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Mechanical vs. Manual Anastomosis in Colorectal Cancer Surgery: A Comparative Analysis

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Rezumat

Anastomoza mecanică vs. manuală în chirurgia cancerului colorectal: o analiză comparativă

Introducere: cancerul colorectal este o afecțiune frecventă şi gravă, rezecția chirurgicală fiind tratamentul principal pentru cazurile localizate. Dehiscența anastomotică (DA) rămâne o complicație postoperatorie semnificativă, iar anastomozele sunt realizate fie prin sutură manuală, fie mecanic, fiecare având beneficii şi provocări.
Material şi Metode: acest studiu retrospectiv a analizat 100 de pacienți cu cancer rectal care au suferit rezecție chirurgicală, cu anastomoze efectuate prin sutură manuală (n=50) sau mecanic (n=50). Rezultatele primare au inclus ratele de fistule şi complicațiile postoperatorii, iar cele secundare au vizat durata intervenției, perioada de spitalizare şi calitatea vieții.
Rezultate: anastomoza mecanică a redus timpul procedurii (15 ± 5 minute vs. 30 ± 5 minute; $p < 0.01$) şi a îmbunătățit calitatea vieții la 12 luni (HQI: 87 vs. 75; $p < 0.01$). Incidența fistulelor a fost mai mare la pacienții cu sutură manuală față de sutura mecanică, dar fără diferențe semnificative (12% vs. 22%; $p = 0.29$). Anastomoza mecanică a redus perioada de spitalizare (12,66 vs. 13,58 zile), dar cea manuală a permis recuperarea mai rapidă a tranzitului intestinal (82% vs. 76%).

Concluzii: anastomoza mecanică este eficientă, dar cea manuală rămâne utilă în cazuri complexe. Alegerea tehnicii trebuie adaptată fiecărui pacient.

Cuvinte cheie: cancer colorectal, dehiscienţa anastomotică, fistula anastomotică, cancer de rect

Abstract

Background: colorectal cancer is a common and serious condition, with surgical resection being the primary treatment for localized cases. Anastomotic dehiscence (AD) remains a significant post-operative complication, and anastomoses are typically created using either manual suturing or mechanical stapling, each with specific benefits and challenge.

Material and Methods: this retrospective study analyzed outcomes in 100 rectal cancer patients who underwent surgical resection, with anastomoses performed via manual suturing (n=50) or mechanical stapling (n=50). Primary outcomes included fistula rates, postoperative complications, and recovery metrics. Secondary outcomes focused on operative time, hospital stay and quality of life.

Results: mechanical anastomosis reduced procedure time (15 ± 5 minutes vs. 30 ± 5 minutes; $p < 0.01$) and improved quality of life at 12 months (HQI: 87 vs. 75; $p < 0.01$). The incidence of fistulas was higher in patients with manual suturing compared to mechanical suturing, but without significant differences (12% vs. 22%; $p = 0.29$). Mechanical anastomosis shortened the hospitalization period (12.66 vs. 13.58 days; but manual suturing allowed for faster recovery of intestinal transit (82% vs. 76%).

Conclusions: mechanical anastomosis is more efficient, but manual anastomosis remains valuable in complex cases. Technique selection should be tailored to individual patient needs and surgical conditions.

Key words: colorectal cancer, anastomotic dehiscence, anastomotic fistula, rectal cancer

Introduction

Colorectal cancer is a leading global health concern, ranking as the third most frequently diagnosed cancer and the second most common cause of cancer-related mortality. In 2020, over 1.9 million new cases were diagnosed, with nearly 935,000 deaths worldwide (1). Despite ongoing advancements in understanding the biology of colorectal cancer and the development of neo-adjuvant therapies for specific cancer stages, surgical resection remains the cornerstone of treatment for achieving curative outcomes in localized disease (2-4). Successful resection requires a secure anastomosis, which is critical for ensuring positive surgical outcomes (5). However, anastomotic dehiscence continues to be one of the most significant postoperative challenges, leading to complications such as increased morbidity, prolonged hospital stays, and heightened mortality (2,6,7). This complication remains a primary concern for surgeons and healthcare providers, necessitating continued research into prevention and management strategies.

Anastomotic dehiscence, also named anastomotic leak, is defined as disruption in the continuity of intestinal anastomosis associated with leakage of the luminal contents into the peritoneal cavity. Incidence ranges between 2% and 19% depending on the location of the anastomosis, with higher incidence in low rectal anastomoses (8,9). AD leads to severe complications such as intra-abdominal sepsis, reoperation, prolonged hospitalization, and, in

extreme circumstances, mortality rates reaching as high as 30-40%. The outcomes are better if there is early detection and treatment (10-12).

Manual and mechanical anastomosis are the two primary techniques used in colorectal surgery to rejoin bowel segments after resection. Manual anastomosis involves the surgeon suturing the bowel segments together, typically in a single or double-layer fashion. This method provides the surgeon with maximum control and precision, which is especially beneficial when working in challenging anatomical regions or narrow spaces . It allows for a high degree of customization to the individual patient's anatomy. However, manual anastomosis is more time-consuming compared to its mechanical counterpart and requires a high level of surgical skill and experience (13-16).

