Review Article

The Impact of Minimally Invasive Surgical Techniques on Long-Term Outcomes in Elderly Patients with Colorectal Cancer: A Systematic Review

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ABSTRACT

The study aimed to assess the long-term impact of minimally invasive surgical (MIS) techniques on elderly patients with colorectal cancer (CRC). A search across four databases identified 898 relevant publications, with 407 of which were reviewed. Five studies included 1743 patients, with 58.1% being males. Results showed that 3-year overall survival rates varied from 60.3% in laparoscopic surgery patients to 88.9% in transanal total mesorectal excision (TaTME) patients. Local recurrence-free survival ranged from 75% to 88.1%. Elderly patients had worse outcomes, with higher local recurrence rates and shorter OS and LRFS compared to non-EP patients. Laparoscopic surgery showed comparable five-year survival outcomes to open colectomy, indicating its viability as an alternative. Studies on TaTME demonstrated favorable long-term outcomes, with low recurrence rates and improved surgical feasibility in low rectal cancer. In patients aged 80 and older, laparoscopic surgery was associated with lower 90-day mortality, reduced hospital stays, and better survival outcomes compared to open surgery.

Keyword: Minimally invasive surgeries; Laparoscopic surgery; TaTME; Colorectal cancer; Elderly; Systematic review.

Introduction

Colorectal cancer (CRC) is the fourth most prevalent cancer diagnosed worldwide and the third most lethal, according to GLOBOCAN 2018 data. In 2018, there will likely be approximately 1 million fatalities and over 2 million new cases [1]. It is the second most prevalent in England and Wales with regard to of both incidence and mortality [2]. It is the third most common cancer in the US, with an estimated 149,000 new cases and 55,000 deaths in 2006 [3]. First reported in 1991, laparoscopic colorectal resections were made possible by the development of MIS [4]. Laparoscopic CRC surgery has mostly been carried out in randomized trials throughout the last ten years [4]. Many surgeons were reluctant to use laparoscopy for CRC in clinical practice because of concerns regarding irradical laparoscopic resections, which were raised in

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the early 1990s by reports of case series of port-site metastases [5, 6]. Traditionally, open surgery has been the standard approach for CRC resection. However, laparoscopic and robotic-assisted treatments are examples of MIS techniques that have gained popularity because of their potential advantages, which include less post-operative pains, shorter hospital stays, and quicker recovery. Despite these advantages, the long-term impact of MIS techniques on elderly patients, particularly in terms of survival, functional outcomes, and quality of life, remains a subject of ongoing debate. In order to inform clinical decision-making, this systematic review attempts to compile the most recent data about the long-term impacts of MIS procedures in elderly patients with colorectal cancer [7, 8]. Elderly patients with CRC present unique surgical challenges due to age-related physiological changes, comorbidities, and reduced physiological reserves. While MIS have been associated with better short-term outcomes, their influence on long-term survival, recurrence rates, post-operative complications, and quality of life in older adults is not well established. Given the growing preference for MIS approaches in oncologic surgery, it is essential to evaluate their effectiveness in this population. Understanding whether MIS techniques provide sustained benefits or introduce new risks in elderly CRC patients will help optimize treatment strategies and improve patient-centered outcomes [8]. The purpose of this systematic study is to assess how MIS procedures affect older CRC patients over the long run. Specifically, it seeks to assess survival outcomes, disease recurrence, and overall quality of life following MIS compared to conventional open surgery.

Methods

This systematic review satisfied the GATHER and PRISMA criteria.Selection criteria:

Inclusion Criteria:

1. Studies involving elderly patients (aged ≥65 years) diagnosed with CRC undergoing surgical treatment.
2. Studies assessing MIS techniques, including laparoscopic, robotic-assisted, or transanal minimally invasive surgery (TAMIS).
3. Studies comparing MIS techniques to open surgery or different MIS.
4. Studies reporting long-term outcomes, including OS, disease-free survival (DFS), and recurrence rates.
5. Cohort studies, case-control studies, and randomized controlled trials (RCTs) containing pertinent data.
6. Studies conducted within the last five years (2020-2024).
7. Studies with a minimum follow-up of 12 months post-surgery.
8. Studies published in English.

