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Ann Ital Chir, 2023 94, 4: 425-432
pii: S0003469X23039179
Online ahead of print 2023 - April 20
free reading: www.annitalchir.com

Sercan Yüksel*, Uğur Topal**, Ece Batur*, Erdal Karaköse***, İsmail Çalıkoğlu*, Erdal Ercan*, Zafer Teke***, Hasan Bektaş*

**Departments of General Surgery, University of Health Sciences, Başakşehir Çam and Sakura City Hospital, Istanbul, Turkey*
***Departments Surgery Oncology, University of Health Sciences, Başakşehir Çam and Sakura City Hospital, Istanbul, Turkey*
****Departments of Gastroenterological Surgery, University of Health Sciences, Başakşehir Çam and Sakura City Hospital, Istanbul, Turkey*

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AIM: *Surgery is the optimum treatment approach in cases of colorectal cancer, with open or minimally invasive surgery options applied to patients in general surgery clinics. We present here an assessment of our use of robotic colorectal surgery for the treatment of colorectal cancer.*
METHOD: *The outcomes of robotic colorectal surgeries performed in the General Surgery Clinic of Basaksehir Cam and Sakura City Hospital were evaluated. The demographic data, indications, type of surgery, complications, duration of postoperative stay and pathology results of the patients were recorded, and the surgical results were evaluated retrospectively.*
RESULTS: *Of the 50 patients who underwent robotic colorectal surgery selected for the study, 19 were female and 31 were male, with a mean age of 60.9 years. Among the patients, 48% received neoadjuvant treatment and the most common tumor localization was the rectosigmoid region (40%), the most frequently performed operation was low anterior resection (44%). An ostomy was created in 50% of the patients, and two patients were converted. The mean duration of surgery was 191 minutes, the mean tumor diameter was 36 mm, the mean total number of lymph nodes dissected was 22.2 and the rate of complications of Clavien Dindo grade 3 or higher was 10%, namely anastomotic leak, anastomotic bleeding and chylous fistula. The mean length of hospital stay was 5 days, and one patient was reoperated due to the development of stomal necrosis. The rate of 90-day unplanned readmission was 10% and the most frequent cause was sub-ileus. One patient died in the postoperative period.*
CONCLUSION: *Robotic surgery is a minimally invasive surgical approach that can be successfully applied in centers where perioperative and postoperative complications can be managed.*

KEY WORDS: Colorectal Cancer, Minimally Invasive Surgery, Robotic Surgery

Introduction

Colorectal cancer is the third most common malignancy and the second most common cause of cancer death worldwide, with an estimated 1.9 million cases worldwide in 2020, leading to an estimated 0.9 million deaths [1].

Advances in science and technology have led to the introduction of minimally invasive surgical techniques as a new option for the radical treatment of tumors. These include endoscopic surgery, laparoscopic resection and da Vinci surgical system resection, the use of which is increasing day by day for the treatment of gastrointestinal cancer. Minimally invasive techniques involving reduced tissue trauma have resulted in fewer complications and decreased blood loss than with conventional surgery. The goal of minimally invasive surgery is to decrease trauma to a minimum in the performance of radical tumor surgery. To this end, high-resolution devices offering greater magnification have been developed for use in gastrointestinal cancer surgery, aiding

Pervenuto in Redazione Novembre 2022. Accettato per la pubblicazione Febbraio 2023
Correspondence to: Sercan Yüksel, MD, University of Health Sciences, Başakşehir Çam and Sakura City Hospital, Department of General Surgery, Istanbul, Turkey, (e-mail: drsercanyuksel@gmail.com)

surgeons in the avoidance of unnecessary damage since it provides a better view of the tumor and the surrounding tissues when compared to conventional surgery. Every new development in surgery, however, comes with new challenges, and the main problems with robotic surgery are the learning curve and proving the oncological efficacy of the method, as well as the cost implications [2-5].

Laparoscopic colorectal surgery comes with the usual challenges associated with traditional laparoscopic surgery, and these challenges are particularly important in such confined areas as the pelvis, increasing the difficulty of laparoscopic rectal surgery. Robotic surgical systems provide stable 3-dimensional images through a surgeon-controlled camera and devices with 7 degrees of flexibility, providing markedly improved ergonomics and a tremble filter, leading robotic surgery to be adopted by many surgical subspecialties over the last decade with the goal of overcoming the limitations of laparoscopic surgery [6-8].

