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CHAPTER 28

Robotic surgery in patients with colorectal cancer: Techniques and benefits - Integrative review

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ABSTRACT

Surgical procedures using robotics are excellent options when you want to have fewer risks during and after surgery, not to mention that the recovery that the patient has when the surgery was performed using robotic means is much better and less painful than when it is performed without using these means. The objective of this study was to analyze various surgical methods using robotics, the risks and benefits of each surgery through an integrative review. In this context, the origins, impacts and evolution of robotics in the surgical field were also explored, with research and studies using descriptors such as "Robotic Surgery", "Robot Enhanced Procedures" and "Robot Assisted and Enhanced Surgical Procedures", using "LILACS", "PubMed" and "BVS" as references. However, the field of robotic surgery today is very broad and encompasses various types of treatments and procedures. It is an area of medicine that is constantly evolving, because as new technologies emerge, so do new types of methods and procedures, so the purpose of publishing this article is to bring the latest in the medical field involving robotics in today's surgical procedures, also specifying what surgical procedures using robotics are, how they are performed and their benefits, a fact that will be clearly exposed in the following chapters and paragraphs.

Keywords: Robotic Surgery, Robot Enhanced Procedures, Robot Assisted and Enhanced Surgical Procedures.

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INTRODUCTION

Technological advances in the medical field, with emphasis on the surgical field, have brought innovations to the treatment of various diseases, such as colorectal cancer [1, 2], which most of the time had very invasive surgical methods for resolving this disease, with the example of "Resection" surgery, where the abdominal part is opened to remove the part affected by cancer.

However, studies, research and work have brought to the medical field the use of robotics in surgical procedures, which will be the topic covered in this detailed analysis, bringing the latest and most innovative developments in this area. Thus, it is worth noting that the research collected for analysis presented the use of robotics as an emerging platform in the minimally invasive surgical era, which aims to overcome the limitations of laparoscopy [3], the surgical process using robotics offers fewer risks, as invasion is minimal and estimated blood loss is lower, in addition to its postoperative being low risk and less painful [3, 4].

In view of the surgeries using robotic technology, such methods end up taking longer, but this is minimal when compared to the benefits, but, nowadays, the biggest obstacles to the use of this surgery is the cost that is required to have this technology in surgical centers, in addition to the specialization that the surgeon needs to have in order to operate using robotics, which is why, nowadays in the 21st century, this technology is still little used and difficult to find in Brazil.

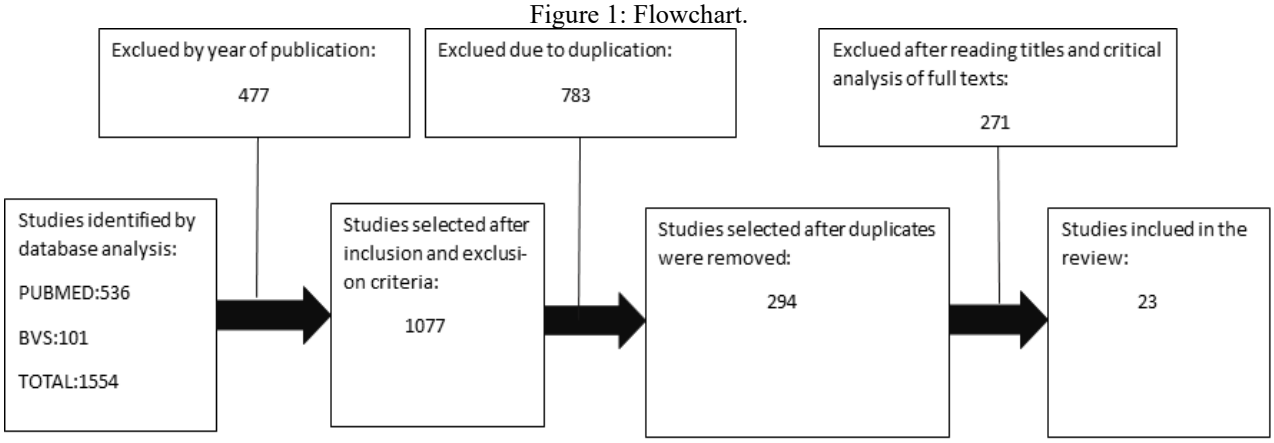
However, the objective of this study was to analyze various surgical methods using robotics, the risks and benefits of each surgery through an integrative review, through studies and research, seeking to update information on advances in robotic surgery in the treatment of colorectal cancer, concisely presenting the latest medical techniques and procedures in this area. Although, it is necessary to clarify doubts and address issues related to the methods used, due to the lack of available information.