In contrast, mechanical anastomosis utilizes staplers to join the bowel segments, which is a faster and more reproducible method. The use of staplers ensures consistency in the construction of the anastomosis, particularly in terms of the size and integrity of the staple line. This makes it a preferred method in many surgical centers, especially for those that perform high volumes of procedures. Mechanical anastomosis also offers distinct advantages in minimally invasive surgery, including laparoscopy and robotic-assisted techniques (16,17). However, despite these advantages, mechanical anastomosis is not without its concerns. One of the primary issues is the potential for leakage at the staple line, which can lead to serious complications, including infection and sepsis. This risk is particularly pronounced when tissues are acutely edematous, friable, or compromised by factors such as radiation therapy or advanced disease. Leakage at the staple line can undermine the benefits of a faster, more efficient procedure, necessitating vigilant monitoring and, in some cases, re-operation. As a result, while mechanical anastomosis offers speed and consistency, it also requires careful consideration of the patient's specific condition and the surgeon's experience with stapling devices (14,16,18).

Current Debate: Which Technique is Superior?

For many years, there has been ongoing debate about which anastomotic technique - manual or mechanical - is superior in preventing AD. The literature presents conflicting data regarding the effectiveness of each technique in reducing this complication. Some studies suggest that mechanical anastomosis is associated with a lower rate of anastomotic leakage, particularly in low anterior resections (19,20). The precision and consistency of staplers may contribute to this reduced leakage rate. A meta-analysis concluded that stapled colorectal anastomoses have a slightly lower risk of leakage compared to hand-sewn techniques, especially in low rectal resections (17,21).

On the other hand, other reports advocate that manual anastomosis can yield better outcomes, particularly for patients with fragile bowel tissue or inflammation (22). Manual suturing allows for more individualized tension and vascular adjustments at the anastomosis site, which can be crucial in these cases (23,24). Results from a randomized controlled trial by Karliczek et al. found no clinically significant difference in anastomotic leak rates between manual and mechanical techniques in colorectal surgery (25). Additionally, factors such as tumor location, patient characteristics (including age, body mass index, and comorbidities), and the underlying pathology all influence the risk of AD. As a result, the choice of technique is often based on the specific clinical scenario and the surgeon's expertise (26,27).

Anastomotic dehiscence remains one of the key challenges in colorectal cancer surgery. Both mechanical and manual anastomoses offer distinct advantages and risks. While mechanical anastomosis has gained widespread acceptance for its speed and reproducibility, manual anastomosis remains relevant, especially in complex cases where a more tailored approach is needed. Further research is required to identify the optimal approach to reduce AD and improve patient outcomes following colorectal cancer surgery (28).

This paper aims to make a descriptive comparison between mechanical and manual anastomosis after rectal resection in elective surgery.

Materials and Methods

Study Design

This study is a retrospective, descriptive analysis designed to compare the outcomes of mechanical versus manual suturing techniques in rectal cancer surgery. A cohort of 100 patients diagnosed with rectal cancer and undergoing colorectal termino-terminal anastomosis was enrolled. These patients were admitted to the surgical department of the Clinical Nephrology Hospital Dr. Carol Davila in Bucharest, Romania, between January 2021 and December 2022. The study aimed to assess various surgical outcomes, including complications, recovery time, and long-term results. All participants provided informed consent before enrolling in the study, ensuring ethical standards were met. Additionally, the study was approved by the local institutional review board, which ensured that all research protocols adhered to rigorous ethical guidelines for patient care and confidentiality. The inclusion of patients was based on specific criteria, ensuring that the results accurately reflect the impact of the anastomosis techniques on rectal cancer surgery outcomes.

Patient Population

Inclusion Criteria:

- Diagnosis of rectal cancer requiring colorectal resection with an anastomosis.
- Age greater than 18 years.
- No history of previous major abdominal surgery involving the colon or rectum.
- Eligible for either manual or mechanical anastomosis.

Exclusion Criteria:

- Patients undergoing emergency surgery or requiring urgent intervention.
- Severe comorbidities or contraindications for surgery.
- Incomplete clinical records or failure to provide informed consent.

A total of 100 patients diagnosed with rectal cancer were enrolled in the study. These patients were divided into two groups of 50 patients each, with one group receiving manual anastomosis and the other receiving mechanical anastomosis.

- Manual Anastomosis Group: fifty patients underwent hand-sewn anastomosis, performed by a single surgical team using standard suturing techniques. All anastomoses were performed in a single-layer continuous fashion, following accepted colorectal surgical practices.
- Mechanical Anastomosis Group: fifty patients underwent colorectal anastomosis with a circular stapler. The use of mechanical stapling followed standard surgical guidelines, with a circular stapling device used to achieve end-to-end anastomosis.

Both groups received colorectal termino-terminal anastomoses, and the same surgical team conducted all procedures to ensure consistency and reduce inter-surgeon variability.