The present evidence suggests that robot-assisted colorectal cancer surgery provides good short-term efficacy and the potential advantages associated with minimally invasive techniques [9,10]. While early data is sufficient to make a preliminary comparison of laparoscopic and robotic surgical approaches in terms of oncological outcomes, the lack of data prevents a comparison of long-term oncological results. While early oncological outcome and dissection width have been found to be comparable with laparoscopic surgery, the advantages of robotic surgery on long-term survival have yet to be proven [11-13,8].

The present study describes the experience gained at a newly established robotic surgical center in a tertiary care hospital and a review of literature.

Material and Method

After obtaining ethics board approval for the study, the first 50 cases that underwent robotic colorectal surgery starting from March 2021 were included in this single-center study. Patients under 18 years of age, with non-curative surgery, and patients with tumors of the right and transvers colon were excluded from the study. All patients were informed of the surgical procedure and the possible complications and provided written informed consent.

The study data were accessed prospectively from the hospital's automation systems, from nurse observation forms, from pathology reports and from clinical records, and were analyzed retrospectively.

The analyzed parameters were age, sex, American Society of Anesthesiologists (ASA) grade, levels of preoperative tumor markers, hemoglobin and albumin levels, neoadjuvant treatment status, prior COVID infection, operative details (such as type and duration of operation, conversion to open surgery, intraoperative complications, placement of an ostomy, reoperation, duration of hospital stay, postoperative complications, 90-day unplanned readmission and postoperative 30-day mortality), pathological tumor details (such as type, diameter, perforation, radial margin, closest surgical margin, surgical margin positivity, lymphovascular invasion, perineural invasion, presence of tumor budding, presence of tumor deposits, response to neoadjuvant treatment, total number of dissected lymph nodes and metastatic lymph nodes and pathological stage) and the status of adjuvant treatment. Surgical indications were determined by an institutional multidisciplinary committee based on discussions of each patient. All patients were evaluated from routine preoperative colonoscopy and screening by thoracic, abdominal and pelvic computed tomography (CT), from magnetic resonance imaging (MRI) in patients with rectal tumors and from PET-CT when necessary. Patients with T3/T4 or N+ rectal cancer received concurrent chemoradiotherapy (CCRT) prior to the operation.

The pathological staging of the disease was made according to the 8th edition of the TNM Classification [14]. Unplanned reoperation was defined in line with the ACS NSQIP definition as any surgical procedure under general, spinal or epidural anesthesia during the first 30 days of the index operative procedure, except for follow-up procedures based on pathology results [15]. Conversion to open surgery was defined as the completion of any part of the operation other than the extirpation of the specimen using an open technique. The duration of surgery was defined as the time from the first skin incision to the end of the abdominal closure. Anastomotic leak was defined as a breach in anastomotic integrity documented by a combination of clinical, radiological and operative tools. The Dindo-Clavien classification was used to define and grade postoperative complications [16].

Surgical Technique

All operations were performed by the same surgeon (HB), and the Da Vinci Xi Surgical System (Intuitive Surgical, Inc., Sunnyvale, CA, USA) was for all robotic procedures.

Pneumoperitoneum of up to 10 mm Hg intraabdominal pressure was produced in the patients via a puncture using a Veress needle at the umbilicus. An 8-mm robotic port was placed at the midclavicular line and all quadrants of the abdomen were viewed through a 30-degree optic to exclude peritoneal metastasis. Three 8-mm robotic ports were then placed on the anterior axillary line in the right lower quadrant, on the midclavicular line in the left upper quadrant and on the anterior axillary line, and all ports were aligned to produce a horizontal line between the right spina iliaca anterior superior and left arcus costae, with a 6-10 cm distance between them. A 12-mm laparoscopic port was placed in the right upper quadrant, making a triangle with the

two robotic ports on the right side of the abdominal wall to be used for the introduction and exit of devices for clipping and aspiration, the linear endostapler, and gauzes and sutures by the assisting surgeon. The operating table was set in a 45-degree Trendelenburg position after the ports were introduced. The Da Vinci Surgical System was approached to the operating table from the left side of the patient.