MATERIALS AND METHODS

This study represents a integrative review that began with the scientific question "What are the benefits of robotic surgery in the prognosis of patients with colorectal cancer?", and after choosing the topic, scientific articles were analyzed in the Virtual Health Library (VHL) and National Library of Medicine (PUBMED) databases through inclusion and exclusion criteria, such as year of publication (2019-2024) in addition to the adequacy of English as the official language, in the exclusion criteria, duplicate studies and those that did not answer the question proposed by the theme were removed from this research. Consequently, the descriptors used were: robot-enhanced procedures, robotic surgery, robot-enhanced surgery and colorectal cancer, found in the Health Science Descriptors (DECS).

After checking the studies, 1554 published works related to the basic theme were found, which were then thoroughly analyzed according to the aforementioned parameters, so that 1077 remained under inspection, and 477 works were excluded. They were then screened for duplicate articles using the Endnote platform, and 784 materials were discarded. Then, after reading the titles and removing the works that were not in line with the theme, 55 surveys were included to read the full text. Finally, 24 articles were used to write this study, which will be cited in the references section. All of the above information can be seen in the flowchart in figure 1.

Figure 1: Flowchart.



RESULTS

The types of studies, objectives, and conclusions of the fourteen studies on oncological robotic surgery were elaborated in a descriptive manner and presented in Table 1.

Table 1 - Analysis of selected articles

Title	Authors/year	Study type	Objective	Conclusion
Robotic total pelvic exenteration for rectal cancer: case report and review of literature.	Stefan et al., 2021[5].	Case report.	The report describes the performance of a robotic total pelvic exenteration (TPE) in August 2018 to treat a locally advanced rectal cancer at our institution.	The robotic technique enhances the feasibility and safety of multiple organ resections for locally advanced pelvic cancers with curative intent. Literature highlights the advantages of robotic pelvic surgery, including better access to narrow areas, a stable platform, rapid interchangeability between operators using dual consoles, and superior visualization of anatomy through the three-dimensional screen.