Outcomes

Primary Outcomes:

- Postoperative Fistula Rate: Fistula rate = No of patients with fistula/Total No of patients. The anastomotic dehiscence rate in colorectal cancer is defined as the proportion of patients undergoing colorectal anastomosis after cancer resection who experience a clinically or radiologically confirmed disruption of the anastomotic integrity. This condition may manifest as the leakage of gas, enteral contents, or purulent fluid through a drainage system or as extraluminal contrast on imaging studies. The presence of a fistula was confirmed through clinical examination, imaging studies (such as contrast-enhanced computed tomography), or visual confirmation during re-intervention surgery, if necessary.
- Postoperative Complications: any complica-

tion arising during the postoperative period, including bleeding, infection, or reoperation, was recorded.
- Overall Survival: patient survival was tracked from the time of surgery through the study period, with follow-up assessments at 30 days, 6 months, and 12 months.

Secondary Outcomes:

- Length of Surgery: the time from the initial incision to wound closure was recorded in minutes for each patient.
- Length of Hospitalization: the number of days from surgery to hospital discharge was documented for each patient.
- Postoperative Pain: measured using the Visual Analog Scale (VAS).
- Patient-Reported Quality of Life: Assessed using the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire (EORTC QLQ-C30) at 6 and 12 months postoperatively, measuring physical, emotional, and social well-being.

Data Collection and Statistical Analysis

Demographic data, including age, sex, body mass index (BMI), preoperative clinical status (ASA score), and tumor characteristics (location, size, stage), were collected for each patient. Postoperative complications were monitored, and follow-up assessments occurred at routine intervals: 30 days, 6 months, and 12 months. Descriptive statistics were used to summarize baseline characteristics, and differences in outcomes between the two anastomotic techniques were assessed using Chi-square tests for categorical variables and t-tests for continuous variables. Statistical significance was set at $p < 0.05$.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki and all applicable regulatory requirements. The confidentiality of patient data was maintained throughout the study, and all participants were informed of their right to withdraw at any time without consequence.

Results

Procedure Duration for Colorectal Anastomosis

The average time required to complete a colorectal anastomosis varies significantly between manual and mechanical techniques. For the manual separate thread technique, the procedure typically takes about 30 ± 5 minutes, while the mechanical stapling technique reduces this time to 15 ± 5 minutes. This difference represents a 50% reduction in procedural time ($p < 0.01$), highlighting the efficiency and time-saving potential of mechanical anastomosis. The reduction in time is particularly valuable in high-volume surgical settings, where operational efficiency can directly impact clinical workflow, reduce anesthesia exposure, and improve operating room turnover.

Further analysis of the total operative time (from incision to closure) shows a clear disparity between the two techniques. Surgeries utilizing manual anastomosis averaged 2.9 hours, whereas those employing mechanical anastomosis were completed in approximately 2.3 hours. This 0.6-hour (36-minute) reduction in surgical duration with mechanical anastomosis is significant ($p < 0.01$) and further underscores the time-saving advantage offered by stapling techniques. The mechanical method's consistent and rapid performance can lead to reduced operating room time, potentially lowering costs and improving patient throughput, particularly in institutions with high patient volumes. This time difference not only enhances the efficiency of surgical procedures but may also contribute to better resource allocation and cost-effectiveness in colorectal surgery settings.

Anastomotic Fistula

Anastomotic Fistula and Type of Anastomosis

The incidence of anastomotic fistula varied between the manual and mechanical anastomosis groups. In the group that underwent

manual anastomosis, a higher rate of fistula formation was observed, with 22% of patients developing an anastomotic leak. This relatively higher incidence can be attributed to the inherent challenges of manual suturing, which requires meticulous attention to detail and precise suture placement. Manual techniques, while offering greater control in specific situations, can also result in increased variability in the suture quality and tissue handling, potentially leading to greater risk of leaks.

In contrast, the group that received mechanical anastomosis, using a circular stapler, experienced a 12% incidence of fistulas. The lower incidence in this group suggests that the mechanical stapling technique may provide a more consistent and secure closure, thanks to the precision and uniformity of the stapler, which minimizes variations in suture tightness and placement. The stapling technique generally ensures a more uniform approximation of bowel edges, reducing the likelihood of leakage and improving the overall integrity of the anastomosis.

However, despite these differences, the statistical analysis revealed that the difference in fistula rates between the two groups was not statistically significant (p=0.29), indicating that while mechanical anastomosis showed a lower incidence of fistulas, the overall effect was not large enough to be considered significant.

Analysis of Anastomotic Fistulas and Preoperative Radiotherapy

The data indicate that a significant proportion of patients who developed anastomotic fistulas had received preoperative radiation therapy - 81% in the manual anastomosis group and 66% in the mechanical anastomosis group. These high percentages suggest a potential association between preoperative radiotherapy and the increased incidence of fistula formation in colorectal surgeries. Although the difference in the rates of pre-operative radiation therapy between the groups was observed, statistical analysis revealed that this difference was not statistically significant (p = 0.92). This indicates that, while a higher proportion of patients who developed fistulas had undergone radiation therapy, the association did not reach statistical significance in this sample.

Differences Between Manual and Mechanical Anastomosis in Timing and Incidence of Postoperative Fistula Formation

In this study, we observed distinct patterns in the timing and incidence of postoperative fistula formation between the manual and mechanical anastomosis groups. These differences underscore the varying degrees of risk associated with each technique during the early and later postoperative periods.