Exclusion Criteria:

1. Studies focusing on patients younger than 65 years or without subgroup analysis for elderly patients.
2. Studies evaluating only chemotherapy, radiotherapy, or palliative care without surgical intervention.
3. Studies including only open surgery without a MIS.
4. Research that doesn't reveal long-term outcomes and instead focuses only on perioperative outcomes (such as blood loss, operating time, and hospital stay).
5. Case studies and brief series of cases involving less than ten patients.
6. Animal or laboratory studies without human participants.
7. Non-English publications or studies with insufficient data on long-term outcomes.

Search strategy: To find pertinent research on the long-term effects of MIS procedures on elderly patients with colorectal cancer, a comprehensive search was conducted. Four electronic databases were examined by the reviewers: SCOPUS, Web of Science, Cochrane, and PubMed. After eliminating duplicates, we uploaded all of the abstracts and titles found via computerized searches into Rayyan. Every text from a paper that satisfied the requirements for inclusion based on its abstract or title was gathered and carefully examined. The suitability of the retrieved papers was assessed separately by two reviewers, who also discussed and addressed any discrepancies. The limited number of studies included in this systematic review can be attributed to several factors. First, the focus on minimally invasive techniques (e.g., laparoscopic or robotic surgery) in elderly colorectal cancer patients represents a niche yet clinically significant area, as older adults are often underrepresented in surgical trials. Second, strict inclusion criteria—such as long-term oncological outcomes (e.g., 5-year survival or disease recurrence) and studies exclusively comparing minimally invasive versus open surgery in elderly cohorts—further narrowed the pool of eligible research. Additionally,

many studies lacked stratified age-group analyses or sufficient follow-up duration, leading to their exclusion.

Data extraction: Data from studies that satisfied the inclusion requirements were extracted by two objective reviewers using a predetermined and uniform manner. The data listed below was obtained and noted: (i) First author; (ii) Design of the study; (iii) Year of publication; (iv) Country; (v) Sample size; (vi) Gender; (vii) Age; (viii) Duration of follow-up; (ix) OS; (x) LRFS; (xi) Surgical intervention; and (xii) Key findings.

Quality review: Because the ROBINS-I approach allows for a comprehensive analysis of confounding, we utilized it to evaluate the possibility of bias because bias arising from missing variables is common in research in this field. The ROBINS-I technique is intended to evaluate non-randomized research and may be applied to cohort designs in which participants exposed to varying staffing levels are monitored over time. Two reviewers separately assessed each paper's risk of bias, and disagreements were resolved through group discussion [9].

Results

Using the above search method, 898 papers were found (Figure 1). Following the elimination of duplicates (n = 491), 407 articles were assessed using the abstract and title. Of these, 315 did not meet the requirements for eligibility, thus only 90 full-text articles were left for a thorough examination. Five individuals met the criteria for eligibility with synthesised evidence for analysis. Sociodemographic and clinical outcomes: Of the 1743 patients in the 5 trials were included, 1013 (58.1%) were men. Every study that was included used retrospective cohorts [11-15]. In Japan, two studies were conducted [11, 12], two in Germany [13, 14], and one in the UK [15]. The follow-up duration ranged from 36 months [13, 14] to 49 months [11]. The 3-year overall survival (OS) rates demonstrated considerable variability, spanning from 60.3% for laparoscopic surgery in elderly patients [12] to 88.9% for transanal total mesorectal excision (TaTME) [14]. Similarly, local recurrence-free survival (LRFS) ranged from 75% in laparoscopic surgery cohorts [11] to 88.1% in TaTME patients [14], highlighting the impact of surgical technique on oncologic outcomes. Notably, Sueda et al. [11] reported that elderly patients faced significantly worse prognoses, including higher local recurrence rates and reduced OS, cancer-specific survival, and LRFS compared to younger cohorts. This contrasted with findings by Takahashi et al. [12], which revealed no significant difference in 5-year OS between laparoscopic and open colectomy, suggesting comparable long-term efficacy for both approaches in selected populations. Studies evaluating TaTME consistently reported favorable long-term results. Völkel et al. [13] observed a low local recurrence rate (3 cases over a median follow-up of 2.7 years), underscoring the procedure's precision in achieving clear resection margins. Grundler et al. [14] further reinforced these findings, noting that TaTME effectively addressed the anatomical complexities of low rectal surgery, with only 8 patients experiencing recurrence and achieving exceptional 3-year LRFS (88.1%) and OS (88.9%). These outcomes position TaTME as a promising technique for optimizing tumor control in challenging rectal cancer cases. For patients aged 80 years or older, laparoscopic surgery demonstrated distinct advantages over open procedures. Rossi et al. [15] found that laparoscopy was associated with a significantly lower 90-day mortality rate, shorter postoperative hospital stays, and improved overall and disease-free survival. These benefits suggest that minimally invasive approaches may be particularly advantageous for elderly patients, who often face higher risks of postoperative complications and prolonged recovery.