Robotic colorectal resections were performed following the defined standard approach. An anterior, low anterior or abdominoperineal resection was selected based on the localization of the tumor. Total mesorectal excisions (TME), partial mesorectal excisions (PME) and complete mesocolic excisions (CME) were made in patients with tumors localized in the mid or distal rectum, the proximal rectum and colon, respectively. During the medial dissection of the descending colon, the inferior mesenteric artery (IMA) was clipped using Hem-o-lock and excised 1 cm above its exit from the aorta by dissection using Monopolar Curved Scissors (Intuitive da Vinci Robotic Surgical Systems). The mesocolonic dissection was continued in the cauda-cranial direction, preserving the aortic sympathetic plexuses, and the inferior mesentedic vein (IMV) was clipped with a Hem-o-lock and cut at the lower margin of the pancreas at the exit point. Continuing through the cranio-caudal direction and preserving the aortic sympathetic plexuses, a medial dissection was performed and the mesocolon was dissected free from the promontorium. The posterior part of the mesocolon was dissected from medial to lateral, preserving the perirenal fascia. Toldt's fascia was cut starting from the splenic side to the pelvic peritoneal space. The gastrocolic ligament was cut at the left half of the transvers colon to mobilize the splenic flexura of the colon, and the colophrenic and colosplenic ligaments were cut. The mesoclon of the distal transverse colon was dissected over the pancreas.

The distal resection margin was determined as the promontorium for tumors of the sigmoid colon, 5 cm distal to the tumor for proximal rectal (rectosigmoid) tumors (rectosigmoid) and at the pelvic base for distal rectum tumors. The mesorectum was freed up to the resection margin, preserving the hypogastric nerves circumferentially. The mesorectum and the distal and proximal margins of the mesocolon were excised using Monopolar Curved Scissors and Maryland Bipolar Forceps (Intuitive da Vinci Robotic Surgical Systems). A distal resection of the colon or rectum wall was performed using an endostapler through the 12-mm assistant port. In patients who underwent abdominoperineal resection or who were planned for a colostomy, the proximal resection of the descending colon was performed intracorporeally. A Pfannenstiel incision was performed in patients planned to undergo a colorectal anastomosis and the incision was enlarged to suit the tumor dimensions. The specimen was taken out of the abdomen using an Alexis Wound protector-retractor (Applied Medical) placed in the incision. The proximal resection margin was the descending colon with an adequate blood supply and was cut using a 75 mm linear stapler.

An anvil was inserted into the proximal colon and secured with a purse string using a no. 0 nonabsorbable monofilament polypropylene suture material, and the colon was returned into the abdomen at the anastomosis phase. The Alexis Wound protector-retractor (Applied Medical) was closed using a Laparoscopic Cap and the pneumoperitoneum was reinstituted. A circular stapler was advanced through the trans anal route and an intracorporeal anastomosis was performed using a video assisted technique. An end colostomy was performed at the left lower quadrant in patients planned to undergo abdominoperineal resection or no colorectal anastomosis. A loop ileostomy was performed 30 cm proximal to the ileocecal valve in the right lower quadrant in patients with mid and distal tumors and who underwent TME. The specimen was taken out of the abdomen through the perineum in patients who underwent abdominoperineal resection.

Statistical Analysis

IBM SPSS Statistics for Windows (Version 24.0. Armonk, NY: IBM Corp) was used for the statistical analysis of the data. Categorical data were expressed as numbers and percentages, and continuous data as mean and standard deviation (median and minimum-maximum values, where required).

Results

The study included 50 patients with a mean age of 60.9 years, and the male sex was more prominent (62%). The most frequent ASA score was 2, the mean Hgb and albumin levels were 12.2 and 42.1, respectively, the median CEA and Ca 19-9 levels were 3.4 and 10.1, respectively. Among the patients, 48% had received neoadjuvant treatment and the most common localization of the tumor was the rectosigmoid region (40%). The demographic and clinical characteristics of the patients are presented in (Table I).

The most common procedure applied was a low anterior resection (44%), an ostomy was created in 50% of the patients; and two patients were converted to open surgery due to perioperative bleeding and inadequate blood supply to the proximal colon to be anastomosed. One patient experienced intraoperative bleeding, and the mean duration of the operation was 191 minutes. Intraoperative details are presented in (Table II).

