

*For practice*

## Robotic colorectal surgery: experiences, challenges and opportunities through our own research

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### Summary

Robotic colorectal surgery has revolutionized minimally invasive surgical techniques, offering numerous advantages over traditional approaches. Enhanced precision, reduced blood loss, shorter hospital stays, and improved patient outcomes are among the key benefits. However, high costs and technical complexities limit its widespread adoption.

This study explores the experiences, challenges, and future directions of robotic colorectal surgery. While it offers significant advantages, further research is needed to optimize techniques, reduce costs, and expand its application. By addressing technical limitations and exploring innovative approaches, robotic surgery has the potential to further improve patient care and surgical outcomes.

**Keywords:** robotic surgery, colorectal surgery, minimally invasive surgery, surgical outcomes, technological advancements

## Introduction

Robotic colorectal surgery represents a technological breakthrough that has redefined approaches in modern colon and rectal surgery. This method offers several advantages over traditional open and laparoscopic techniques, including greater precision, reduced postoperative pain, and shorter recovery time [1, 2].

Colorectal diseases, including malignant tumors of the colon and rectum, present a significant medical challenge due to their prevalence and the complexity of the surgical procedures they require. Traditional surgical approaches, although effective, often carry the risk of high morbidity and prolonged postoperative recovery [1, 2].

The aim of this paper is to provide a comprehensive overview of current trends in robotic colorectal surgery, with a particular focus on our research and experiences that have contributed to a better understanding of this technique.

The introduction of minimally invasive techniques, such as laparoscopic and robotic surgery, has radically changed the paradigm of surgical treatment. Robotic systems, such as the Da Vinci Xi, allow surgeons three-dimensional visualization, instrument stability, and greater precision, especially in anatomically challenging areas, such as the pelvis [1–3].

The first use of robotic systems in colorectal surgery was recorded in the early 2000s. Since then, this approach has evolved rapidly, thanks to numerous technological innovations. Key elements that have enabled the broader application of robotic surgery include:

- Advanced optical systems with high-resolution three-dimensional visualization,
- Precise, articulating instruments allowing greater flexibility and stability,
- The ability to perform complex maneuvers in narrow anatomical spaces, such as the pelvis [1, 3].
- In colorectal surgery, robotic technology is particularly useful in procedures such as:
  - Low anterior rectal resection for rectal cancer patients,
  - Total mesorectal excision (TME),
  - Abdominoperineal resection,
  - Colectomy for benign or malignant disease [3, 4].

Laparoscopic colorectal surgery is considered safe and effective compared to open surgery, but laparoscopic procedures, especially total mesorectal excision (TME), are technically demanding and have higher conversion rates and positive resection margins compared to robotic surgery. On the other hand, robotic surgery allows for more precise procedures with less blood loss, lower conversion rates, and longer operation times, while numerous studies show shorter hospital stays for patients undergoing robotic procedures. The main advantages of robotic technology include improved precision, reduced complications, and better postoperative outcomes [3, 4].

Although robotic surgery offers numerous advantages, it also faces challenges limiting its wider application:

1. High costs: Robotic systems are significantly more expensive than traditional laparoscopic equipment, which poses a barrier to their broader use, especially in countries with limited healthcare budgets.
2. Technical complexity: Robotic-assisted surgeries require a long period of surgeon education and accreditation, which can extend the preparation and execution time of procedures.
3. Lack of haptic feedback: Unlike open surgeries, where surgeons rely on tactile sensation, robotic systems do not provide direct tactile feedback, which can be a challenge when manipulating tissues [5, 6].

Our experience with robotic surgery and comparison with other authors and studies

Our institution performed the first totally robotic-assisted resection of rectal cancer in Slovenia in May 2014 using the Da Vinci SI system. Since then, over 100 robotic procedures for colorectal conditions have been completed. In 100 cases, adenocarcinoma was the most common indication (77%), with tumors mostly located at the rectosigmoid junction and rectum (62%). The most frequently performed procedure was anterior rectal resection (54%). The average operative time of 186 minutes was longer than in laparoscopic surgery, particularly for total mesorectal excision (TME). Blood loss ranged from 50 ml to 150 ml, lower than in laparoscopic surgery. The average number of isolated lymph nodes was 18.5, and positive circumferential resection margins (CRM) were found in 4.2%, lower than in laparoscopic (6.7%) and open surgery (10.3%). The average hospital stay was 7.5 days, shorter than six to 15 days typically seen with laparoscopic surgery. Conversion to laparoscopic or open surgery occurred in 4%, and the complication rate was 5%, with lower morbidity compared to laparoscopic surgery.