In the manual anastomosis group, the incidence of fistulas was notably higher during the second to fourth postoperative days, with 7 cases (14%) identified in this early period. This suggests that the manual technique may be particularly vulnerable in the immediate postoperative phase. The need for precise suture placement in manual anastomosis places significant stress on the tissue, potentially compromising its integrity and leading to complications such as fistula formation. The manual technique requires meticulous attention to tissue handling and suture placement, and minor variations in technique may contribute to increased risk during the early healing stages.

Furthermore, in the extended postoperative window from 5 to 7 days, an additional 4 cases of fistulas occurred. This continued vulnerability indicates that while some initial healing may have occurred, manual anastomosis may still be prone to complications due to the ongoing demands placed on tissue during the healing process. The reliance on hand-sewn suturing techniques, although offering precise control, may not provide the same level of consistent and secure closure as mechanical methods, making the anastomosis more susceptible to failure during this critical phase.

In contrast, the mechanical anastomosis group exhibited a slightly lower incidence of fistulas in the early postoperative period, specifically between the second and fourth days, with 4 cases (8%). This reduction in incidence can be attributed to the inherent consistency and security offered by the stapling technique. Mechanical stapling provides a uniform, reliable seal that is less prone to variation compared to manual suturing, which may contribute to a more stable anastomosis site during the critical early stages of recovery.

Despite the advantages of mechanical stapling, fistula formation was not completely eliminated. In the 5-7 day postoperative window, the incidence dropped further, with only 2 cases of fistula formation. This suggests that the mechanical method may offer some protection against early complications, as the stapled anastomosis is less susceptible to failure once the healing process stabilizes. The lower incidence of fistulas in the later period further supports the idea that the mechanical anastomosis technique provides a more stable and secure closure, which may facilitate better healing and reduce the likelihood of complications in the extended postoperative phase.

Relationship Between Anastomotic Dehiscence and Anastomotic Height

An analysis of the relationship between anastomotic dehiscence and anastomotic height in rectal cancer patients underscores the significant impact of anastomotic location on postoperative complications.

Among the 11 patients who developed an anastomotic fistula from manual anastomosis group, 55% (6 patients) had low anastomoses situated 5-6 cm from the anal verge. This suggests a potential association between lower anastomotic height and an increased risk of dehiscence. Anastomoses closer to the anal verge may experience greater mechanical stress during the postoperative period, including elevated intraluminal pressure and heightened sphincter activity. These factors can compromise anastomotic integrity, contributing to higher fistula formation rates in this subgroup.

In the mechanical anastomosis group, 6 patients experienced anastomotic dehiscence, with 50% (3 patients) involving low anastomoses at 5-6 cm from the anal verge. This consistency across both groups reinforces the hypothesis that lower anastomotic sites are inherently more susceptible to dehiscence, irrespective of the anastomosis technique employed. Notably, the overall incidence of dehiscence is lower in the mechanical anastomosis group compared to the manual group, suggesting that mechanical techniques may offer additional protective benefits, even in anatomically challenging cases.

Management of Anastomotic Fistulas

Regarding the management of anastomotic fistulas, notable differences were observed between the manual and mechanical anastomosis groups. These differences shed light on variations in complication severity and the clinical strategies adopted to address them, providing valuable insights into the outcomes associated with each surgical technique.

In the manual anastomosis group, 11 patients experienced anastomotic fistulas. Of these, 7 patients (64%) with minor fecal leakage were successfully managed conservatively, employing strategies such as vigilant clinical monitoring, minimal stercoral drainage, and close observation for signs of systemic infection. The success of conservative management in these cases suggests that the leaks were localized and did not progress to significant tissue necrosis or systemic complications. However, 4 patients (36%) required surgical reintervention due to severe complications, including acute abdomen and stercoral peritonitis. In these cases, re-intervention involved rectal transection closure and the formation of a temporary colostomy to manage contamination and stabilize the patient.

In contrast, the mechanical anastomosis group included 6 patients with anastomotic fistulas. Among them, 5 patients (83%) with minor fecal leakage were successfully treated

conservatively, using clinical monitoring and minimal drainage similar to the manual group. These patients did not experience progression to widespread infection or severe peritoneal involvement. However, 1 patient (17%) required surgical reintervention due to stercoral peritonitis, necessitating the creation of a temporary colostomy to control contamination and stabilize the patient.

While the surgical reintervention rate was higher in the manual anastomosis group (36%) compared to the mechanical group (17%), the difference was not statistically significant ($p = 0.60$). This suggests that the disparity in outcomes may be attributed to chance rather than a definitive advantage of one technique over the other.

All of this was be highlighted in the *Table 1*, offering a clear and concise summary of the key findings regarding anastomotic fistulas between the two techniques employed.

