

## Abdominoperineal Resection for Rectal Cancer: Open, Laparoscopic or Robotic Approach What is the treatment of choice in experienced minimally invasive surgical teams?

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### Rezumat

*Amputația de rect în cancerul rectal: abordul deschis, laparoscopic sau robotic. Care sunt opțiunile echipelor cu experiența în chirurgia minimal invazivă?*

*Obiective:* Studiul compară amputațiile de rect (AR) realizate minimal invaziv (laparoscopic și robotic) și deschis, prin analiza datelor intraoperatorii și postoperatorii precoce, și prin identificarea criteriilor de selecție pentru alegerea abordului adecvat, în echipele cu experiență în chirurgia clasică și minimal invazivă (MI).

*Metode:* Caracterul studiului este retrospectiv, desfășurat între anii 2008-2020, în care au fost incluși 233 de pacienți cu rezecții abdominoperineale realizate pentru cancer de rect inferior sau de canal anal. Lotul de pacienți a fost divizat în două grupuri, în funcție de abordul utilizat: grupul “Chirurgie Minimal Invazivă” (MI) - operațiile efectuate laparoscopic și robotic, și grupul “Chirurgie Deschisă” (OS) – operațiile efectuate clasic. Datele preoperatorii ale pacienților au fost analizate cu scopul de a identifica abordul optim cât și principalele criterii de selecție.

*Rezultate:* Un procent semnificativ crescut de pacienți cu istoric chirurgical abdominal a fost identificat în grupul operațiilor deschise ( $p = .0002$ ). În același grup au fost notate pierderi sangvine semnificativ mai mari ( $p = .02$ ), și un număr crescut de rezecții simultane ( $p = .041$ ). Evoluția postoperatorie precoce a fost marcată

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de o morbiditate semnificativ mai mică în grupul MI ( $p=0.005$ ), cu mortalitate înregistrată doar în grupul operat deschis (3 cazuri), la pacienți cu comorbidități severe. Rezultatele histopatologice au identificat un număr semnificativ mai mare de stadii T2 în grupul MI ( $p=0.037$ ).

**Concluzii:** Chirurgia minimal invazivă oferă un avantaj important în AR, prin evitarea inciziilor suplimentare, piesa de rezecție fiind extrasă prin plaga perineală. Succesul AR MI pare să fie asigurat de o bună selecție preoperatorie a pacienților, la care se alătură experiența echipelor chirurgicale în chirurgia clasică și MI a cancerului rectal. Superioritatea tehnicii robotice în comparație cu abordul laparoscopic este susținută și de acest studiu, prin lipsa cazurilor de conversie.

**Cuvinte cheie:** cancer rectal, amputație de rect, chirurgie minimal invazivă, abord robotic, excizia totală de mezorect

## Abstract

**Objectives:** The present study compares abdominoperineal resection (APR) performed by minimally invasive and open approach, regarding preoperative selection criteria, intraoperative and early postoperative aspects, in choosing the suitable technique performed by surgical teams with experience in both open and minimally invasive surgery (MIS).

**Methods:** This is a retrospective study, conducted between 2008-2020. Two hundred thirty-three patients with APR performed for low rectal or anal cancer were included. The cohort was divided into two groups, depending on the surgical approach used: Minimally Invasive Surgery (laparoscopic and robotic procedures) and Open Surgery (OS). The perioperative characteristics were analyzed in order to identify the optimal approach and a possible selection criteria.

**Results:** We identified a high percentage of patients with a history of abdominal surgery in the open group ( $p=0.0002$ ). Intraoperative blood loss was significantly higher in the open group ( $p=0.02$ ), with an increased number of simultaneous resections ( $p=0.041$ ). The early postoperative outcome was marked by significantly lower morbidity in the MIS group ( $p=0.005$ ), with mortality recorded only in the open group (3 cases), in patients that associated severe comorbidities. The histopathological results identified a significant number of patients with stage T2 in the MIS group ( $p=0.037$ ).

