colorectal Dis 21:847–848
12. Samalavicius NE, Klimasauskiene V, Janusonis V, Samalavicius A, Dulskas A (2020) Robotic total mesorectal excision for mid-rectal cancer using the Senhance® robotic platform—a video vignette. Colorectal Dis 22:592–593
13. Samalavicius NE, Janusonis V, Smolskas E, Dulskas A (2020) Transanal and robotic total mesorectal excision (robotic-assisted TaTME) using the Senhance® robotic system—a video vignette. Colorectal Dis 22:114–115
14. Samalavicius NE, Smolskas E, Janusonis V, Deduchovas O, Dulskas A (2019) Robotic sigmoid resection for locally advanced cancer cancer using the Senhance® Transenterix robotic platform—a video vignette. Colorectal Dis 21(10):1216

15. Denost Q, Adam JP, Rullier A et al (2014) Perineal transanal approach: a new standard laparoscopic sphincter-saving resection in low rectal cancer, a randomized trial. Ann Surg 260:993–999
16. Dindo D, Demartines N, Clavien PA (2004) Classification of surgical complications: a new proposal with evaluation in a cohort of 6336 patients and results of a survey. Ann Surg 240(2):205–213
17. Stephan D, Sälzer H, Willeke F (2018) first experiences with the new Senhance® telerobotic system in visceral surgery. Visc Med 34(1):31–36
18. deBeche-Adams T, Eubanks WS, de la Fuente SG (2019) Early experience with the Senhance®-laparoscopic/robotic platform in the US. J Robot Surg 13(2):357–359
19. Darwich I, Stephan D, Klöckner-Lang M, Scheidt M, Friedberg R, Willeke F (2020) A roadmap for robotic-assisted sigmoid resection in diverticular disease using a Senhance Surgical Robotic System: results and technical aspects. J Robot Surg 14(2):297–304
20. Kataoka A, Hirano Y, Kondo H, Shimamura S, Kataoka M, Asari M, Fujii T, Ishikawa S, Ishii T, Yamaguchi S (2020) Right hemicolectomy with D3 lymph node dissection for right-sided transverse colon cancer using the Senhance robotic system: a case report. Surg Case Rep 6(1):263
21. Hirano Y, Kondo H, Miyawaki Y, Sugita H, Sakuramoto S, Yamaguchi S (2020) Single-incision plus two-port robotic surgery for sigmoid colon cancer using the Senhance robotic system. Asian J Endosc Surg. https://doi.org/10.1111/ases.12822
22. Kondo H, Yamaguchi S, Hirano Y, Ishii T, Obara N, Wang L, Asari M, Kato T, Takayama T, Sugita H, Sakuramoto S, Koyama I (2020) A first case of ileocecal resection using a Senhance surgical system in Japan. Surg Case Rep 6(1):95
23. Stephan D, Darwich I, Willeke F (2020) First clinical use of 5 mm articulating instruments with Senhance robotic system. Surg Technol Int 37:63–67