Other Postoperative Complications

Pelvic abscesses were an exclusively observed complication in the manual anastomosis group, with an incidence of 2 cases, accounting for 4% of the patients in this cohort. These abscesses developed secondary to anastomotic fistulas and were managed through ultrasound-guided drainage performed via minimally invasive surgical techniques. This finding suggests that manual suturing may predispose patients to a heightened risk of pelvic infections, particularly in the context of anastomotic leaks. The complete absence of pelvic abscesses in the mechanical anastomosis group implies that the stapling technique may confer a superior ability to achieve a watertight closure, thereby mitigating the risk of postoperative pelvic infections. Further investigation into the underlying biomechanical differences between these techniques is warranted to substantiate this hypothesis.

Postoperative bleeding, characterized by diffuse hemorrhage without an identifiable focal source, was documented in both groups and necessitated surgical reintervention to achieve hemostasis. In the manual anastomosis group, four patients (8%) experienced significant postoperative bleeding accompanied by hematoma formation. This slightly elevated rate of hemorrhagic events may be attributable to the greater degree of tissue handling and vascular trauma intrinsic to the manual suturing process. The meticulous nature of the suturing technique may inadvertently increase the likelihood of vascular injury, underscoring the necessity for refined operative techniques in such cases. In the mechanical anastomosis group, three patients (6%) presented with postoperative bleeding requiring surgical intervention. While the incidence was marginally lower compared to the manual group, the occurrence of such complications highlights the universal need for vigilant intraoperative and postoperative monitoring, regardless of the anastomotic technique employed.

Wound-related complications were reported in both the manual and mechanical anastomosis groups, with some variations in incidence rates between the two techniques. Wound suppuration was observed in 8% of patients in the manual anastomosis group compared to 6% in the mechanical group. In both cohorts, these infections were effectively managed with drainage and antibiotic therapy, preventing

Table 1. Key findings regarding anastomotic fistulas.

Parameter		Manual Anastomosis	Mechanical Anastomosis
Incidence of Fistulas		22% (11 patients)	12% (6 patients)
Preoperative Radiotherapy	With Radiotherapy	81% (9 patients)	66% (4 patients)
	Without Radiotherapy	19% (2 patients)	34% (2 patients)
Timing	Fistulas (2-4 days)	14% (7 patients)	8% (4 patients)
	Fistulas (5-7 days)	8% (4 patients)	4% (2 patients)
Height	Low Anastomoses (5-6 cm)	55% (6 patients)	50% (3 patients)
Management	Conservative Management	64% (7 patients)	83% (5 patients)
	Surgical Reintervention	36% (4 patients)	17% (1 patient)

progression to severe soft tissue infection. Wound hematoma was rare in both groups, with a slightly higher incidence in the manual group (6%) compared to the mechanical group (2%). None of the cases necessitated surgical reintervention, indicating that conservative measures were sufficient for resolution. Wound seroma emerged as the most prevalent wound complication, with an incidence of 16% in the manual group and 10% in the mechanical group. Seromas were managed through daily evacuation, leading to prompt resolution in all cases without adverse long-term outcomes. The higher frequency of seromas in the manual group could reflect the increased tissue handling and disruption associated with manual suturing (*Table 2*).

Although the manual anastomosis group demonstrated slightly higher rates for some complications, none of the differences between the two techniques reached statistical significance. This statistical irrelevance highlights the comparable overall safety profiles of the manual and mechanical anastomosis techniques, underscoring that the choice of method should be guided by patient-specific factors and surgeon expertise rather than an assumed difference in complication rates.

Analysis of Intestinal Transit Recovery

Recovery patterns in intestinal transit demonstrated significant differences between the manual and mechanical anastomosis techniques, with the outcomes favoring the manual approach in terms of speed and overall efficiency.

Patients undergoing manual anastomosis exhibited a quicker recovery of bowel function. Specifically, 82% of patients resumed gas transit by the fourth postoperative day, and 70% restored fecal transit by days four to five. This suggests that manual suturing has minimal impact on bowel motility, likely due to reduced manipulation of the intestines during surgery. The more precise handling associated with manual anastomosis may contribute to this expedited recovery process. Recovery in the mechanical group was comparatively slower. Gas transit returned more gradually over the first postoperative week, with 24% of patients not resuming fecal transit until after the seventh day. This delay could be attributed to technique-related factors, such as the biomechanical properties of stapled anastomoses, or to variations in postoperative management practices that may have influenced recovery dynamics.

Morbidity and Mortality in Relation to Anastomotic Dehiscence

The interplay between morbidity, mortality, and anastomotic dehiscence reveals crucial distinctions between manual and mechanical anastomosis techniques in colorectal surgery. Anastomotic dehiscence, a significant complication, often dictates postoperative outcomes, influencing patient recovery, healthcare costs, and overall survival.

The manual anastomosis group exhibited a morbidity rate of 46% and a mortality rate of 4%, likely influenced by a higher rate of anastomotic dehiscence. The variability inherent to hand-sewn sutures may elevate the risk of dehiscence, leading to complications such as infection and sepsis, which significantly contribute to morbidity and mortality. These outcomes underscore the importance of surgical precision, as factors such as the

Table 2. Other postoperative complications

Complication	Manual Anastomosis Group (n=50)	Mechanical Anastomosis Group (n=50)	Management Strategy
Pelvic Abscess	2 (4%)	0	Ultrasound-guided drainage
Postoperative Bleeding	4 (8%)	3 (6%)	Surgical reintervention
Wound Suppuration	4 (8%)	3 (6%)	Drainage and antibiotics
Wound Hematoma	3 (6%)	1 (2%)	Conservative measures
Wound Seroma	8 (16%)	5 (10%)	Daily evacuation

surgeon's skill and the patient's tissue quality play critical roles in determining the success of the anastomosis.