**Conclusions:** Minimally invasive surgery provides a major advantage to APR, by avoiding an additional incision, the specimen being extracted through the perineal wound. The success of MIS APR seems to be assured by a good preoperative selection of the patients, alongside with experienced surgical teams in both open and minimally invasive rectal resections. The lack of conversion identified in robotic APR confirm the technical superiority over laparoscopic approach.

**Key words:** rectal cancer, abdominoperineal resection, minimally invasive surgery, robotic approach, total mesorectal excision

## Introduction

The abdominoperineal resection (APR) has been considered for many years the only therapeutic *choice* for patients with rectal cancer, even though it is a mutilating procedure. Current studies report a rate of yet increased post-operative complications due to the inconveniences caused by the permanent

stoma and the remaining empty pelvic space (1). Nevertheless, there are still indications for APR although their number has decreased.

The development of surgical techniques applied in low rectal cancer together with the understanding of pathological mechanisms of tumor dissemination, as well as the use of staplers have led to a decrease in the total number of APR and an increase in rectal resec-

tions with sphincter preservation. Despite the progress of sphincter saving procedures, the very low rectal cancer often requires APR. The association of total mesorectal excision (TME) with APR decreases the rate of local recurrence (2). With a definitive colostomy, which cannot be avoided, APR brings good results on long term oncological outcome and ensures its presence in the therapeutic arsenal of low rectal cancer (3). There are currently fewer but clear indications for APR in the cases of low rectal cancer, anal cancer or sphincter dysfunction (4).

In the early '90s, the first studies of the laparoscopic approach in colorectal cancer were published (5). The results demonstrated the technical feasibility of the procedures, but their spread was limited due to the lack of oncological outcome evidence (metastasis at the site of trocar insertion/local recurrence) (6).

The benefits of laparoscopy in terms of better visualization of the dissection plans and anatomical structures, quickly led to its implementation in rectal surgery. In addition, minimally invasive APR benefits from the absence of an abdominal incision, the removed specimen being extracted through the perineal wound.

Over the past 20 years, the minimally invasive techniques have been in continuous progress. In the General Surgery Department where this study was conducted, the first robotic TME was performed 13 years later after the first laparoscopic APR in 1995 (7-9).

The robotic platform offers additional advantages by overcoming the inconvenients encountered in laparoscopy. In addition, the robot offers a 3D image, dexterity, surgical precision and ergonomics, favoring dissection especially in narrow spaces or areas difficult to reach by open surgery, such as the pelvis (10). Even if nowadays the number of APR is decreasing and it is performed in most cases by open approach, it is necessary to emphasize the advantage of the minimally invasive procedure, supported by the positive outcome in terms of postoperative morbidity and promising oncological results.

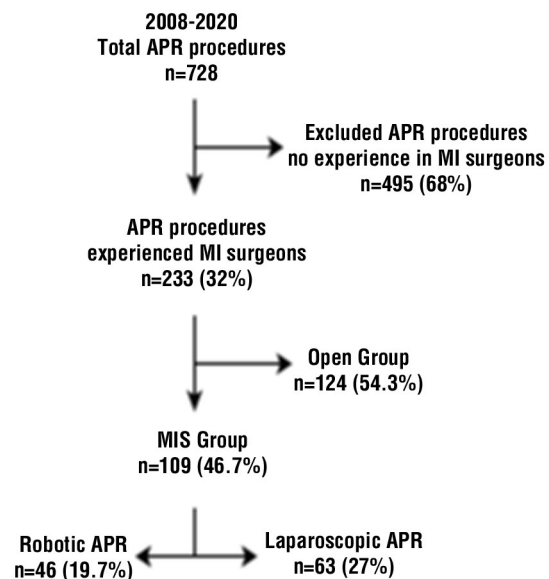
The aim of this study is to compare APR

performed by experienced surgical teams in rectal resections, through open surgery (OS) or minimally invasive surgery (MIS).