The mean tumor diameter was 36 mm; the total number of dissected lymph nodes and metastatic lymph nodes was 22.2 and 0.7, respectively; the median distance to the surgical margin was 25 mm; half of the patients had

Table I - *Demographic data and preoperative findings of the patients*

		N:50
Age (Mean ± SD) (Min-Max)		60.9±15.3 (18–91)
Gender	Male	31 (62)
	Female	19 (38)
ASA score	1	7 (14)
	2	31 (62)
	3	11 (22)
	4	1 (2)
Hgb g/dl (mean ± SD) (Min-Max)		12.2±1.9 (8–16.7)
Albumin g/L (mean ± SD) (Min-Max)		42.1±4.3 (30–49)
CEA (median) (min-max)		3.4 (1–805)
Ca19.9 median (min-max)		10.1 (2–173)
Neoadjuvant treatment	Not Received	26 (52)
	Chemoradiotherapy	19 (38)
	Radiotherapy	3 (6)
	Total neoadjuvant treatment	2 (4)
Tumor Localization	Splenic flexura	2 (4)
	Sigmoid Colon	9 (18)
	Rectosigmoid	20 (40)
	Proximal rectum	6 (12)
	Mid rectum	3 (6)
	Distal rectum	5 (10)
	Rectum	5 (10)

Table II - *Intraoperative characteristics*

		N:50
Operation	Low Anterior Resection	22 (44)
	Miles Procedure	11 (22)
	Low Anterior Resection + loop ileostomy	9 (18)
	Low Anterior Resection + end colostomy	1 (2)
	Anterior Resection	3 (6)
	Anterior Resection end colostomy	4 (8)
Ostomy	None	25 (50)
	Loop ileostomy	9 (18)
	End colostomy	16 (32)
Conversion		2 (4)
Intraoperative complications	Bleeding	1 (2)
Duration of Operation (mean ± SD) (Min-Max)		191+57.5 (55–330)

lymphovascular invasion, and perineural invasion was seen in 38% and budding in 54% of the cases. Grade 2 tumors were most prominent in the sample, and the most common stage was 2a (38%). Response to neoadjuvant treatment was seen in 77% of the cases, although to various degrees. Four patients had macroscopic tumor perforation, no patients had a positive surgical margin and four patients had tumor deposits. The pathological properties are presented in (Table III).

The mean postoperative duration of hospital stay was 5 (2-12) days, with one patient with a clinical picture of postoperative ileus remaining hospitalized for 12 days. Clavien Dindo grade >3 complications were seen in 10% of cases, and included anastomotic leak, anastomotic bleeding and chylous fistula. Anastomotic leakage was detected in one patient, and one patient was re-operated due to the development of ostomy necrosis. The rate of 90-day unplanned readmission was 10% and the most frequent cause was sub-ileus. One patient with a comorbidity of liver cirrhosis died postoperatively. The perioperative and postoperative clinical outcomes are presented in (Table IV).

Discussion

The Da Vinci S Surgical System was introduced to surgery in 2000 after being granted approval by the FDA. The potential benefits of robotic surgery for resections of colon and rectal cancer have been recognized by colorectal surgeons. Robotic surgery can be considered a qualitative leap in the surgical tools available to

Table III - *Histopathological characteristics*

		N:50
Tumor diameter (mean ± SD) (Min-Max)		36.9+20.4 (0–110)
Total number of lymph nodes (mean ± SD) (Min-Max)		22.2+16 (5–106)
Number of metastatic lymph nodes (mean ± SD) (Min-Max)		0.7+1.4 (0–6)
Median surgical margin (min-max)		25 (1–100)
Presence of Lymphovascular invasion		25 (50)
Presence of Perineural invasion		19 (38)
Presence of tumor budding		27 (54)
Pathological Grade	G0	4 (8)
	G1	9 (18)
	G2	37 (74)
Pathological Stage	0	6 (12)
	1	10 (20)
	2A	19 (38)
	3A	2 (4)
	3B	13 (26)
Treatment effect n:26	None	6 (23)
	Partial	16 (61.5)
	Complete	4 (15.5)