Discussion

The findings of this systematic review highlight the long-term impact of MIS techniques, particularly laparoscopic surgery and TaTME, on elderly patients with CRC. However, patients in the elderly exhibited significantly worse outcomes, including higher recurrence rates and poorer survival metrics, emphasizing the need for careful patient selection and tailored post-operative management. Laparoscopic surgery, in particular, demonstrated comparable long-term survival outcomes to open colectomy, suggesting that it is a viable and potentially superior alternative due to its benefits of reduced hospital stay and lower perioperative mortality, particularly in patients aged 80 years and older. Consistent with our findings, Buyia *et al.* reported that the long-term results of open surgery and laparoscopic surgery for colon cancer are same [16]. However, there are not enough included patients or published researches for rectal cancer to make any valid inferences. The surgical technique for laparoscopic CRC resection is not totally standardized due to variations in approach (lateral to medial vs. medial to lateral mobilization), patient posture, extraction sites, and intra-versus extracorporeal connections. One of the most challenges may be determining which patients are unsuitable for a

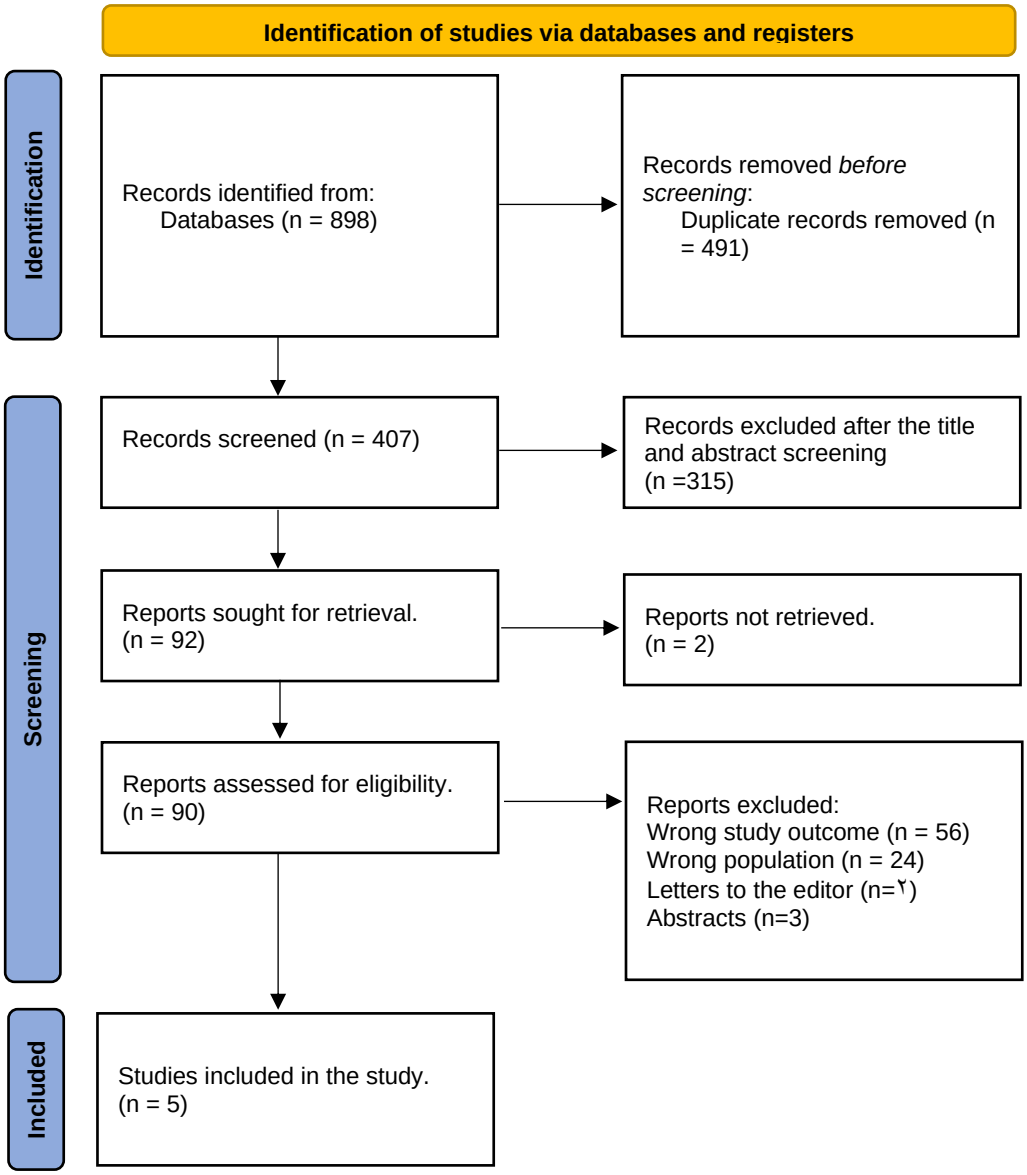

Figure 1: PRISMA flowchart [10].

Table 1: Outcome measures of the included studies.

Study ID	Country	Study design	Sociodemographic	Surgery	Follow-up (months)	3-year OS (%)	LRFS (%)	Main outcomes