## Patients and Methods

This retrospective study includes 233 patients operated in the General Surgery Department between January 2008 and December 2020, by teams with experience in both OS and MIS. The main diagnosis was low rectal or anal canal cancer, for which APR was performed by open (124-53.21%) or minimally invasive approach [laparoscopic (63-27.03%) and robotic (46-19.74%)]. From a total of 728 cases of APR, we excluded patients operated for local recurrence after rectal resections, anastomotic stenosis and inflammatory-infectious diseases, or who were operated by surgeons without experience in minimally invasive surgery. The general structure for patient selection is presented in *Fig. 1*.

APR was indicated in cases where the tumor was less than 4 cm from the anus, presented sphincter invasion or invasion of the levator ani muscles, as well as anal canal tumors.



**Figure 1.** Flow-chart of patient selection

The assessment protocol of the patients with rectal cancer consisted of hematological parameters, tumor markers, chest X-ray, EKG, proctoscopy with biopsy, pelvic MRI/CT, transrectal ultrasound and secondary examinations depending on the associated pathology. Preoperative radio-chemotherapy was performed in all patients with stage higher than T3 after MRI or transrectal ultrasound examination.

Preoperative mechanical bowel preparation and antibiotic prophylaxis according to the clinic's protocol were performed. Surgical procedures were performed under general anesthesia. The following intraoperative parameters were assessed: surgical time, blood loss, conversion rate and concomitant resections. The hospital stay, morbidity, mortality and rate of reintervention were analyzed in the early postoperative outcome. Histopathological characteristics included: tumor staging, the number of harvested lymph nodes and the evaluation of complete pathological response after chemoradiation.

All the patients were fully informed on the chosen procedures and on the need to perform a permanent stoma. Prior to surgery informed written consent was obtained. The study protocol followed the recommendations of the unit's ethics board.

## *Surgical Technique*

### *Laparoscopic APR*

The positioning of the patient is similar as in the open technique: modified lithotomy position. Given the need to maintain pneumoperitoneum during the abdominal time, a systematic two-steps approach of resection is necessary. For the laparoscopic abdominal time, 4 trocars are used, positioned in the following manner: a 10 mm trocar for camera is placed on the right side of the umbilicus, a 12mm trocar in right iliac fossa, also used for stapler insertion, 10 mm trocar in the right abdominal flank. The trocar in the left iliac fossa can be inserted at the level of the future stoma. The principles of this intervention are similar to those of open surgery. Integrity of

TME *en bloc* with the entire anal sphincter is the main purpose of this intervention, which gives a cylindrical appearance of the resected specimen. Additional tools such as Harmonic Scalpel (Ethicon Endo-Surgery, Inc., Cincinnati, OH) or The LigaSure device (Valleylab, Boulder, CO) are required. In this technique, mobilization of the splenic flexure is usually not necessary. The parietal peritoneum is incised on the right side of the rectosigmoid junction. Dissection is continued in the avascular presacral plane, following latero-medial direction. Superior rectal vessels are dissected, ligated and cut at their origin. The ligation of the inferior mesenteric vessels at their origins in low rectal cancer is not commonly performed, due to fact that it does not improve the survival rate, as shown in multiple studies (11,12). Posterolateral dissection of the mesorectum is performed with preservation of fascia propria recti. It is necessary to ensure a good visualization to protect the hypogastric nerves. After the lateral dissection of the mesorectum, the last remaining plane is the anterior one. The lateral incisions of the pelvic peritoneum are joined at the level of recto-uterine or recto-vesical pouch. By postero-superior traction of the mesorectum the anterior plane is dissected at the level of the rectovaginal septum in women, and posteriorly from the Denonvilliers fascia in men, up to the pelvic floor. When the circumferential pelvic floor is identified, the abdominal time of the resection ends. The proximal sigmoid colon is sectioned using an endoscopic stapler. The completion of the abdominal time continues with performing the colostomy and drains placement through the orifices of the trocars.