Table IV - *Perioperative and Postoperative Clinical Outcomes*

		N:50
Duration of Postoperative Stay (mean ± SD) (Min-Max)		5±1.53 (2–12)
Clavien-Dindo degree of complication	1	39 (78)
	2	6 (12)
	3a	4 (8)
	5	1 (2)
Anastomotic leak		1 (2)
Reoperation		1 (2)
90-day readmission to the hospital	None	45 (90)
	Sub-ileus	3 (6)
	Anastomotic leak	1 (2)
	Ostomy necrosis	1 (2)
Postoperative mortality		1 (2)

surgeons, facilitating a minimally invasive approach to treatment, although it may be "annoying" for mediocre surgeons due to technical challenges and anatomical locations [17]. In the present study, describing the experience of a single surgeon with robotic colorectal surgery, it is established that robotic applications can be applied safely for the management of colorectal cancers, with low morbidity, mortality and adequate oncological dissection. The circumferential resection margin (CRM) of rectal cancer is defined as a >1 mm range from the tumor tissue to the surgical radial margin. TME in lower rectal cancers is still challenging, even in the hands of specified surgeons, and especially in male and obese patients with a narrow pelvis. For this reason, robotic approaches have come to be widely accepted for the TME of low rectum cancers [3]. CRM positivity was seen in four patients in the present series. Another operative factor known to have a significant effect on oncological outcome is the number of dissected lymph nodes [18], with 12 being the minimal recommended number for lymph node excision by the College of American Pathologists in colorectal resections. No statistically significant differences were found in any of the parameters in a review of literature comparing robotic resection with conventional open and laparoscopic resection [18-21]. The mean number of dissected lymph nodes was found to be 22 and was considered as adequate for lymph node dissection in the present series.

There are continued concerns relating to the duration of operations with robotic surgery and effect of docking on the [22]. While some authors report longer durations for robotic surgery than laparoscopic TME, others report similar durations [23,24]. Although the duration of operation seems to be long in robotic surgery, the lengthened operation time has been suggested to be acceptable to some extent, unless it leads to morbidity. The mean dura-

tion of surgery was 190 minutes in the present study, although the durations decreased as the surgeon gained experience.

The demonstration of the superiority of robotic surgery over conventional laparoscopic surgery in terms of short-term and pathological outcomes failed in many studies, with longer operation durations and lower rates of conversion to open surgery being reported. That said, there have been studies suggesting that urinary bladder and sexual functions are better preserved by robotic surgery [8]. The United Kingdom Medical Research Council and the National Health Research Institute published a Robotic and Laparoscopic Rectal Cancer (ROLARR) study in 2009 assessing the feasibility, efficacy and short- and long-term oncological results of robotic-assisted surgery when compared with conventional laparoscopic rectal cancer surgery. The ROLLAR study reported no superiority of robotic surgery in terms of conversion to open surgery, oncological outcome and complication rates, and it was stated that there was insufficient the evidence to conclude that robotic assisted laparoscopic surgery decreased the risk of conversion to open laparotomy [25]. In the present study, conversion to open surgery was encountered in two patients, and the causes were not robot-specific, being bleeding in one patient who had cirrhosis, and colonic ischemia in the other.

Some authors have reported lower complication rates in patients who underwent robotic surgery in their studies comparing minimally invasive surgical techniques in colorectal cancer. Crippa et al compared 317 patients (52.8%) who underwent robotic surgery and 283 patients (47.2%) who underwent laparoscopic surgery in their series of 600 patients who were similar in terms of age, sex and body mass index (BMI). The general incidence of short-term complications in patients who underwent robotic surgery was found to be lower than in the laparoscopic group (37.2% vs 51.2% $P < 0.001$) (26). There is no doubt that robotic flexibility is promising for rectal cancer surgery when compared to laparoscopy, although multi-center prospective studies are required to support its use. The rate of complications graded Clavien Dindo 3 and above was 10% in the present series, which was considered acceptable. Only one patient required surgical intervention, while other complications were managed with endoscopic and radiological interventions.

The negative effects of anastomotic leak on both overall survival and cancer-specific survival have already been demonstrated in previous studies. Anastomotic leaks have been emphasized to be detrimental not only in the postoperative period, but also in the long-term [18,27]. Ravindra et al. found the rate of anastomotic leak to be similar in the robotic and laparoscopic groups in their study comparing the postoperative non-oncological outcomes of their patients [28]. In the present series, an anastomotic fistula developed in one patient who had Parkinson's disease and based on the belief that future problems would occur in ostomy care, we performed no loop ileostomy and performed TM; this patient was treated with loop ileostomy.