In contrast, the mechanical group demonstrated a morbidity rate of 38% and a mortality rate of 2%, reflecting lower complication rates overall. The consistent and secure seal provided by mechanical stapling devices likely reduces the risk of anastomotic dehiscence, leading to fewer severe postoperative complications. This improved anastomotic integrity translates into reduced incidences of life-threatening conditions such as peritonitis and sepsis, which are often associated with dehiscence.

Postoperative Pain Levels Analysis

Postoperative pain levels, assessed using the Visual Analog Scale (VAS), revealed a minor difference between the manual and mechanical anastomosis groups. While the scores indicated a slight variation in pain perception, the difference was not statistically significant, suggesting that both groups experienced comparable levels of postoperative discomfort.

Patients in the manual anastomosis group reported an average VAS pain score of 4.5, reflecting a modestly higher level of postoperative pain compared to the mechanical group. This slightly elevated pain level may be attributed to increased tissue manipulation and handling during the suturing process, which could lead to greater localized inflammation and tenderness at the surgical site. On the other hand, patients in the mechanical anastomosis group reported a lower average VAS pain score of 4.0. This marginal reduction in pain could be associated with the use of stapling devices, which likely minimized tissue trauma and reduced nociceptive stimulation. However, the observed difference in pain scores does not appear to be clinically significant, indicating that both techniques result in similar postoperative pain experiences.

Hospitalization Overview

The analysis of hospitalization revealed similar overall durations between the manual and mechanical anastomosis groups, with slight variations in specific phases of care. The total hospital stay was nearly identical in both groups, with the manual group averaging 19.04 days and the mechanical group averaging 19.12 days. This similarity suggests that the type of anastomosis does not meaningfully influence the overall duration of hospitalization. While there are minor numerical differences, they are not clinically significant, indicating comparable outcomes between the two techniques.

In terms of postoperative hospital stay, patients in the mechanical group demonstrated a slightly shorter average duration of 12.66 days compared to 13.58 days in the manual group. This trend toward faster recovery in the mechanical group may be attributed to procedural efficiencies associated with mechanical stapling, such as reduced intraoperative trauma or quicker initial healing. However, the small difference in postoperative stay does not suggest a substantial advantage for either technique.Conversely, the ICU stay was longer in the mechanical group, averaging 6.12 days compared to 5.40 days in the manual group. The extended ICU stay for the mechanical group may reflect a greater need for postoperative monitoring or differences in patient profiles, such as comorbidities or intraoperative complications. Despite this difference, it does not appear to have a significant impact on overall hospitalization outcomes (*Fig. 1*).

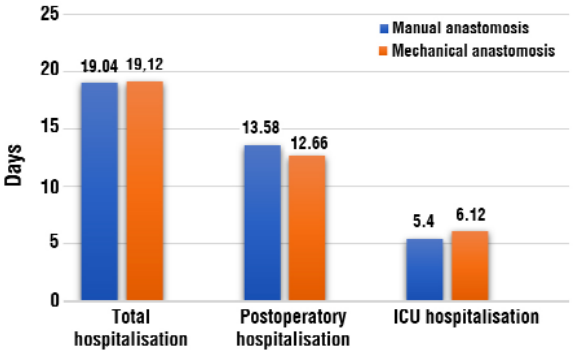

Figure 1. Hospitalization Overview

Long-Term Survival and Quality of Life

Early Survival

At 1, 3, and 6 months after discharge, the manual and mechanical anastomosis groups demonstrated slightly different survival rates. The manual anastomosis group showed a 96% survival rate (2 patients deceased), while the mechanical anastomosis group exhibited a 98% survival rate (1 patient deceased). These findings indicate a small early difference in outcomes between the two techniques.

Long-Term Survival Trends

A divergence in survival rates emerged over time. By 12 months, survival in the manual group decreased slightly to 90% (45 patients), while the mechanical group maintained a higher survival rate of 96% (48 patients). This difference may reflect variations in factors such as long-term complications, patient-specific conditions, or the durability of the anastomosis over time.

Quality of Life

The study highlighted significant differences in quality of life at 12 months post-surgery between patients undergoing mechanical and manual anastomosis, as measured by the HQI. The mechanical anastomosis group demonstrated improved long-term outcomes, maintaining an HQI score of 87, compared to a more pronounced decline to 75 in the manual anastomosis group. This difference was statistically significant ($p < 0.01$) and reflects the potential of mechanical stapling to provide superior postoperative quality of life.

The sustained HQI in the mechanical group may be attributed to factors such as reduced postoperative complications, greater anastomotic integrity, and faster recovery trajectories. Conversely, the greater decline observed in the manual group could indicate an increased burden of postoperative challenges, such as complications or slower functional recovery. These findings suggest that mechanical anastomosis offers tangible benefits in preserving health-related quality of life over the long term, potentially enhancing patient satisfaction and overall recovery outcomes.