Perineal time is performed with the patient in the same position, after a purse-string suture is placed on external anal sphincter. An elliptical incision is made starting from the center of the perineum in men and from the external edge of the posterior vaginal wall, in women; it is continued posteriorly between the coccyx and the anus. For low rectal tumors, a wider excision of the perianal skin is required. The deep dissection in the ischio-rectal fat is performed. The lower hemorrhoidal vessels

are identified in a posterolateral position and ligated. Using the tip of the finger as a guide, the posterior dissection is carried out, anterior of the coccyx, after the sectioning of the anococcygeal ligament. A posterior communication with the pelvis is identified. Then the dissection of the levator ani is performed under direct vision. When the resection specimen is mobilized posterolateral, it remains attached to the anterior region. The specimen is pulled out posteriorly, favoring the anterior dissection and the last step of the resection. The hemostasis is ensured, the drainage tubes are positioned and the perineal wound is closed.

### *Robotic APR*

In this study the robotic assisted APR were performed using DaVinci S and DaVinci Si Surgical Systems (Intuitive Surgical, Sunnyvale, CA, USA). All procedures used three robotic arms. The position was the same as in the laparoscopic approach with the robotic cart situated on the left side of the patient, at the hip level. The trocars placement is specific for this procedure. A 12 mm trocar for camera was inserted paraumbilical on the right side and three 8 mm robotic trocars were placed on the left iliac fossa, upper abdomen on the midline and right iliac fossa. In the right flank was inserted a 12 mm trocar for laparoscopic assistance. This procedure respects all the surgical steps described in the laparoscopic technique. First the superior rectal vessels were identified and ligated. After that, mobilization of sigmoid colon and rectosigmoid junction had been made. The robotic arms were attached to trocars positioned in the left and right iliac fossa. The rectum was handled in the dissection process by the assistant using the epigastric trocar. TME dissection was realized using monopolar robotic scissors and hook or Harmonic Scalpel focusing on preserving hypogastric nerves and pelvic autonomic nerve plexus. After complete dissection of mesorectum and circumferential exposure of levator ani muscle, the sigmoid colon was

transected by the assistant with Endo-GIA stapler, through the trocar placed in the right abdominal flank. The robotic system was removed and the stomal orifice was performed in the left iliac fossa through which the colonic stump was extracted. The perineal step was made in the same manner like it was described at the laparoscopic procedure (9).

### *Statistical Analysis*

Clinicopathological variables were analyzed comparatively, between the 2 groups (MIS vs. OS), using Student T-test and two-sided Fisher exact test. Statistical significance was defined as a p value  $\leq 0.05$ . The analysis was performed using IBM SPSS Statistics ver. 21.0 (IBM Co., Armonk, NY, USA).

## **Results**

### *Patient and Tumor Characteristics*

Demographic information and the characteristics of the studied group are presented in *Table 1*. Using the type of surgical approach the entire lot was divided in two groups: MIS (Laparoscopic and Robotic APR) and OS APR. All the patients included in this study had the maximum age of 85 years old and a preoperative ASA score less than or equal to III. There are no statistically significant differences in the average age, which was around 63 years. The body mass index was higher in the OS group, but with no statistical significance. This indicated that BMI was not a criterion in the general selection of patients for surgical approach. A significant difference was identified in the case of abdominal surgical history, in favor of the Open group. Majority of patients underwent preoperative radiochemotherapy, except for those with MRI T1-2 stage, without associated lymphadenopathy or emergency criteria (active bleeding or peritumoral abscess). All the resections were considered R0.

An overview of the studied groups demonstrates a slightly decreasing trend in the total number of APR carried out yearly (*Fig. 2*).