There is a lack of consensus in literature on whether robotic surgery is associated with lower postoperative mortality. In two recent studies, robotic surgery was found to be associated with a significant decrease in mortality [29,30], although systematic reviews and meta-analyses do not support this thesis [18,31]. The cause of mortality was not associated with robotic surgery in the single patient who died in the present study, although it is not possible to draw a definite conclusion since given the small scale and non-comparative design of the study.

The hospitalization duration recorded in many prospective and retrospective cohort studies is similar for the robotic and laparoscopic surgery groups, although minimally invasive surgery has been reported to be superior to conventional surgery [32-34]. The mean hospital stay was 5 days in the present study, with the main reason for the prolonged hospital stays being subileus development.

The present study has some limitations, the first of which is its retrospective design. Secondly, no subgroup analyses were performed due to the small sample size, and thirdly, no randomization principles were followed at the time of patient selection. As an additional limitation, no cost analysis was performed.

Conclusions

Based on the findings of the present study it can be concluded that robotic applications in colorectal surgery can be safely applied with adequate oncological dissection and acceptable postoperative complication rates, although the actual benefits of the use of robotic systems in colorectal surgery should be analyzed and established. Accordingly, further studies with larger samples are needed for the evaluation of these aspects. We suggest that the role of minimally invasive techniques in gastrointestinal surgery will become more and more important as a result of the continuing interest and investigations into minimally invasive surgery techniques.

Riassunto

Rappresenta il migliore approccio terapeutico del cancro del colon-retto, realizzabile sia con chirurgia aperta tradizionale o minimamente invasiva.

Viene presentata qui la nostra esperienza di chirurgia robotica per cancro del colon e del retto.

Sono stati valutati i risultati degli interventi chirurgici robotici colorettali eseguiti nella Clinica di Chirurgia Generale di Basaksehir Cam e Sakura City Hospital. I

dati demografici, le indicazioni, il tipo di intervento chirurgico, le complicanze, la durata della degenza postoperatoria e gli esiti patologici dei pazienti sono stati registrati e i risultati chirurgici sono stati valutati retrospettivamente.
Risultati: Dei 50 pazienti sottoposti a chirurgia colorettale robotica selezionati per lo studio, 19 erano femmine e 31 maschi, con un'età media di 60,9 anni. Tra i pazienti, il 48% è stato sottoposto preventivamente ad un trattamento neoadiuvante e la localizzazione tumorale più comune è stata la regione rettosigmoidea (40%). L'intervento più frequentemente eseguito è stata la resezione anteriore bassa (44%). Una stomia è stata utilizzata nel 50% dei pazienti e due pazienti sono stati convertiti a chirurgia open. La durata media dell'intervento chirurgico è stata di 191 minuti, il diametro medio del tumore è stato di 36 mm, il numero totale medio di linfonodi sezionati è stato di 22,2 e il tasso di complicanze secondo Clavien Dindo di grado 3 o superiore è stato del 10%, vale a dire perdita anastomotica, sanguinamento anastomotico e fistola chilosa. La durata media della degenza ospedaliera è stata di 5 giorni e un paziente è stato rioperato per intervenuta necrosi stomale. Il tasso di nuovo ricovero non programmato a 90 giorni è stato del 10% e la causa più frequente era una subocclusione. Un paziente è deceduto nel periodo postoperatorio.
Conclusione: la chirurgia robotica è un approccio chirurgico minimamente invasivo che può essere applicato con successo nei centri in cui è possibile gestire le complicanze perioperatorie e postoperatorie.

References

1. Xi Y, Xu P: *Global colorectal cancer burden in 2020 and projections to 2040.* Transl Oncol, 2021; 14(10):101174, doi:10.1016/j.tranon.2021.101174.

2. Ye SP, Zhu WQ, Huang ZX, Liu DN, Wen XQ, Li TY: *Role of minimally invasive techniques in gastrointestinal surgery: Current status and future perspectives*. World J Gastrointest Surg, 2021; 13(9):941-52, doi: 10.4240/wjgs.v13.i9.941.

3. Liu G, Zhang S, Zhang Y, Fu X, Liu X: *Robotic surgery in rectal cancer: Potential, challenges, and opportunities.* Curr: reat Options Oncol, 2022; 23(7):961-79, doi: 10.1007/s11864-022-00984-y.

4. Di Lascia A, Tartaglia N, Petruzzelli F, et al: *Right hemicolectomy: Laparoscopic versus robotic approach.* Ann Ital Chir, 2020; 91:478-85.