Short learning curve in transition from laparoscopic to robotic-assisted rectal cancer surgery: a prospective study from a Finnish Tertiary Referral Centre.	Kolehmainen et al., 2023[6].	Retrospective observational study	The aim here was to study the transition from laparoscopic to robotic-assisted surgery among experienced laparoscopic surgeons.	In a study, one patient passed away within a month, but the death wasn't linked to the procedure. Surgical and oncological outcomes were consistent across all surgeons. However, surgeons with more experience in laparoscopic rectal cancer surgery had shorter console times, indicating improved efficiency. This suggests that experienced laparoscopic colorectal surgeons can safely adopt robotic-assisted rectal cancer surgery.
Robotic Versus Laparoscopic Surgery for Rectal Cancer: A Comprehensive Review of Oncological Outcomes.	Lam et al., 2021[7].	Meta-analysis.	To comprehensively compare the oncological outcomes of robotic versus laparoscopic surgery in the treatment of rectal cancer, assessing and synthesizing the available evidence to elucidate the differences between these surgical approaches.	While further randomized trials are required for validation, both techniques - laparoscopic and robotic-assisted surgery - are presently deemed acceptable for minimally invasive treatment of rectal cancer. Surgeon preference plays a crucial role in ensuring safe and optimal resection.
Essential technical aspects in robotic colorectal surgery: mastering the Da Vinci Si and Xi platforms.	Morrell et al., 2021[8].	Technical review article.	The aim of this study is to describe and guide on the technical aspects applied to standardized robotic colorectal surgery, showing the differences between the Si and Xi systems and ensuring maximum efficiency, particularly in left colon and rectal surgeries.	Robotic colorectal surgery is deemed feasible and safe in the hands of experienced surgeons, yet it still encounters challenges. Despite the Da Vinci Xi platform demonstrating greater versatility with a more user-friendly design incorporating technological advancements, proper mastery of the technology by the surgical team is essential for its seamless robotic execution in a single step.
Time interval between the completion of radiotherapy and robotic-assisted surgery among patients with stage I-III rectal cancer undergoing preoperative chemoradiotherapy.	Huang et al., 2020[9].	Retrospective observational study	The study examined short-term clinical and oncological outcomes in stage I-III rectal cancer patients undergoing preoperative chemoradiotherapy followed by robotic rectal surgery, with intervals of over 10 weeks between radiotherapy completion and robotic-assisted surgery. It also	Robotic-assisted surgery following a prolonged interval appears safe and feasible for rectal cancer patients undergoing preoperative chemoradiotherapy (CCRT). The study suggests that a time interval of 10–12 weeks is viable, as it yielded comparable clinical and perioperative outcomes and preferable oncological outcomes. However, future prospective randomized

			compared outcomes between different interval lengths (10–12 weeks vs ≥12 weeks).	clinical trials are needed to confirm these findings.
Comparison of pathologic outcomes of robotic and open resections for rectal cancer: A systematic review and meta-analysis.	Guo et al., 2021[10].	Systematic review.	The adoption of robotic surgery for rectal cancer treatment is steadily increasing. This meta-analysis aims to compare the pathological outcomes among rectal cancer patients who underwent either open rectal surgery (ORS) or robotic rectal surgery (RRS).	According to the existing evidence, robotic resection for rectal cancer yields comparable pathological outcomes to open rectal surgery (ORS) concerning factors such as CRM positivity, number of harvested lymph nodes, complete TME rates, and DRM.
Colorectal robotic surgery: INCA's experience.	Valadão et al., 2019[11].	Retrospective cohort study.	This report summarizes the single institutional experience with the use of the Da Vinci Platform in robotic colorectal surgeries conducted at an oncological surgery reference center in Brazil.	Robotic surgery is deemed safe and effective for colorectal cancer procedures, showing positive outcomes in hospital stay duration and complication rates with low conversion rates. However, obesity increases the risk of surgical complications in this context.
Feasibility and safety of robotic surgery for low rectal cancer combined with transanal total mesorectal excision.	Ando et al., 2023[12].	Retrospective observational study	The objective is to evaluate the safety and practicality of a hybrid surgical approach that combines robotic surgery with Transanal Total Mesorectal Excision (TaTME), referred to as hybrid TaTME. Parte superior do formulário	Robotic colorectal surgery, utilizing the Da Vinci Xi platform, is both feasible and safe when conducted under the supervision of skilled surgeons. While this technology provides enhanced flexibility and ease of use, its effective implementation relies on the proficiency of the surgical team. While a single docking approach is feasible, it necessitates adept utilization of the robotic system by the team.