Sueda et al., 2021 [11]	Japan	Retrospective cohort	Cases: 730 Median age: 71 Females: 414 (55.2%)	Laparosco-pic surgery	49	82%	75%	The elderly experienced worse outcomes, including a higher rate of local recurrence compared to the non-elderly. OS, cancer-specific survival, and LRFS were significantly shorter in the elderly.
Takahashi et al., 2021 [12]	Japan	Retrospective cohort	Cases: 242 Median age: 83 Y Females: 118 (48.7%)	Laparosco-pic surgery	NM	60.30 %	NM	Long-term results showed no discernible difference in 5-year OS between the groups that underwent laparoscopic and open colectomy.
Völkel et al., 2022 [13]	Germany	Retrospective cohort	Cases: 100 Med age: 62.9 Y Females: 65 (65%)	TaTME	36	82.90 %	81.9 %	TaTME is linked to positive long-term results. There were only three individuals who experienced a local recurrence at the median follow-up period of 2.7 years.
Grundler et al., 2024 [14]	Germany	Retrospective cohort	Cases: 378 Med age: 61.1 Y Females: 272 (72%)	TaTME	36	88.90 %	88.1 %	TaTME is linked to positive long-term outcomes and is successful in resolving the technical and anatomical difficulties of low rectal surgery. Eight people experienced local recurrence, resulting in an 88.1% 3-year LRFS rate. 88.9% was the 3-year OS rate.
Rossi et al., 2020 [15]	UK	Retrospective cohort	Cases: 293 Median age: 83 Y Females: 144 (49.1%)	Laparosc opic surgery	NM	72.40 %	NM	When compared to open procedures, laparoscopic surgery for patients in their 80s is associated with a much lower 90-day mortality rate, a shorter post-operative length of stay, and higher overall and disease-free survival.