5. Yalav O, Topal U, Gumus S, Unal AG, Rencuzogullari A: *Laparoscopic versus open total radical gastrectomy for advanced gastric cancer: Surgical outcomes*. Ann Ital Chir, 2021; 92:609-15.

6. Mak TW, Lee JF, Futaba K, Hon SS, Ngo DK, Ng SS: *Robotic surgery for rectal cancer: A systematic review of current practice*. World J Gastrointest Oncol, 2014; 6(6):184-93, doi: 10.4251/wjgo.v6.i6.184.

7. Kwak JM, Kim SH: *Robotic surgery for rectal cancer: An update in 2015.* Cancer Res.

8. Shah MF, Nasir IUI, Parvaiz A: *Robotic surgery for colorectal cancer*. Visc Med, 2019; 35(4):247-50, doi: 10.1159/000500785.

9. Cheng CL, Rezac C: *The role of robotics in colorectal surgery.* BMJ, 2018; 360:j5304, Published 2018; 12, doi: 10.1136/bmj.j5304.

10. Zarak A, Castillo A, Kichler K, de La Cruz L, Tamariz L, Kaza S: *Robotic versus laparoscopic surgery for colonic disease: A meta-analysis of postoperative variables*. Surg Endosc, 2015; 29(6):1341-47, doi: 10.1007/s00464-015-4197-7.

11. Wilder FG, Burnett A, Oliver J, Demyen MF, Chokshi RJ: *A review of the long-term oncologic outcomes of robotic surgery versus laparoscopic surgery for colorectal cancer, published correction appears in indian.* J Surg, 2016; 78(3):220, Indian J Surg, 2016; 78(3):214-19, doi: 10.1007/s12262-015-1375-8.

12. Park EJ, Cho MS, Baek SJ, et al: *Long-term oncologic outcomes of robotic low anterior resection for rectal cancer: A comparative study with laparoscopic surgery*. Ann Surg, 2015; 261(1):129-37, doi: 10.1097/SLA.0000000000000613.

13. Park EJ, Cho MS, Baek SJ, et al: *Long-term oncologic outcomes of robotic low anterior resection for rectal cancer: A comparative study with laparoscopic surgery.* Ann Surg, 2015; 261(1):129-37, doi: 10.1097/SLA.0000000000000613.

14. Weiser MR: AJCC 8th Edition: *Colorectal Cancer*. Ann Surg Oncol, 2018; 25(6):1454-55, doi: 10.1245/s10434-018-6462-1.

15. Cohen ME, Ko CY, Bilimoria KY, et al: O*ptimizing ACS NSQIP modeling for evaluation of surgical quality and risk: patient risk adjustment, procedure mix adjustment, shrinkage adjustment, and surgical focus*. J Am Coll Surg, 2013; 217(2):336-46.e1, doi: 10.1016/j.jamcollsurg.2013.02.027.

16. Dindo D, Demartines N, Clavien PA: *Classification of surgical complications: A new proposal with evaluation in a cohort of 6336 patients and results of a survey*. Ann Surg, 2004; 240(2):205-13, doi: 10.1097/01.sla.0000133083.54934.ae.

17. Bianchi G, Gavriilidis P, Martínez-Pérez A, et al: *Robotic multiquadrant colorectal procedures: A single-center experience and a systematic review of the literature*. Front Surg, 2022; 9:991704, Published 2022; Aug 17, doi: 10.3389/fsurg.2022.991704.

18. Koedam TWA, Bootsma BT, Deijen CL, et al: *Oncological outcomes after anastomotic leakage after surgery for colon or rectal cancer: Increased risk of local recurrence*. Ann Surg, 2022; 275(2):e420-e427, doi: 10.1097/SLA.0000000000003889.

19. Gavriilidis P, Wheeler J, Spinelli A, de' Angelis N, Simopoulos C, Di Saverio S: *Robotic vs laparoscopic total mesorectal excision for rectal cancers: has a paradigm change occurred? A systematic review by updated meta-analysis*. Colorectal Dis, 2020; 22(11):1506-517, doi: 10.1111/codi.15084.

20. Liao G, Li YB, Zhao Z, Li X, Deng H, Li G: *Robotic-assisted surgery versus open surgery in the treatment of rectal cancer: The current evidence*. Sci Rep, 2016; 6:26981, Published, 2016; May 27, doi: 10.1038/srep26981.