Robotic Surgery in Rectal Cancer: Potential, Challenges, and Opportunities	Liu et al., 2022[18].	Literature review.	This brief review summarized the current status of robotic technology in rectal cancer therapy from the perspective of several mainstream surgical methods, including robotic total mesorectal excision (TME), robotic transanal TME, robotic lateral lymph node dissection, and artificial intelligence, focusing on the developmental direction of robotic approach in the field of minimally invasive surgery for rectal cancer in the future.	With the increase of surgical cases, more and more multicentered andprospectiveresearchwill provide a moresignificant reference for evaluating the safety, effectiveness, surgical, and short-term oncological effects of robotics for rectal cancer surgery.
Oncological outcomes of robotic-assisted total mesorectal excision after neoadjuvant concurrent chemoradiotherapy in patients with rectal câncer.	Chen et al., 2021[14].	Retrospective observational study	To analyze the oncological outcomes of robotic-assisted total mesorectal excision (TME) in patients with rectal cancer after neoadjuvant concurrent chemoradiotherapy (CCRT).	Robotic-assisted TME after neoadjuvant CCRT is safe and effective for treating patients with stage II-III rectal cancer in one institution with acceptable short-term oncological outcomes. It may be a therapeutic alternative to salvage surgery for T4 tumors invading adjacent organs, such as the bladder, prostate, and uterus.
Surgical outcomes of robotic transanal minimally invasive surgery for selected rectal neoplasms: A single-hospital experience.	Huang et al., 2021[9].	Case report.	This paper describes the surgical outcomes of robotic TAMIS for selected rectal tumors.	Based on the short-term results, robotic TAMIS is a feasible and safe technique for the local excision of selected rectal neoplasms.
The severity of postoperative complications after robotic versus laparoscopic surgery for rectal cancer: A systematic review, meta-analysis and meta-regression.	Wang et al., 2020[16].	Meta-analysis.	The study compares postoperative complications within 30 days after robotic surgery (RS) versus laparoscopic surgery (LS) for rectal cancer, using the Clavien-Dindo (C-D) classification to assess severity. Despite RS's demonstrated advantages over LS, few studies have explored the severity of postoperative complications in this context.	Robotic surgery presents as a secure option for treating rectal cancer and could serve as a viable alternative to laparoscopic surgery, potentially reducing the incidence of severe complications, grade IV C-D, and anastomotic leaks. However, additional extensive randomized controlled trials are imperative to validate this assertion.

Comparing outcomes of robotic versus open mesorectal excision for rectal cancer..	Jimenez-Rodriguez et al., 2021[17].	Retrospective observational study	The results of robot-assisted mesorectal excision for rectal cancer have not been fully characterized when compared with open resection.	For individuals with rectal cancer eligible for curative resection, robotic mesorectal excision is linked to decreased complication rates, reduced hospital stays, and comparable oncological results when compared to open mesorectal excision.
Postoperative complications observed with robotic versus laparoscopic surgery for the treatment of rectal cancer: An updated meta-analysis of recently published studies.	Liu et al., 2021[13].	Meta-analysis.	The objective of this study is to conduct an updated meta-analysis comparing postoperative complications observed with robotic versus laparoscopic surgery (LS) for the treatment of rectal cancer.	This updated meta-analysis found that both robotic and laparoscopic surgeries were equally effective in treating rectal cancer, with similar rates of postoperative complications. However, the analysis focused solely on postoperative outcomes and did not consider factors such as surgical duration.
Short- and long-term outcomes of robotic-assisted laparoscopic surgery for rectal cancer: A single-center retrospective cohort study.	Yamanashi et al., 2022[19].	Retrospective observational study	The goal is to examine patients who underwent Robot-Assisted Laparoscopic Surgery (RALS) at a specific facility and then clarify the short- and long-term results of these consecutive cases involving rectal cancer.	Favorable short- and long-term results indicated that robotic-assisted laparoscopic surgery was both safe and technically feasible for treating rectal cancer.
Robotic rectal resection: oncologic outcomes	Fiorillo et al., 2021[20].	Case report.	The purpose of this study is to report a single surgeon's experience on robotic rectal resection (RRR) for cancer, focusing on the analysis of oncologic outcomes, both in terms of pathological features and long-term results.	Under appropriate logistic and operative conditions, robotic surgery for rectal cancer proves to be oncologically effective, with adequate pathological results and long-term outcomes. It also offers acceptable peri-operative outcomes, further confirming the safety and feasibility of the technique.
Feasibility and Safety of Robotic-Assisted Surgery for Rectal Cancer: Short-Term Outcomes of a Pilot Study with da Vinci Xi Platform During COVID-19. Chirurgia (Bucur).	Bliznakova et al., 2023[21].	Single-center, non-randomized	This study aims to assess the clinical outcomes of robotic surgery for rectal cancer during the initial phase of implementing a surgical robot system. Additionally, this period coincided with the first year of the COVID-19 pandemic.	The study results demonstrate the successful integration of the robot-assisted platform into the surgery department despite COVID-19 limitations. This technique is anticipated to emerge as the primary minimally invasive approach for all colorectal cancer surgeries at the Robotic