**Table 1.** Preoperative-assessment data

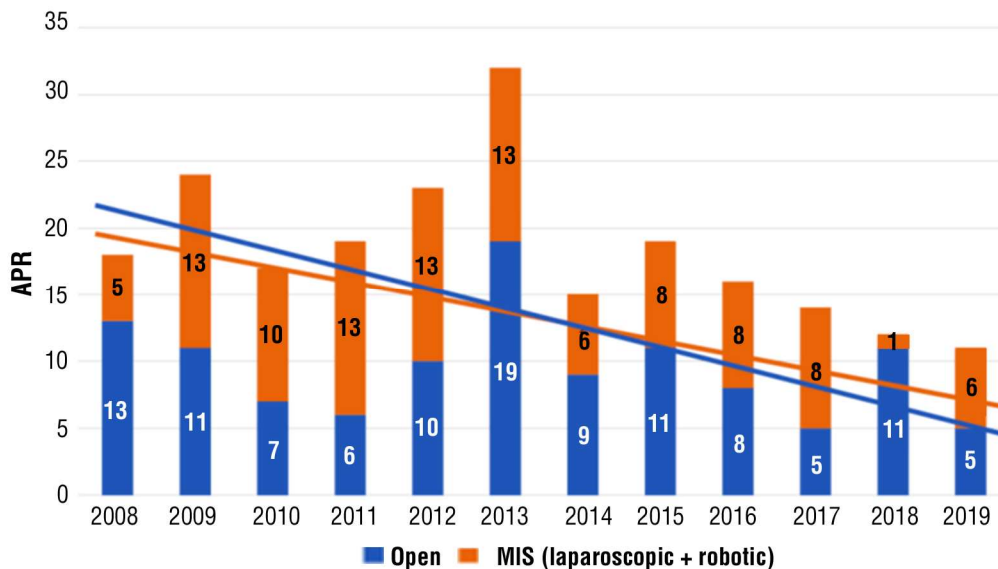
n=233	Laparoscopy (n=63) 27.03%	Robotic (n=46) 19.74%	MIS group	OS group	p value
			Total (n=109) 46.78%	Total (n=124) 53.21%	
M	32(50.79%)	34(73.91%)	66(60.55%)	74(59.67%)	NS
F	31(49%)	12(26.08%)	43(39.44%)	50(40.32%)	NS
age	62.25±10.9	62.21±11	62.23±11	63.46±11	NS
BMI (kg/m <sup>2</sup> )	23.5±4	24.3±3.7	23.9±3.8	25.8±3	NS
previous abd. Surgery	13(20.63%)	8(17.39%)	21(19.26%)	56(45.16%)	.00002
ASA score					
I	28 (44.44%)	19 (41.30%)	47(43.11%)	44 (35.48%)	NS
II	25 (39.68%)	23 (50%)	48(44.03%)	61 (49.19%)	NS
III	10 (15.87%)	4 (8.69%)	14(12.84%)	19 (15.32%)	NS
Preop. RCHT	52(82.53%)	31(67.39%)	83(76.14%)	82(66.12%)	NS

NS- non-significant

**Intraoperative Data and Early Postoperative Outcomes**

Intraoperative data and early postoperative outcomes are presented in *Table 2*. The operating time was lower in the open procedures, with no statistically significant difference. In the OS group, we identified 37 cases with associated resections (5 cases of metastasectomy and 33 cases with associated surgical pathologies or local tumor invasion, p= .041). Intraoperative blood loss was signifi-

cantly higher for patients in the OS group. The conversion rate was present only in MIS group. The average time of hospital stay did not differ significantly. Morbidity was considerably higher in the open group, in terms of wound infections and other type of complications (eviscerations, deep venous thrombosis, cardiac and pulmonary complications). The rate of urinary dysfunction after APR was similar for the two types of surgical approach. It should be noted that the difference between the rate of reintervention was