21. Lim S, Kim JH, Baek SJ, Kim SH, Lee SH: *Comparison of perioperative and short-term outcomes between robotic and conventional laparoscopic surgery for colonic cancer: A systematic review and meta-*

analysis. Ann Surg Treat Res, 2016; 90(6):328-39, doi: 10.4174 /astr.2016.90.6.328.

22. Achilli P, Grass F, Larson DW: *Robotic surgery for rectal cancer as a platform to build on: Review of current evidence.* Surg Today, 2021; 51(1):44-51, doi: 10.1007/s00595-020-020

23. Kim J, Baek SJ, Kang DW, et al: *Robotic resection is a good prognostic factor in rectal cancer compared with laparoscopic resection: Long-term survival analysis using propensity score matching*. Dis Colon Rectum, 2017; 60(3):266-73, doi: 10.1097/DCR. 0000000000000770.

24. Kang J, Yoon KJ, Min BS, et al: *The impact of robotic surgery for mid and low rectal cancer: A case-matched analysis of a 3-arm comparison-open, laparoscopic, and robotic surgery.* Ann Surg, 2013; 257(1):95-101, doi: 10.1097/SLA.0b013e3182686bbd.

25. Jayne D, Pigazzi A, Marshall H, et al: *Effect of robotic-assisted vs conventional laparoscopic surgery on risk of conversion to open laparotomy among patients undergoing resection for rectal cancer: The rolarr randomized clinical trial.* JAMA, 2017; 318(16):1569-80, doi: 10.1001/jama.2017.7219.

26. Crippa J, Grass F, Dozois EJ, et al: *Robotic surgery for rectal cancer provides advantageous outcomes over laparoscopic approach: Results From a Large Retrospective Cohort*. Ann Surg, 2021; 274(6):e1218-e1222, doi: 10.1097/SLA.0000000000003805.

27. Su'a B, Milne T, Jaung R, et al: *Detection of anastomotic leakage following elective colonic surgery: Results of the prospective biomarkers and anastomotic leakage (BALL) study*. J Surg Res, 2022; 273:85-92, doi: 10.1016/j.jss.2021.12.019.

28. Ravindra C, Igweonu-Nwakile EO, Ali S, et al: *Comparison of non-oncological postoperative outcomes following robotic and laparoscopic colorectal resection for colorectal malignancy: A systematic review and meta-analysis*. Cureus, 2022; 14(7):e27015, Published, 2022; Jul 19, doi: 10.7759/cureus.27015.

29. Zheng B, Zhang X, Wang X, et al: *A comparison of open, laparoscopic and robotic total mesorectal excision*: *Trial sequential analysis and network meta-analysis*. Colorectal Dis, 2020; 22(4):382-91, doi: 10.1111/codi, 14872 Robotic Versus Conventional Laparoscopic.

30. Ng KT, Tsia AKV, Chong VYL: *Surgery for colorectal cancer: A systematic review and meta-analysis with trial sequential analysis*. World J Surg, 2019; 43(4):1146-161, doi: 10.1007/s00268-018-04896-7.

31. Liao G, Li YB, Zhao Z, Li X, Deng H, Li G: *Robotic-assisted surgery versus open surgery in the treatment of rectal cancer: The current evidence*. Sci Rep, 2016; 6:26981, Published 2016; May 27, doi: 10.1038/srep26981.

32. Li X, Wang T, Yao L, et al: *The safety and effectiveness of robot-assisted versus laparoscopic TME in patients with rectal cancer: A meta-analysis and systematic review*. Medicine (Baltimore), 2017; 96(29):e7585, doi: 10.1097/MD.0000000000007585.

33. Prete FP, Pezzolla A, Prete F, et al: *Robotic versus laparoscopic minimally invasive surgery for rectal cancer: A systematic review and meta-analysis of randomized controlled trials.* Ann Surg, 2018; 267(6):1034-1046, doi: 10.1097/SLA.0000000000002523.

34. Hollis RH, Cannon JA, Singletary BA, Korb ML, Hawn MT, Heslin MJ: *Understanding the value of both laparoscopic and robotic approaches compared to the open approach in colorectal surgery*. J Laparoendosc Adv Surg Tech A, 2016; 26(11):850-56, doi: 10.1089/lap.2015.0620.