				Surgery Center of Competence.
Robotic versus open surgery for simultaneous resection of rectal cancer and liver metastases: a randomized controlled trial.	Chang et al., 2023[22].	Randomized controlled trial.	To analyze and contrast the short- and long-term outcomes between robot-assisted simultaneous resection and open surgery in patients with rectal cancer and liver metastases.	In our randomized clinical trial, robotic simultaneous resection treatment of patients with rectal cancer and liver metastases resulted in fewer surgical complications, and a faster recovery to those of open surgery. Oncological outcomes showed no significant difference between the two groups.
Robotic Surgery in Rectal Cancer	Oliveira; Barbosa, 2021[23].	Literature review.	This study aims to review the literature on the significance and benefits of robotic surgery in treating rectal cancer, particularly compared to laparoscopic approaches.	Robotic and laparoscopic surgery for rectal cancer showed similar outcomes in terms of blood loss, short- and long-term outcomes, and pathological results. While robotic surgery typically takes longer and is more costly, it offers advantages such as a lower conversion rate to open surgery and benefits for urinary and sexual functions.
Role of minimally invasive surgery for rectal câncer.	Melstrom; Kaiser et al., 2020[24].	Meta-analysis.	The aim of this review is to comprehensively analyze various techniques concerning intra- and perioperative milestones, recovery, complications, and oncological and functional outcomes. It is unrealistic to expect a randomized comparison of all options in a single clinical trial.	The approach of minimally invasive surgery for treating rectal cancer is continually evolving, with laparoscopic and robotic techniques leading the way. The utilization of robotic surgery may result in a more favorable recovery of urinary and sexual functions. Additionally, local excision methods are comparable to conventional procedures. Despite being widely studied and acknowledged; uncertainties persist regarding the superiority of one technique over the other. Future technological advancements may pose additional challenges to current practices.

The current state of robotic colorectal surgery.	Rezende et al., 2019[25].	Literature review.	The purpose was to analyze published outcomes, covering complication rates, conversion, reoperation, mortality, and functional results in urinary, sexual, and fecal areas, as well as oncological outcomes related to overall or disease-free survival. This was conducted to assess the feasibility, safety, and effectiveness of robotic colorectal surgery.	There is a broad consensus on the core multimodal components across current RACS training programmes; however, validated objective assessment is limited and needs to be appropriately standardised to ensure reproducible progression criteria and competency-based metrics are produced to robustly assess progression and competence..
Robotic and robotic-assisted vs Laparoscopic rectal cancer surgery: A meta-analysis of short-term and long-term results.	Tang et al., 2021[26].	Meta-analysis.	Compare short- and long-term outcomes between robotic-assisted and robot-assisted surgeries versus laparoscopic surgery for rectal cancer.	The study suggests that robotic rectal surgery offers improved visualization of pelvic vascular lymph node tissue compared to laparoscopic surgery, enhancing lymph node clearance and protecting pelvic blood vessels. While requiring advanced surgical skills, robotic surgery is deemed safe and feasible for rectal cancer, showing favorable short-term outcomes and comparable long-term effects to laparoscopic surgery. The study concludes that robotic surgery warrants further adoption in appropriate healthcare settings for rectal cancer treatment.
Robotic-Assisted vs. Standard Laparoscopic Surgery for Rectal Cancer Resection: A Systematic Review and Meta-Analysis of 19,731 Patients	Safiejko et al., 2022[27].	Meta-analysis.	The aim of this study is to systematically assess the available evidence in the literature regarding the safety and efficacy of the robotic versus laparoscopic approach in patients undergoing curative surgery for rectal cancer	Robotic-assisted techniques offer numerous advantages compared to laparoscopic methods, including reduced operative time, lower conversion rates to open surgery, shorter hospital stays, and decreased risks of urinary retention, urinary tract infection, or ileus. These benefits contribute to improved survival rates at hospital discharge or within 30 days post-operation.