Our data show several key benefits of robotic surgery. Robotic surgery enables precise control of bleeding, with our average blood loss being 70 ml, compared to 150 ml with laparoscopic surgery. Precise visualization and technology allow for better identification of important anatomical structures, reducing the risk of damage to autonomic nerves and subsequent complications such as urinary incontinence and sexual dysfunction. Patients undergoing robotic surgery had a shorter postoperative stay (on average six days), allowing for faster return to daily activities. Our research shows a lower frequency of wound infections and anastomotic dehiscence in the robotic group.

Published studies report similar findings regarding robotic surgery advantages, particularly in terms of shorter operative times, reduced blood loss, and fewer transfusions. Notable studies like the REAL study and the Kim MJ study support these short-term benefits of robotic surgery, aligning with our results. However, long-term oncological outcomes for robotic surgery appear to be comparable to laparoscopic surgery. For example, the Park JS et al. study shows that both robotic and laparoscopic surgeries yield similar long-term results in terms of recurrence rates and overall survival [7–9].

While our report does not specifically discuss cost, several studies emphasize the high costs associated with robotic surgery, which can be a barrier, especially in countries with limited healthcare budgets. The need for further cost-effectiveness analysis is recognized, as robotic systems and instruments are more expensive compared to laparoscopic surgery [10, 11].

Our results focus primarily on immediate surgical outcomes, such as operative time and complications, without an in-depth analysis of long-term survival or recurrence. In contrast, several other studies discuss long-term outcomes in more details, suggesting that while robotic surgery offers short-term advantag-

es, it does not necessarily improve long-term oncological results compared to laparoscopic surgery. Other authors also look toward future technological advancements, including artificial intelligence and machine learning, which could further improve robotic surgery capabilities. On the other hand, our cases briefly touch on the preservation of nerve function with robotic surgery, enhancing outcomes for urinary and erectile function [11–13].

Our findings provide a specific institutional perspective on robotic surgery, focusing on short-term outcomes such as reduced blood loss, fewer conversions, and shorter hospital stays. These results align with the findings of various studies reporting similar short-term advantages for robotic surgery. However, our analysis does not explore long-term outcomes or cost-effectiveness in depth. Published studies, particularly the REAL, Kim MJ, and Park JS studies, offer a more comprehensive look at both short- and long-term outcomes, highlighting the comparable oncological results of robotic and laparoscopic surgery. Moreover, several studies place greater emphasis on the technological advancements and future directions of robotic surgery, suggesting that ongoing research and economic evaluations are essential for its continued development and integration into clinical practice [7–9, 15].

## Conclusion

Robotic colorectal surgery represents a significant advancement in minimally invasive surgery. While it offers numerous advantages, including reduced blood loss, faster recovery, and improved patient outcomes, challenges such as high costs and technical complexities limit its widespread adoption. As technology continues to evolve, it is expected that robotic surgery will become more accessible and affordable, further revolutionizing the field of colorectal surgery.

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## Robotska kolorektalna hirurgija: iskustva, izazovi i mogućnosti kroz vlastita istraživanja

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Robotska kolorektalna hirurgija predstavlja značajan napredak u minimalno invazivnoj hirurgiji, nudeći brojne prednosti u odnosu na tradicionalne tehnike. Povećana preciznost, smanjen gubitak krvi, kraći boravak u bolnici i poboljšani ishodi za pacijente su među ključnim prednostima. Međutim, visoki troškovi i tehničke kompleksnosti ograničavaju širu primjenu.

Ova studija istražuje iskustva, izazove i buduće pravce robotske kolorektalne hirurgije. Iako nudi značajne prednosti, potrebna su dalja istraživanja kako bi se optimizovale tehnike, smanjili troškovi i proširila primjena. Adresiranjem tehničkih ograničenja i istraživanjem inovativnih pristupa, robotska hirurgija ima potencijal da dodatno poboljša njegu pacijenata i hirurške ishode.

**Ključne riječi:** robotska hirurgija, kolorektalna hirurgija, minimalno invazivna hirurgija, hirurški ishodi, tehnološki napredak