Discussions

The two main techniques for creating colorectal anastomoses are manual suturing and mechanical stapling. Manual anastomosis allows for greater precision and customization, making it particularly valuable in challenging anatomical regions or cases with fragile tissues. However, it is time-intensive, technically demanding, and more prone to variability, relying heavily on the surgeon's expertise. Mechanical stapling, by contrast, offers speed, consistency, and reproducibility, making it the preferred method in high-volume and minimally invasive procedures (24). It provides uniform staple lines and reduces operative time, improving efficiency and recovery outcomes. However, it carries risks of staple line leakage, especially in cases with edematous or compromised tissues (29).

The debate over the superior technique remains unresolved. While mechanical stapling may reduce leakage rates in certain contexts, such as low anterior resections, manual suturing remains advantageous in complex cases requiring individualized adjustments. Factors like tumor location, patient anatomy, and comorbidities influence outcomes, making the choice of technique case-dependent. Despite advancements, anastomotic dehiscence continues to be a major challenge, requiring further research to refine techniques and improve surgical outcomes (13).

The significant disparity in procedural and total operative times between manual and mechanical anastomosis techniques underscores the critical role of efficiency in modern colorectal surgery. The mechanical stapling technique demonstrated a 50% reduction in anastomosis time compared to the manual separate thread method (15 ± 5 minutes vs. 30 ± 5 minutes; $p < 0.01$), emphasizing its potential to streamline surgical workflows. This reduction is particularly valuable in high-volume surgical centers, where time

efficiency directly influences anesthesia exposure, operating room turnover, and overall patient care. The broader impact of this efficiency is reflected in the total operative time. Surgeries utilizing mechanical anastomosis were completed approximately 36 minutes faster than those employing manual techniques (2.3 hours vs. 2.9 hours; $p < 0.01$). This time-saving advantage has significant implications for resource allocation, enabling surgical teams to handle more cases within the same time frame, thus optimizing operating room utilization and improving institutional throughput (30). In addition to operational benefits, reduced procedural times can contribute to better patient outcomes by minimizing anesthesia exposure and postoperative recovery times. These advantages are particularly relevant in institutions managing complex surgical cases or large patient volumes. While the upfront cost of stapling devices may be higher, the overall reduction in operative time, coupled with enhanced clinical efficiency, likely offsets these expenses, offering a cost-effective solution for colorectal surgery (31,32).

Another notable result concerns the incidence of anastomotic fistulas, a critical complication in colorectal surgery. The mechanical group exhibited a lower incidence of fistulas (12%) compared to the manual group (22%). Although this difference did not reach statistical significance ($p = 0.29$), the trend indicates that mechanical stapling may provide a more secure and consistent anastomotic closure. This consistency is particularly beneficial in ensuring an adequate seal and reducing variability, a common challenge with manual suturing, which relies heavily on the surgeon's skill and experience (33,34). However, the importance of manual suturing remains evident, especially in cases involving fragile or irradiated tissues. Manual techniques allow for greater customization and precise adjustments to the anastomotic site, which can be critical in anatomically complex or compromised situations (31,35,36). Protective ileostomies were not used in this series to avoid the risks and complications associated with stoma creation and reversal, such as dehydration, bowel obstruction, and morbidity. Additionally, the decision reflects a focus on optimizing surgical techniques and patient selection to minimize anastomotic dehiscence without reliance on diverting stomas.

Preoperative radiotherapy is a common adjunct in rectal cancer treatment, aiming to reduce tumor size and minimize local recurrence. However, its impact on anastomotic healing is a critical consideration for surgical outcomes. In this study, a substantial proportion of patients who developed anastomotic fistulas had undergone preoperative radiation therapy, with 81% in the manual anastomosis group and 66% in the mechanical group. Although the difference between these groups was not statistically significant ($p = 0.92$), the overall association between radiation therapy and an increased risk of fistula formation underscores the detrimental effects of radiotherapy-induced tissue changes on anastomotic healing. Radiation therapy can lead to several histopathological alterations in colorectal tissues, including endarteritis obliterans, submucosal fibrosis, and mucosal atrophy. These changes result in compromised vascularity and reduced tissue elasticity, impairing the normal healing process of anastomoses (37). The diminished blood supply hinders the delivery of essential nutrients and oxygen, which are vital for tissue regeneration and repair, thereby increasing the susceptibility to complications such as dehiscence and fistula formation. The clinical implications of these findings are significant. Anastomotic leaks and fistulas are associated with increased morbidity, prolonged hospitalization, and can adversely affect long-term survival. Therefore, understanding the impact of preoperative radiotherapy on anastomotic integrity is crucial for surgical planning and patient management (37,38). A multidisciplinary approach is essential when managing patients who have received preoperative radiotherapy. This involves close collaboration between surgeons, oncologists, and radiologists to carefully assess the extent of radiation-induced tissue damage and to plan the surgical

procedure accordingly. Considerations may include the selection of the anastomotic technique, with a preference for methods that minimize tension and ensure adequate blood supply, such as hand-sewn anastomoses in cases with significant tissue fibrosis. Additionally, the use of protective stomas may be contemplated to divert fecal flow and reduce the risk of anastomotic complications in high-risk patients (9,39).