DISCUSSION

HISTORICAL EVOLUTION: FROM TRADITIONAL SURGICAL PRACTICE TO ROBOTIC SURGERY IN THE TREATMENT AND MANAGEMENT OF COLORECTAL CANCER

Colorectal cancer is one of the most prevalent malignancies globally and is classified as potentially fatal, especially when diagnosed in advanced stages. In this context, surgery has emerged as a crucial strategy for treating this type of cancer. It is estimated that between 15 and 30% of rectal cancers present as locally advanced tumors, requiring multivisceral resections. Therefore, surgical intervention plays a key role, allowing for the removal of the primary tumor, along with nearby lymph nodes that may contain cancerous cells. This approach aims not only to mitigate, but also to prevent the spread of the neoplasm, contributing significantly to the effectiveness of the treatment.[5]

In the meantime, with advances in technology and surgical techniques, medicine has increasingly less invasive treatment options, such as laparoscopic surgery and, more recently, robot-assisted surgery. In laparoscopic surgery, small incisions are made in the abdomen to insert a laparoscopic device, allowing the surgeon to view the inside of the patient's body in real time using monitoring cameras. However, laparoscopy still has significant limitations in rectal cancer surgery, including restricted access to narrow pelvic cavities, less dexterity, less precise movements and unfavorable ergonomics when compared to robotic surgery[6,7].

Robotic surgery has emerged as a more promising approach to rectal surgery compared to the laparoscopic approach, thus expanding the possibilities of minimally invasive surgery for patients with colorectal cancer. The first robotic system, called Da Vinci, was introduced in 2006 with the Si platform by Intuitive Surgical Inc. (Sunnyvale, CA, USA). Integrating a surgical console, a trolley with robotic arms and a video tower with high-definition three-dimensional vision, robotic surgery transcends the limitations of laparoscopy, representing a new era in minimally invasive surgery. [8,9]

POTENTIALITIES AND RELEVANT CONTRIBUTIONS OF ROBOTIC SURGERY IN THE TREATMENT OF COLORECTAL CANCER

Robotic surgery, or robot-assisted surgery, has emerged as a prominent approach with positive attributes for the treatment of colorectal cancer. [10] In the study by Liao et al. (apud Valadão et al.,2019), involving 1074 patients, it was possible to compare this approach with conventional surgery (laparoscopy). The results indicated that patients undergoing robotic surgery experienced a significant reduction in blood loss, resulting in less need for transfusions. In addition, there was a reduction in hospital stays and improvements in normal bowel function, indicating a faster recovery of digestive and evacuation functions[11]

Other benefits associated with robotic surgery include the minimization of surgical trauma to patients, wider visualization and technological aid for the precise identification of vascular and

nervous structures. [12,13] In addition, robotic surgery eliminates physiological tremors, offers greater ergonomic comfort and reduces surgeon fatigue[13,14,15,16,17,18,19,20].The robotic system also demonstrates ambidextrous ability during the surgical procedure, providing greater precision and allowing the execution of fine and precise movements, thanks to its advanced computer interface.In addition, there is preservation of the patient's voiding and sexual function, as this technique protects the superior and inferior hypogastric nerve plexus, as well as the pelvic nerve.[21,15]