**Figure 2.** APR procedures carried out yearly in IC Fundeni-General Surgery Department

**Table 2.** Intraoperative and postoperative data

n=233			MIS group	OS group	p value
	Laparoscopy (n=63) 27.03%	Robotic (n=46) 19.74%	Total (n=109) 46.78%	Total (n=124) 53.21%	
Operative time	191'±38	221'±42	206'±39	189'±50	NS
Conversion	8(12.69%)	0	8(12.69%)	-	-
Blood loss	170±50	150±50	160±50	470±70	0.02
Concomitant resection	13(20.63%)	7(15.21%)	20(18.34%)	37(29.83%)	.041
Postoperative hospitalization	11.59±4	10.4±4.3	10.99±4.1	11.92±3.9	NS
Morbidity	18(28.57%)	13(28.26%)	31 (28.44%)	63(50.80%)	.0005
Postoperative hemorrhage	2(3.17%)	0	2(1.83%)	3(2.41%)	NS
Surgical site infection	4 (6.34%)	2 (4.34%)	6(5.5%)	17(13.70%)	.036
Urinary dysfunction	8 (12.69%)	6 (13.04%)	14(12.84%)	16(12.90%)	NS
Other Complications	3 (4.76%)	5 (10.86%)	8(7.33%)	22(17.74%)	0.018
PO Wound dehiscence	0	0	0	2(1.61%)	-
Surgical Reintervention	2(3.17%)	0	2(1.83%)	9(7.25%)	.051
Mortality	0	0	0	3(2.41%)	-

marginally significant, even though it was present in MIS group only after laparoscopic procedure. There were 3 deaths recorded in the immediate postoperative period, in the OS group, caused by severe pneumonia (2 cases) and acute myocardial infarction (1 case).

### Histopathological Features

Histopathological examination data are highlighted in *Table 3*. 96.13% were diagnosed with adenocarcinoma and 3.86% with squamous cell carcinoma. It is noted that a significantly higher number of patients with stage T2 were operated by MIS. Stages T3 and T4 were addressed to MIS and Open surgery in the similar manner. There were not regis-

tered T1 stage in robotic lot. The number of harvested lymph node during the intervention was on average 11.4±3, without significant differences, given the standardized nature of the intervention by complete excision of the mesorectum. Complete tumor regression was identified in both groups, but with no statistically significant difference.

### Discussion

APR is currently performed through 3 approaches: open, laparoscopic and robotic surgery (13). The main purpose of these techniques is to perform the correct total excision of the mesorectum. Given the understanding of the clinical-pathological behavior

**Table 3.** Postoperative pathological data

n=233			MIS group	OS group	p value
	Laparoscopy (n=63) 27.03%	Robotic (n=46) 19.74%	Total (n=109) 46.78%	Total (n=124) 53.21%	
Operative time	191'±38	221'±42	206'±39	189'±50	NS
T(stage-TNM)					
T1	7(11.11%)	0	7(6.42%)	5(4.03%)	NS
T2	23(36.50%)	16(34.78%)	39(35.77%)	29(23.38%)	0.037
T3	27(42.85%)	22(47.82%)	49(44.95%)	66(53.22%)	NS
T4	1(1.58%)	2(4.34%)	3(2.75%)	7(5.64%)	NS
N(stage-TNM)					
N0	39(61.90%)	26(56.52%)	65(59.63%)	81(65.32%)	NS
N1	14(22.22%)	9(19.56%)	23(21.10%)	25(20.16%)	NS
N2	5(7.93%)	5(10.86%)	10(9.17%)	17(13.70%)	NS
M 1 (stage- TNM)	2(3.17%)	5(10.86%)	7(6.42%)	12(9.67%)	NS
TRG1(Complete Tum Regression)	5(7.93%)	6(13.04%)	11(10.09%)	17(13.40%)	NS