Postoperative recovery metrics provided further insight into the differences between the two techniques. Manual anastomosis was associated with faster recovery of intestinal transit, with 82% of patients resuming gas transit by the fourth postoperative day, compared to 76% in the mechanical group. This suggests that the manual technique, despite its longer procedural time, may have less impact on bowel motility, potentially due to reduced manipulation of the intestines during surgery. However, mechanical anastomosis demonstrated an advantage in terms of postoperative hospitalization, with patients discharged slightly earlier (12.66 days vs. 13.58 days for the manual group). Although this difference was not statistically significant, it highlights the potential for mechanical techniques to contribute to a smoother postoperative recovery trajectory. These findings suggest that both techniques offer distinct benefits, and the choice may depend on the specific postoperative outcomes prioritized in individual cases (40).

Long-term quality of life and survival outcomes strongly favored the mechanical technique. At 12 months post-surgery, patients in the mechanical group reported significantly higher quality-of-life scores, as measured by the HQI (87 vs. 75; $p < 0.01$). Additionally, survival rates at one year were slightly higher in the mechanical group (95%) compared to the manual group (90%). These findings underscore the potential of mechanical anastomosis to provide sustained postoperative benefits, likely due to its ability to minimize complications and maintain better anastomotic integrity over time. Improved quality of life is a particularly important metric, as it reflects not only the absence of complications but also the overall well-being and satisfaction of patients following surgery.

The analysis of postoperative complications revealed some differences in the profiles of the two techniques. Pelvic abscesses were observed exclusively in the manual group, affecting 4% of patients, whereas no such cases were reported in the mechanical group. Similarly, wound seromas occurred more frequently in the manual group (16%) compared to the mechanical group (10%). Although these differences did not reach statistical significance, they suggest that mechanical stapling may confer an advantage in reducing the risk of certain complications, particularly those related to wound and pelvic infections. On the other hand, manual anastomosis demonstrated slightly higher rates of faster intestinal recovery, which may be attributable to its precise and individualized approach.

Conclusions

This study highlights the complex interplay between manual and mechanical anastomosis techniques in colorectal cancer surgery, offering insights into their respective advantages and challenges. Mechanical anastomosis demonstrated benefits such as reduced operative time, enhanced consistency, and better long-term quality of life outcomes. These attributes make it a preferred choice in high-volume settings and minimally invasive procedures. Conversely, manual anastomosis remains a valuable technique, particularly in cases involving fragile or compromised tissues, where its precision and adaptability to individual patient anatomy are indispensable. Anastomotic dehiscence remains a significant complication, with similar rates observed between the two methods. Factors such as tissue quality, surgical expertise, and preoperative treatments like radiotherapy play a crucial role in determining outcomes. Mechanical anastomosis showed a trend toward reduced leakage rates and complications, such as pelvic abscesses and wound infections, but manual techniques demon-

strated faster recovery of intestinal function, underscoring the complementary strengths of both approaches. However, this study has important limitations that must be acknowledged. The retrospective design inherently limits the ability to control for confounding variables, such as variations in patient characteristics and intraoperative factors. The sample size, while substantial, may not be sufficient to detect statistically significant differences in rare complications or long-term outcomes. Additionally, the absence of standardized postoperative care protocols introduces variability that may influence recovery and complication rates. The study also did not stratify patients based on critical variables such as tumor location, disease stage, or comorbidities, which could significantly affect anastomotic integrity and healing.

Despite these limitations, the study provides important insights into the nuanced selection of anastomotic techniques, emphasizing the importance of tailoring the approach to the specific clinical scenario, patient factors, and surgeon expertise. Future prospective studies with larger, more diverse patient populations and standardized care protocols are essential to further elucidate the optimal strategies for improving outcomes in colorectal cancer surgery. These efforts will contribute to refining surgical practices and ultimately enhancing patient care.

Author's Contributions

S.S. Marginean, I.R. Strâmbu, D.N. Garofil: conceptualization. All authors: methodology. M. Zurzu, A. Tigora, V. Paic, M. Bratucu: software. P.A. Radu, R.G. Ioan, V. Surlin, V. Strâmbu: validation. D. Cârtu, R.D. Chivu, V. Paic, S.S. Marginean, A. Tigora, M. Zurzu, D.N. Garofil: investigation. I.R. Strâmbu, V. Strâmbu, F. Popa, T. Burcos: resources. D. Cârtu, R.D. Chivu, P.A. Radu, M. Bratucu, R.G. Ioan: data curation. S.S. Marginean, I.R. Strâmbu, D.N. Garofil: writing original draft. All authors: writing - review. All authors have read and agreed to the published version of the manuscript.

Conflict of Interest

All authors declare that they have no conflict of interest.

Ethical Statement

The study was approved by the institutional ethics committee review board, which ensured that all research protocols adhered to rigorous ethical guidelines for patient care and confidentiality.

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