Similarly, in their randomized clinical trial, Chang et al.[22] compared robotic surgery with open surgery for the simultaneous resection of rectal cancer and liver metastases, in which it was noted that 76 patients (44.4%) had surgical complications: 27 (31.4%) in the robotic group and 49 (57.6%) in the open group. The most common surgical complications were pleural effusion (12.2%) and surgical site infection (10.5%) and three patients (3.5%) in the robotic group were hospitalized for anastomotic fistula, while five patients in the open surgery group (5.9%) had anastomotic fistula. Furthermore, additional findings revealed that individuals who underwent robotic surgery had less post-operative abdominal drainage, a lower post-operative WBC and a shorter catheter removal time when compared to the laparoscopic group.[7]

Therefore, given the outstanding benefits of robotic surgery in the treatment of colorectal cancer, it is imperative to recognize the importance of more prospective and randomized multicentre studies in this area. These investigations are essential not only to evaluate the efficacy of the robotic platform in comparison with other approaches, such as open and laparoscopic surgery, but also to fully understand its clinical applicability and potential limitations.[13]

IMPASSES, CHALLENGES AND FUTURE PROSPECTS FOR THE APPLICATION OF ROBOTIC SURGERY IN COLORECTAL NEOPLASMS

Despite its notable benefits, the application of robotic surgery in cases of colorectal neoplasms faces challenges and impasses. In the Robotic vs Laparoscopic Resection for Rectal Cancer (ROLARR) randomized clinical trial, the robotic approach was compared with the laparoscopic approach in rectal cancer, revealing similar conversion rates and the higher costs associated with robotic surgery.[23] At the same time, initial studies corroborate this perspective, estimating that robotic surgery can be up to 2.4 times more expensive than conventional laparoscopy.[24,25]

In addition, it is worth noting the longer operative time associated with robot-assisted surgery, usually due to the additional installation required of this complex robotic system, the long learning curve, which involves training the healthcare team on simulators, the absence of tactile feedback, with the potential to result in tissue injuries due to excessive application of force, and the limited range of movement of the robotic arm, although the surgeon's experience can compensate for this

limitation[25,26]. It is also noteworthy that accessibility to this surgical method is not uniform throughout the population, with urban and rural disparities, as well as socioeconomic disparities, with patients undergoing this surgical technique being predominantly male, white, with private insurance and living in metropolitan areas[27].

In short, there is also the possibility of malfunctioning robotic devices and instruments, which can be a significant concern. These failures can occur due to a variety of reasons, including technical problems, component wear and software failures, resulting in serious complications and additional injuries for the patient.[26,27]

FINAL CONSIDERATIONS

This study, which aims to understand the positive and harmful aspects of robot-assisted laparoscopic surgery, points out that this method is extremely important for the treatment of colorectal cancer. Originally known as abdominoperineal resection, this technique has evolved as a result of an understanding of surgical anatomy and pathological aspects, and is currently known as total mesorectal excision. We believe that advances in technology have made it possible to align the total mesorectal excision technique with laboratory robotics, making it possible to qualify the results, so that its use is increasing, especially in developed countries. This is understandable, given that robot-assisted laparoscopic surgery allows a three-dimensional view, with an enlarged field, no shaking of the robotic arm, camera platforms controlled by the surgical team and good illumination of the pelvis.

On the other hand, the use of this technique requires a large financial investment, as well as being a challenging methodology, requiring qualified professionals with knowledge of precise resection of the tumor margin and an understanding of the functioning of the machinery used, as well as, in certain cases, the need for the professional to have mastery of the surgical reconstruction process. It is worth noting that several studies have shown the importance of preoperative chemotherapy, since it reduces the rate of patients with locally advanced rectal cancer and low lymph node counts.

Therefore, given the facts mentioned above, it can be seen that robotic surgery for colorectal cancer is a costly technique that is difficult to access, due to the scarcity of trained professionals, but together with chemotherapy, it shows improvement rates, helping to maintain the quality of life of individuals and making it possible to cure this pathology.

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