*TaTME= Transanal Total Mesorectal Excision *NM=Not-mentioned

Table 2: Risk of bias assessment using ROBINS-I.

Study ID	Bias due to confounding	Bias in the selection of participants into	Bias in the classification of interventions	Bias due to deviations from the intended interval	Bias due to missing data	Bias in the measurement of outcomes	Bias in the selection of reported result	Overall bias
Sueda et al., 2021 [11]	Low	Low	Mod	Low	Low	Low	Mod	Low
Takahashi et al., 2021 [12]	Mod	Low	Low	Low	Low	Low	Low	Low
Völkel et al., 2022 [13]	Mod	Low	Mod	Low	Mod	Mod	Low	Moderate
Grundler et al., 2024 [14]	Mod	Mod	Low	Low	Low	Mod	Low	Moderate

successful laparoscopic resection. The overwhelming body of evidence indicates that switching to open surgery results in worse oncological outcomes and increased morbidity, such as adhesional blockage and incisional hernia [17]. Body habitus, prior surgery, surgeon expertise, and locally advanced disease are all positive predictors of conversion. There is disagreement over the usefulness of reproducible radiographic metrics, such as magnetic resonance imaging (MRI) pelvimetry [18]. Our results indicate that MIS approaches are generally associated with favorable survival outcomes, with TaTME demonstrating the highest 3-year OS and LRFS rates. On the other hand, TaTME showed promising results in addressing the technical challenges of low rectal cancer, resulting in lower recurrence rates and improved oncological outcomes. These findings align with the growing body of evidence supporting MIS approaches as safe and effective treatment options for elderly CRC patients. TaTME blends conventional laparoscopic or robotic abdominal surgery with transanal mesorectal excision and specimen extraction. TaTME combined the better ergonomics of standard laparoscopy with some of the difficulties associated with getting good views and retraction for dissection in a tight, challenging pelvis [7]. The TaTME was made possible by Sylla [19] initial description of NOTES transanal rectosigmoid excision utilizing a transanal endoscopic microsurgery system in human cadavers [20] and thereafter in a rectal cancer patient. The approach was swiftly adopted by many locations worldwide. Telem et al. further supported the results of a 2016 meta-analysis of seven short episodes, which showed much higher rates of complete TME and significantly lower rates of circumferential resection margin positive, using data from the TaTME collaborative registry [21].

Strengths and limitations: In order to evaluate the long-term effects of MIS procedures in older CRC patients, this review offers a thorough synthesis of the information currently available, based on many retrospective cohort studies. A key strength of this analysis is its focus on an older population, a group often underrepresented in surgical oncology research. By evaluating both laparoscopic surgery and TaTME. The study offers valuable insights into the relative benefits of these approaches for different tumor locations and patient subgroups. However, several limitations must be acknowledged. All included studies were retrospective in nature, which introduces the potential for selection bias and limits the ability to draw causal conclusions. The variation in follow-up duration across studies also presents a challenge in directly comparing long-term outcomes. Additionally, the absence of randomized controlled trials (RCTs) restricts the strength of the evidence, as RCTs would provide more robust comparisons between surgical approaches. Another notable limitation is the lack of data on functional recovery and quality of life, which are particularly relevant considerations for elderly patients undergoing surgery. Addressing these gaps in future research will be essential in refining MIS strategies and maximizing patient-centered outcomes.

Conclusion

This systematic review supports the growing adoption of MIS techniques for CRC in elderly patients, particularly laparoscopic surgery and TaTME. Laparoscopic surgery offers comparable long-term survival outcomes to open colectomy, while TaTME appears to provide superior oncological control in low rectal cancer. To enhance long-term results for older CRC patients, future research should focus on improving perioperative care and patient selection criteria.

Conflict of Interest

None

Funding

None

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