of rectal cancer, the distal resection margin required for a radical resection has decreased to 1 cm in patients with neoadjuvant therapy (14,15). Along with the use of circular staplers, that allows to perform low anastomoses, all these factors contributed to the decrease in the total number of APR (16). This is also highlighted in the present study. TME performed laparoscopically is still a matter of dispute and it is not generally accepted. There are trials that report non-inferiority of the technique and studies that have failed to prove it (COLOR I and II trials, CLASICC trial and COREAN vs. ALaCaRT and Z6051) (17-22). The total percentage of MIS APR performed in the clinic between 2008-2020 is 46,78%, considering only the procedures performed by experienced surgeons in both open and minimally invasive approach. The difficulties encountered in the laparoscopic dissection of the mesorectum due to: narrow pelvic space, reduced visual field and rigidity of the laparoscopic instruments can decrease the integrity of the mesorectum. To avoid a cone shape, the robotic platform offers clear advantages, overcoming these obstacles. 3D visualization and the articulated instruments of the robotic platform help to provide an efficient and convenient dissection of the rectum. They were no statistical differences regarding sex, age or average BMI in studied groups. Conversion to open surgery was recorded only in the laparoscopic subgroup. The main reasons were local tumor invasion, previous abdominal surgery and pneumo-peritoneum intolerance. A comparative study based on the US nation-wide database also revealed a significantly lower conversion rate for robotic APR compared with laparoscopic APR (5.7% vs.13.4%) (23). Lack of conversion in the robotic group supports the efficiency of the platform used in surgery of the lower rectum. The mean operative time did not differ significantly, the robot's docking time was excluded from the operating time, due to the large variations related to the experience of the surgical team. In the OS group a significant number of cases have had previous

abdominal surgery. The percentage of concomitant resections was higher compared to MIS ( $p=0.041$ ), which significantly increased the operating time. They were probably the main cause of significantly higher intra-operative blood loss. Postoperative morbidity was significantly increased in the OS group: higher number of wound infections, cardiovascular or pulmonary complications, and ileus. The rate of postoperative urinary dysfunction was similar in both groups, consistent with data reported in the literature (24). The majority of the patients met two significant criteria for predictive postoperative urinary dysfunction: low rectal cancer and preoperative radiotherapy (25). Three death cases (2.41%) were recorded in the OS group, the patients had multiple severe comorbidities, with MIS contra-indications. The median postoperative stay was lower in the MIS group, although statistically insignificant. This difference could be explained by the higher number of complex surgical procedures performed by the open approach (associated resections, previous abdominal surgery) and thus the higher percentage of morbidity.

Corroborating the pathological data with the surgical approach resulted that a higher number of tumors in stage T2 were in the MIS group. This low stage favors MIS procedure due to tumor size, which is considered a difficulty factor for intraoperative handle of mesorectum (26). There were no differences between the number of cases with complete pathological response after neoadjuvant radio-chemotherapy between the two groups.

## Conclusions

APR remains the standard surgical procedure indicated for very low rectal cancer, those that invade the anal sphincter or levator ani muscles, as well as anal tumors. The inconvenience of a permanent colostomy is surpassed by the oncological benefits of this procedure. MIS brings a major advan-

tage by avoiding an additional incision: the specimen being extracted through the perineal wound. The main purpose of MIS is the integrity of TME; therefore, it is necessary to be performed in cancer centers by surgeons specialized in laparoscopic and robotic surgery. The success of APR seems to be assured by a good preoperative selection: pelvic dimensions, preoperative staging and personal history of abdominal surgery. Cases with increased difficulty benefit from the advantages of the robotic platform, also pointed out in this study by the lack of conversions. Nevertheless, there is still a role for open APR even in well trained MIS team. Further studies are needed to assess the individual characteristics to select patients for MIS.

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### Author's Contributions

Daniel Gavrilă and Ovidiu Bitere share first authorship. This paper uses data from Dr. Daniel Gavrilă's PhD thesis "Minimally invasive surgery of rectal cancer".

### Conflict of Interest

Daniel Gavrilă, Ovidiu Bitere, Gabriela Droc, Monica Lacatus, Corina Minciuna, Vlad Ilie, Bogdan Trandafir, Vlad Herlea, Stefan Tudor, Catalin Vasilescu declare that they have no conflict of interest.

### Ethics Approval

Review Board approval was obtained for using patient data in the present study.

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